



Alexandria University
Fac. Of Agric (Saba Basha),
Department of Soil and Agric. Chemistry

**Development of a specific gravity separator for
medicinal and aromatic plant seeds.**

BY

HAITHAM HOUSSEIN YOUSIF MOHAMED

**A Thesis submitted on partial fulfillment of the
Requirement governing the award for the degree of**

DOCTOR OF PHILOSOPHY

in

AGRICULTURAL SCIENCES

(AGRICULTURAL ENGINEERING)

SOIL AND AGRICULTURAL CHEMISTRY DEPARMENT

Fac. Of Agric. (Saba Basha)

UNIVERSITY OF ALEXANDRIA

2011



Alexandria University
Faculty of Agriculture Saba Basha
Department of Soil and Agric. Chemistry

**Development of a specific gravity separator for medicinal
and aromatic plant seeds.**

Presented By

HAITHAM HOUSSEIN YOUSIF MOHAMED

For The Degree Of

DOCTOR OF PHILOSOPHY

In

AGRICULTURAL SCIENCES

(AGRICULTURAL ENGINEERING)

Examiners' Committee:

Approved

Prof. Dr. Ahmed El-Raei Soliman

**Emeritus Professor of Agricultural Engineering,
Department of Agricultural Engineering Faculty of
Agriculture, Cairo University.**

.....

Prof. Dr. Samir. Younis

**Emeritus Prof. of Agricultural Engineering, Department of
Agricultural Engineering and Biological Systems Faculty of
Agriculture, El-Shatbi Alexandria University.**

.....

Prof. Dr. Saad F. Ahmed

**Emeritus Prof. of Agricultural Engineering, Department of
Agricultural Engineering and Biological Systems Faculty of
Agriculture, El-Shatbi Alexandria University.**

.....

Prof. Dr. Ahmed El-Sayed. Gomaa

**Prof. of Agricultural Engineering and the Head of Soil and Agric.
Chemistry Department, Faculty of Agriculture, Saba Basha,
Alexandria University.**

.....

ADVISORS' COMMITTEE

Prof. Dr. Saad F. Ahmed

**Emeritus Prof. of Agricultural Engineering,
Department of Agricultural Engineering and
Biological Systems Faculty of Agriculture,
El-Shatbi Alexandria University.**

.....

Prof. Dr. Ahmed El-Sayed. Gomaa

**Prof. of Agricultural Engineering and the
Head of Soil and Agric. Chemistry
Department, Faculty of Agriculture, Saba
Basha, Alexandria University.**

.....

Prof. Dr. Gamal Sharaf

**Prof. of Agricultural Engineering,
Department of Soil and Agric. Chemistry
Faculty of Agriculture, Saba Basha,
Alexandria University.**

abroad

LIST OF CONTENTS

LIST OF TABLES	
LIST OF FIGURE.....	
ACKNOWLEDGMENT	
ABSTRACT	
I- INTRODUCTION	1
II- REVIEW OF LITERATURE	3
1- Factors affecting cleaning process	3
1-1 Physical properties of grain crops.....	3
1-1-1 Size	8
1-1-2 Shape.....	11
1-1-3 Weight	12
1-1-4 Density.....	14
1-1-5 Moisture content.....	14
1-1-6 Surface texture.....	16
1-2 Mechanical properties.....	16
1-2-1 Coefficient of friction.....	16
1-2-2 Angle of repose.....	19
1-3 Aerodynamic properties.....	20
1-3-1 Terminal velocity.....	21
1- 3-2 Drag force.....	33
2 - Different forms of separation methods.....	36
2 - 1 Screening separation.....	36
2 - 2 Aerodynamic separation.....	38
2 - 3 Specific gravity separation.....	41
2 - 4 Indented cylinder separators.....	48
2 - 5 Color separator.....	50
2 – 6 Surface texture separation.....	52
2 - 7 Magnetic separator.....	54
2 - 8 Spiral separator.....	55
III MATERIALS AND METHODS.....	56
1-Materials.....	56
1-1 Description of cleaning and grading machines.....	56
1-1-1 Specific gravity separation machine.....	56
1-1-2 Pre-Cleaner machine.....	61
1-2 Crop conditions.....	63
1-2-1 Caraway crop.....	64
1-2-2 Anise crop.....	65

