Chapter 3
Experiment on Characteristics of Ground Ocimum Seed Powder

There are several medicinal plants grown in Thailand that have been used as laxatives for years, the most well-known and inexpensive one is ocimum seeds. It has long been used as foods and deserts. Studies on ocimum seeds as bulk laxatives in this country were firstly conducted by Ketusinh and Arunlakshana back in 1950, yet there have not been any further reports on this subject since then. Till the last few years, the used of this seed as bulk laxatives was the subject of interest again which was probably due to the major impact of vastly use of imported plantago seeds, commercial available under the trade name "Metamucil". Preliminary study reveals that the husk of ocimum seeds possesses similar or even better laxative effect compared to plantago seeds. This so called "husk" is actually the outmost thin-layer portion of the seed coat which contains swellable substance as shown in Figure 3.1, and it is this part of the seed to be used as laxative drug.

It was reported (25) that air-dried seeds contain approximately 14 % of moisture, and when in contact with water, swelling part, fine hairs which were tightly coiled up like a spring, will absorb water, uncoil rather forcefully and push themselves out through the covering skin. Recently, Rojanapanthu *et al* (1,2) investigated some characteristics of the swelling substance, and found that it contains about 10 % of moisture and the viscosity corresponding to its concentration in water is shown in Table 3.1. In water it possesses pseudoplastic flow phenomena and a concentration of 0.15 % weight by volme it behaves as thixotropic substance.

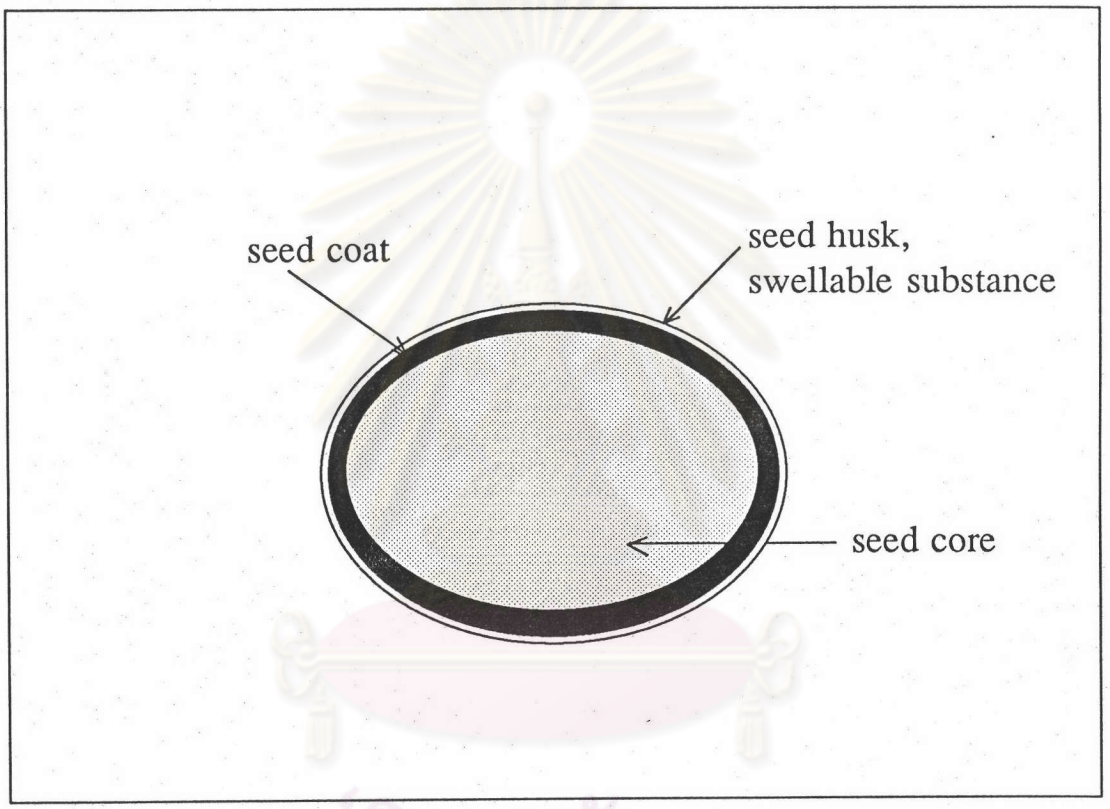


Figure 3.1 Schematic representation showing ocimum seed structure

Table 3.1 Apparent viscosity of ocimum seed swelling substance at various concentrations in water (2)

Concentration (g/100 ml)	Viscosity (cps)
0.05	40
0.10	156
0.15	351
0.20	576
0.25	845
0.40	1,050
0.60	5,360
0.80	8,360
1.00	12,900
2.00	13,000

As discussed earlier, very few physical properties of whole seeds and swelling part have been reported. In this study, some characteristics of ground ocimum seed powder which are basic parameters and other properties concerning fluidization process will be investigated.