	Page
1-3 Instrumentation.....	66
1-3-1 Balances.....	66
1-3-2 Vernier caliper.....	66
1-3 -3 Tachometer.....	66
1-3-4 Terminal velocity apparatus.....	66
1-3-5 Electronic air meter.....	67
1-3-6 Electronic angle meter.....	68
1-3-7 Seed counter CONTADOR.....	68
2-Methods.....	68
2-1 Factors affecting machine performance.....	69
2-1-1 Lateral slope.....	69
2-1-2 Oscillation speed.....	70
2-1-3 Air velocity	70
2-1-4 Separation surface.....	70
2-2 Measurements.....	72
2-2-1 Terminal velocity.....	72
2-2-2 Measuring of seed dimensions and projected area.....	73
2-2-3 Measuring of the bulk density.....	73
2-2-4 Measuring of the angle of repose.....	73
2-2-5 Measuring of the coefficient of friction.....	75
2-2-6 Measuring of the specific gravity.....	75
2-2-7 Measuring of thousand seed weight.....	76
2-3 Machine performance.....	77
2-3-1 Seed distribution.....	77
2-3-2 MOG distribution.....	77
2-3-3 Thousand seed weight distribution.....	77
2-3-4 Seed loss.....	78
2-3-5 MOG rejected.....	78
2-3-6 Cleanliness.....	78
2-3-7 Separating efficiency.....	78
2-3-8 Effectiveness.....	79
2-3-9 Period of time.....	79
2-4 Movement theory	80
IV- RESULTS AND DISCUSSIONS.....	83
Physical and aerodynamic properties for anise and caraway seeds.....	83
1- Preliminary experiments.....	92

1-1 First group.....	92
	Page
1-2 Second group.....	92
1-3 Third group.....	92
1-3 Fourth group.....	93
2- Main experiments.....	95
2-1 Effect of lateral slope.....	95
2-1-1 Anise first experiments group.....	95
2-1-2 Anise second experiments group.....	106
2-1-3 Anise third experiments group.....	116
2-1-4 Anise fourth experiments group.....	126
2 -1-5 Caraway first experiments group.....	137
2 -1-6 Caraway second experiments group.....	147
2-1-7 Caraway third experiments group.....	157
2-1-8 Caraway fourth experiments group.....	167
2-2 Effect of oscillation speed.....	177
2-2-1 Anise first experiments group.....	177
2-2-2 Anise second experiments group.....	184
2-2-3 Anise third experiments group.....	191
2-2-4 Anise fourth experiments group.....	197
2-2-5 Caraway first experiments group.....	204
2 -2-6 Caraway second experiments group.....	211
2 -2-7 Caraway third experiments group.....	217
2 -2-8 Caraway fourth experiments group.....	224
2-3 Effect of air velocity.....	231
2-3-1 Anise experiments.....	231
2-3-2 Caraway experiments.....	232
V- SUMMARY AND CONCLUSION.....	242
VI- REFERENCES	247
APPENDIX (A)	
APPENDIX (B)	
VII- ARABIC SUMMARY	