3.1 Determination of Moisture Content

Ten-gram sample of ground ocimum seed mixture at ambient condition and sample having been dried in hot air oven at 70 °C for 1 hour were weighed using Ohous moisture balance under temperature of 110 °C. The remaining weight of sample was detected and recorded after constant weight was maintained for at least 30 minutes. Moisture content in percentage was calculated based on the weight loss on drying as shown in Table 3.2. Under ambient condition, ocimum seed powder has equilibrium moisture content of about 10 - 14 % whereas dry powder at 70 °C for 1 hour has the moisture content about 5 - 6 %. Indeed, it took several hours in order to completely dry, in hot air oven, this 5 - 6 % moisture content.

3.2 Powder Analysis

3.2.1 Experimental procedure

3.2.1.1 Sieving

Ocimum seed powder used throughout this experiment was obtained from grinding and passing through U.S. standard sieve number 20. For particle size analysis, U.S. standard sieve number 20, 40, 60, 80, 100, 120, 140, 200 and 325 were selected (Table 3.3). Selection of sieves were based on two criteria; (a) previous experiment (26) on this powder classification, employing sieve number 20, 40, 60, 80 and 100, and (b) owing to limitation of available sieve in market during this study. Forty grams of sample randomly collected from different

Table 3.2 Moisture content of ground ocimum seed powder

sample no.	moisture content (%)
Ambient condition *	
1	11.5
2	10.2
3	12.4
4	13.8
5	11.6
Oven-dry at 70 °C for 1 hour	
1	5.4
2	6.0
3	5.2
4	5.8
5	5.3

* collected on each day during experiment

Table 3.3 U.S. standard sieves and their openings used in ground ocimum seed particles size analysis

sieve number	opening (μm)
20	841
40	420
60	250
80	177
100	149
120	125
140	105
200	74
325	44

position in the container were placed in standard sieves and fitted on Tyler's sieve shaker. Sieve shaking time, required to stabilized the result according to ASTM procedure (27), was tested, and it was found that 30 minutes is most efficient. Sample was oven-dried at 70 °C for 1 hour before sieving because fine particles were adhered and tended to agglomerate on the sieve openings (Figure 3.2) which was due to high moisture content

3.2.1.2 Optical microscopic observation.

Each class of ocimum seed powder was diluted with pure glycerin and smeared on a microscope slide. The samples were directly observed and photographed via optical microscope.

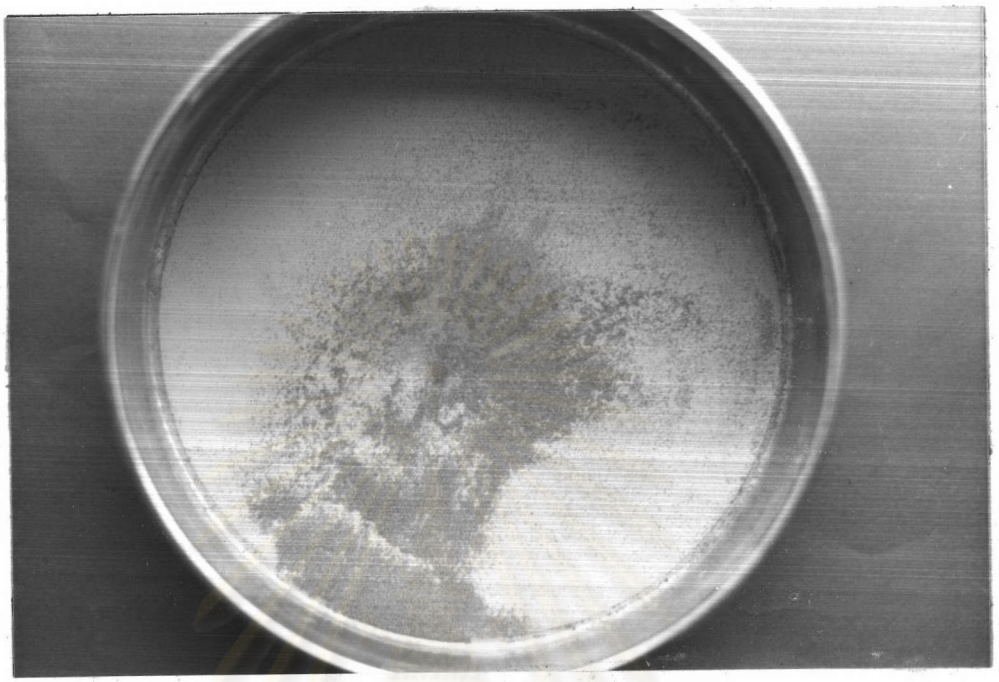
3.2.1.3 Swelling properties

Swelling character of each class of powder was tested following Rojanapanthu *et al* method (2). Ocimum powder 0.5 g was dispersed with small amount of 95% ethyl alcohol in 100 ml measuring cylinder and 80 ml of distilled water was then added. The dispersion was thoroughly mixed with stirring rod and volume was finally adjusted to 100 ml with purified water. Reading of dispersion volume for each particle class was made at 10 minutes and 24 hours after samples had been prepared.

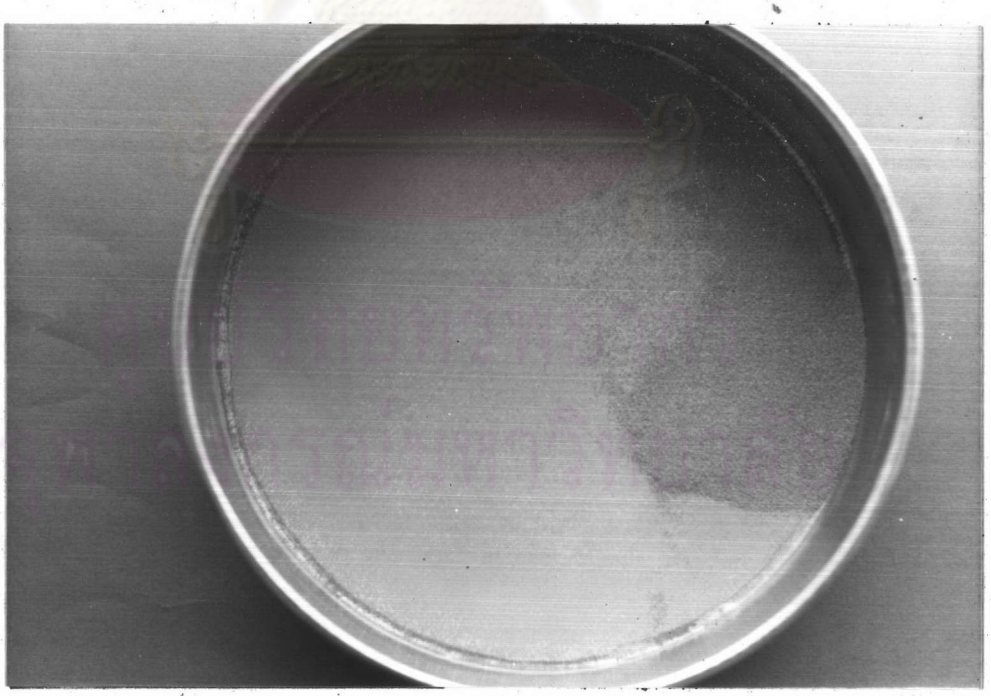
3.2.2 Results and discussions

3.2.2.1 Composition of ground ocimum seed powder

Direct observation on sieve-classified powder, as in Figure 3.3, shows that their color shade corresponding to their particle sizes from coarse to fine is in the range of black to yellow white accordingly. It may roughly be divided into 3 groups; the first is composed of particles larger than 177 μm with color somewhat



A



B

Figure 3.2 Adsorption and agglomeration of fine particles on sieve opening due to moisture (a), compared to sieve opening which free from fine particles when the powder was dried before sieving (b).