LIST OF TABLES

No.	Page
1. Physical properties of rough rice.....	4
2. Physical properties of some grains crops	6
3. Physical properties of flax crop.....	6
4. Some physical properties of rapeseed crop.	7
5. Grain dimensions of some cereals.....	9
6. Size distribution of oil bean seeds at 8.73% MC, (d.b.)	11
7. Analysis of a sample of wheat straw pieces taken from a whole crop harvest.....	12
8. Static coefficient of friction for gain.....	16
9. Friction angles for seed on steel surface.....	17
10. Values of the friction coefficient for several materials over metallic surface.....	17
11. Angle of repose for some grains.	19
12. Floating velocity for threshed materials.....	20
13. Terminal velocity of the seeds.....	22
14. Summary of some aerodynamic properties for wheat crop.	26
15. Angle of repose, terminal velocity and rupture properties of rape seeds at different moisture contents.....	33
16. Effect of moisture content and variety on drag coefficient.....	34

17. Mean of aerodynamic properties of wheat samples at different mass.	35
18. Physical characteristics of the materials for segregation test.	42
No.	Page
19. Gravity table deck layout (Krueger et al, 2007).	47
20. Physical and aerodynamic properties of anise seeds (Pimpinella anisum) Egypt, 2008.....	84
21. Physical and aerodynamic properties of caraway seeds (Carum Carvi) Egypt,2008.....	84
22. Terminal velocity of anise seeds, caraway seeds and MOG for anise and caraway.....	86
23. Effect of lateral slope and oscillation speed on seed, MOG distribution and period of time at air velocity of 1.53m/s and woven wire 47 mesh.....	104
24. Effect of lateral slope and oscillation speed on thousand seed weight at air velocity of 1.53m/s and woven wire 47 mesh.....	105
25. Effect of lateral slope and oscillation speed on seed, MOG distribution and period of time at air velocity of 1.31m/s and woven wire 325 mesh.....	114
26. Effect of lateral slope and oscillation speed on thousand seed weight at air velocity of 1.31m/s and woven wire 325 mesh.....	115
27. Effect of lateral slope and oscillation speed on seed, MOG distribution and period of time air velocity of 1.42m/s and woven wire 325 mesh.....	124
28. Effect of lateral slope and oscillation speed on thousand seed weight at air velocity of 1.42m/s and woven wire 325 mesh.....	125
29. Effect of lateral slope and oscillation speed on seed, MOG distribution and period of time at air velocity of 1.53 m/s and woven wire 325 mesh.....	134
30. Effect of lateral slope and oscillation speed on thousand seed weight at air velocity of 1.53 m/s and woven wire 325 mesh.....	135
31. Effect of lateral slope and oscillation speed on seed , MOG distribution and period of time at air velocity of 1.53 m/s and woven wire 47 mesh.....	145
32. Effect of lateral slope and oscillation speed on thousand seed weight at air velocity of 1.53 m/s and woven wire 47 mesh.....	146
33. Effect of lateral slope and oscillation speed on seed , MOG distribution and period of time at air velocity of 1 m/s and woven wire 325 mesh	155
34. Effect of lateral slope and oscillation speed on thousand seed weight at air velocity of 1 m/s and woven wire 325 mesh.....	156
35. Effect of lateral slope and oscillation speed on seed , MOG distribution and period of time at air velocity of 1.22 m/s and woven wire 325 mesh	165

36. Effect of lateral slope and oscillation speed on thousand seed weight at air velocity of 1.22 m/s and woven wire 325 mesh.....	166
37. Effect of lateral slope and oscillation speed on seed , MOG distribution and period of time at air velocity of 1.53 m/s and woven wire 325 mesh	175
38. Effect of lateral slope and oscillation speed on thousand seed weight at air velocity of 1.53 m/s and woven wire 325 mesh.....	176

LIST OF FIGURES

No.	Page
1. Relationship between the product of equivalent diameter and seed weight.....	13
2. Static coefficient of friction device	18
3. Vertical air column for separation stigma from the other parts of flower.....	21
4. Tolerance interval covering 95% of terminal velocity values at 0.95 confidence level straw values are for various lengths..	24
5. Terminal velocity apparatus	28
6. Air column used for measurement of terminal velocity	29
7. Terminal velocity apparatus	29
8. Cross section of vertical wind tunnel	31
9. The effect of length and node positions on terminal velocity of wheat straw	32
10. Variation of drag coefficient of sunflower seed with moisture content	34
11. Schematic layout of the experimental device for the study of solids screening	36
12. Schematic diagram of the experimental box fixed on a gravity separator	38
13. Effect of air velocity and amplitude on segregation efficiency index at a fixed rotational speed of 500 rpm; r is the vibrating amplitude	39
14. The Cross Flow Classifier.	40