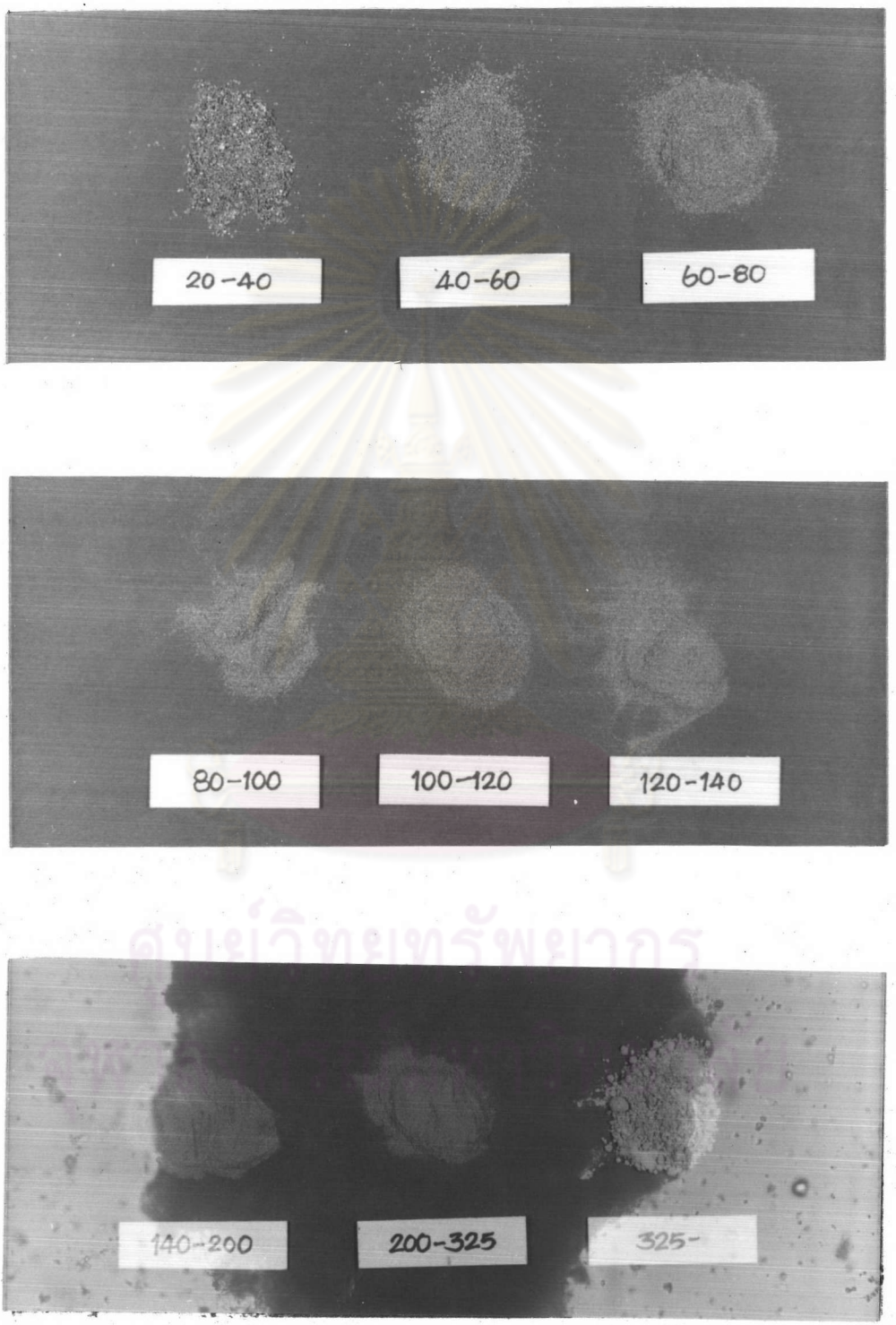


Figure 3.3 Three groups of particles roughly classified by apparent color

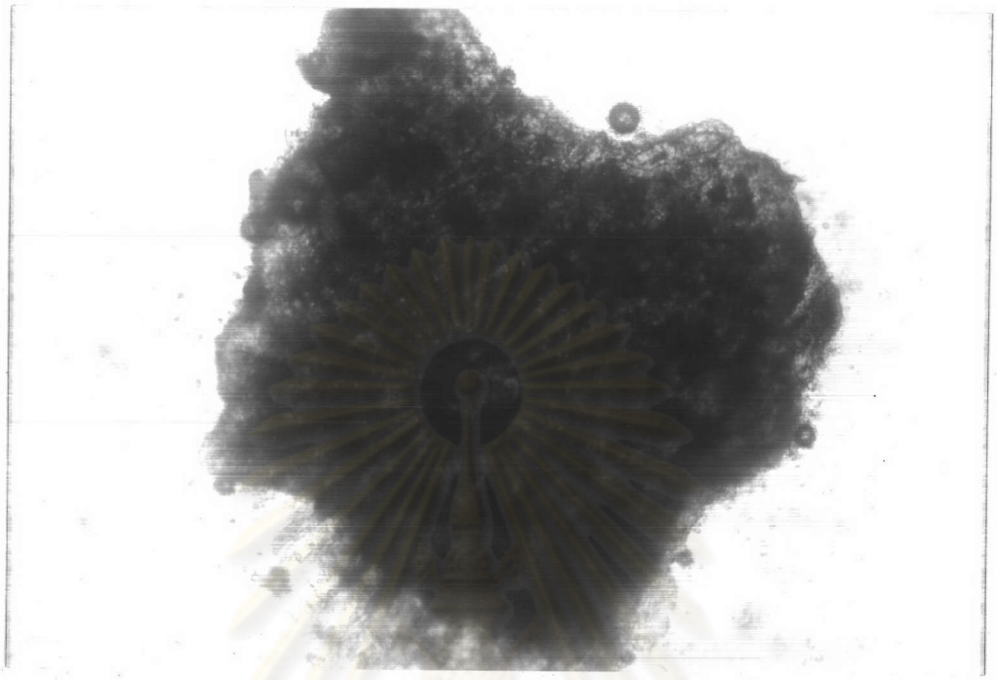
in black shade, second group having color ranging from black brown to white brown shade possesses particle sizes within the range of 44 to 177 μm, and the last group, whose particles are smaller than 44 μm, is yellow white in color.