15. Typical components of a gravity table separator	42
16. Vacuum gravity separator with rectangular deck and knife type of divider	43
17. (a) Normal barley, (b) ergot.....	44
18. relationship between discharge gate of separation and free fat acidity	45
No.	Page
19. Gravity table operation and sampling locations	46
20. Indented cylinder separator	49
21. Principle operation of color separator	50
22. Details of the grading area showing the air ejectors and the outlets	51
23. Scheme of the sorting machine.....	52
24. Schematic diagram of velvet roll separator.....	53
25. Friction cleaning unit	54
26. The main parts of the gravity separation machine.....	57
27. Gravity separation machine	56
28. The seed quality at outlet openings of the gravity separator	58
29. Grading deck.....	59
30. Woven wire 47 mesh.....	59
31. Woven wire 325 mesh	59
32. Centrifugal fan and deflectors	60
33. Gravity separator deflectors.....	60
34. Round perforations sieve.....	61

35. Slotted perforations sieve	61
36. The main parts of the pre-cleaner machine.....	62
37. Pre-cleaner machine	63
38. Caraway plant	64

No.	Page
39. Anise plant.....	65
40. Digital tachometer	66
41. Terminal velocity apparatus	67
42. Electronic air meter..	67
43. Electronic angle meter	68
44. Seed counter CONTADOR	68
45. The seed distribution in outlet openings	69
46. Anise and caraway seeds cleaning and grading flow diagram for experiments group....	71
47. The bulk density and angle of repose apparatus	74
48. The angle of repose	74
49. Coefficient of friction apparatus	75
50. Terminal velocity of anise seeds and MOG.....	86
51. Terminal velocity of caraway seeds and MOG.....	86

52. Light MOG in caraway.....	87
53. Heavy MOG in caraway.....	87
54. Light MOG in anise.....	87
55. Heavy MOG in anise	87
55-a. Frequency distribution curve for anise seeds and MOG.....	88
55-b. Frequency distribution curves for good and broken seeds.....	88
No.	Page
55-c. Frequency distribution curves for anise seeds and MOG.	88
55-d. Frequency distribution curve for anise seeds.	89
55-e. Frequency distribution curves for anise seeds and MOG.	89
55-f. Frequency distribution curve for caraway seeds.	90
55-g. Frequency distribution curves for good and broken seeds.	90
55-h. Frequency distribution curve for caraway seeds and MOG.	90
55-i. Frequency distribution curves for caraway seeds and MOG.....	91
55-j. Frequency distribution curves for caraway seed and MOG.	91
56. Anise experimental diagram.....	94
57. The seed quality at outlet openings of the gravity separator.....	95
58. Effect of lateral slope on seeds percent at different oscillation speeds.....	97
59. Effect of lateral slope on MOG percent at different oscillation speeds.....	97
60. Effect of lateral slope on seeds percent at different outlet openings and oscillation speeds.....	98

61. Effect of lateral slope on MOG percent at different outlet openings and oscillation speeds.....	99
62. Effect of lateral slope on thousand seed weight at different outlet openings and oscillation speeds.	101
63. Effect of lateral slope on period of time at different oscillation speeds.	103
64. Effect of lateral slope on seeds percent at different oscillation speeds.....	107
65. Effect of lateral slope on MOG percent at different oscillation speeds.....	107
66. Effect of lateral slope on seeds percent at different outlet openings and oscillation speeds.....	109
67. Effect of lateral slope on MOG percent at different outlet openings and oscillation speeds.....	110
No.	Page
68. Effect of lateral slope on thousand seed weight at different outlet openings and oscillation speeds.	111
69. Effect of lateral slope on period of time at different oscillation speeds.	113
70. Effect of lateral slope on seeds percent at different oscillation speeds.....	117
71. Effect of lateral slope on MOG percent at different oscillation speeds.....	117
72. Effect of lateral slope on seeds percent at different outlet openings and oscillation speeds.....	119
73. Effect of lateral slope on MOG percent at different outlet openings and oscillation speeds.....	120
74. Effect of lateral slope on thousand seed weight at different outlet openings and oscillation speeds.	121
75. Effect of lateral slope on period of time at different oscillation speeds.	123
76. Effect of lateral slope on seeds percent at different oscillation speeds.....	127
77. Effect of lateral slope on MOG percent at different oscillation speeds.....	127

78. Effect of lateral slope on seeds percent at different outlet openings and oscillation speeds.....	129
79. Effect of lateral slope on MOG percent at different outlet openings and oscillation speeds.....	130
80. Effect of lateral slope on thousand seed weight at different outlet openings and oscillation speeds.	132
81. Effect of lateral slope on period of time at different oscillation speeds.	133
81-a. Caraway experimental diagram.....	136
82. Effect of lateral slope on seeds percent at different oscillation speeds.....	138
83. Effect of lateral slope on MOG percent at different oscillation speeds.....	138
No.	Page
84. Effect of lateral slope on seeds percent at different outlet openings and oscillation speeds.....	140
85. Effect of lateral slope on MOG percent at different outlet openings and oscillation speeds.....	141
86. Effect of lateral slope on thousand seed weight at different outlet openings and oscillation speeds.	142
87. Effect of lateral slope on period of time at different oscillation speeds.	144
88. Effect of lateral slope on seeds percent at different oscillation speeds.....	148
89. Effect of lateral slope on MOG percent at different oscillation speeds.....	148
90. Effect of lateral slope on seeds percent at different outlet openings and oscillation speeds.....	150
91. Effect of lateral slope on MOG percent at different outlet openings and oscillation speeds.....	151
92. Effect of lateral slope on thousand seed weight at different outlet openings and oscillation speeds.	152
93. Effect of lateral slope on period of time at different oscillation speeds.	154
94. Effect of lateral slope on seeds percent at different oscillation speeds.....	158

95. Effect of lateral slope on MOG percent at different oscillation speeds.....	158
96. Effect of lateral slope on seeds percent at different outlet openings and oscillation speeds.....	160
97. Effect of lateral slope on MOG percent at different outlet openings and oscillation speeds.....	161
98. Effect of lateral slope on thousand seed weight at different outlet openings and oscillation speeds.	162
99. Effect of lateral slope on period of time at different oscillation speeds.	164
100. Effect of lateral slope on seeds percent at different oscillation speeds.....	168
101. Effect of lateral slope on MOG percent at different oscillation speeds.....	168
102. Effect of lateral slope on seeds percent at different outlet openings and oscillation speeds.....	169
No.	Page
103. Effect of lateral slope on MOG percent at different outlet openings and oscillation speeds.....	170
104. Effect of lateral slope on thousand seed weight at different outlet openings and oscillation speeds.	172
105. Effect of lateral slope on period of time at different oscillation speeds.	174
106. Effect of oscillation speed on seeds percent at different lateral slopes.....	178
107. Effect of oscillation speed on MOG percent at different lateral slopes.....	178
108. Effect of oscillation speed on seeds percent at different outlet openings and lateral slopes.....	179
109. Effect of oscillation speed on MOG percent at different outlet openings and lateral slopes.....	180
110. Effect of oscillation speed on thousand seed weight at different outlet openings and lateral slopes.	182
111. Effect of oscillation speed on period of time at different lateral slope..	183
112. Effect of oscillation speed on seeds percent at different lateral slopes.....	185