Test of swelling properties has also clearly shown that particles smaller than 44 μm do not swell (see section 3.2.2.3). Figure 3.4 is the photographic evidences of microscopic observation comparing the composition of each particle class obtained from sieving. The black opaque portion is the core of seed coat and transparent portion represents the swelling substance. Particles with 20-40, 40-60 and 60-80 mesh cut size (Figure 3.4-A, B and C) are composed of seed coat with swellable substance attached on them. Swellable particles are observed with the cut sized of 80-100 mesh to 325- mesh. For 80-100 mesh group (Figure 3.4 D) there is a trace amount of swellable fraction; and for 100-120 (Figure 3.1 G) mesh group, swellable fraction is markedly increased and approximately 50% in content. Particles within the range of 120-140, 140-200 and 200-325 mesh sizes (Figure 3. 4-F, G, H) are mostly swellable substances. For the last group of particles (Figure 3.4-I), whose sizes are mostly fine granules with trace element of swellable substance, these fine granules are the composition of seed core.

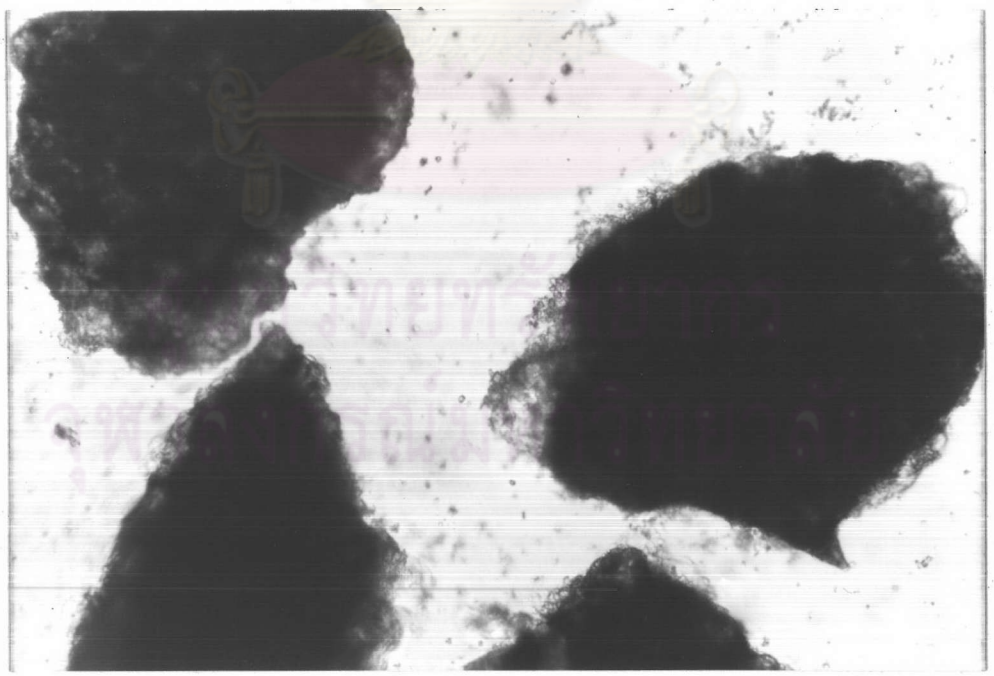
In conclusion, there are three groups of particles in ground ocimum seed powder; (a) particles of seed coat with swellable substance remaining attached on them, (b) particles of swellable substance which are intermediate size and (c) granules of seed core.

3.2.2.2 Particle size analysis (28)

Tables 3.4 is the results of sieve analysis of each sample using Tyler's sieve shaker. The average value of weight in each cut size from Table 3.4 was calculated and the resulting mean particle size of 149.46 μm was obtained (Table

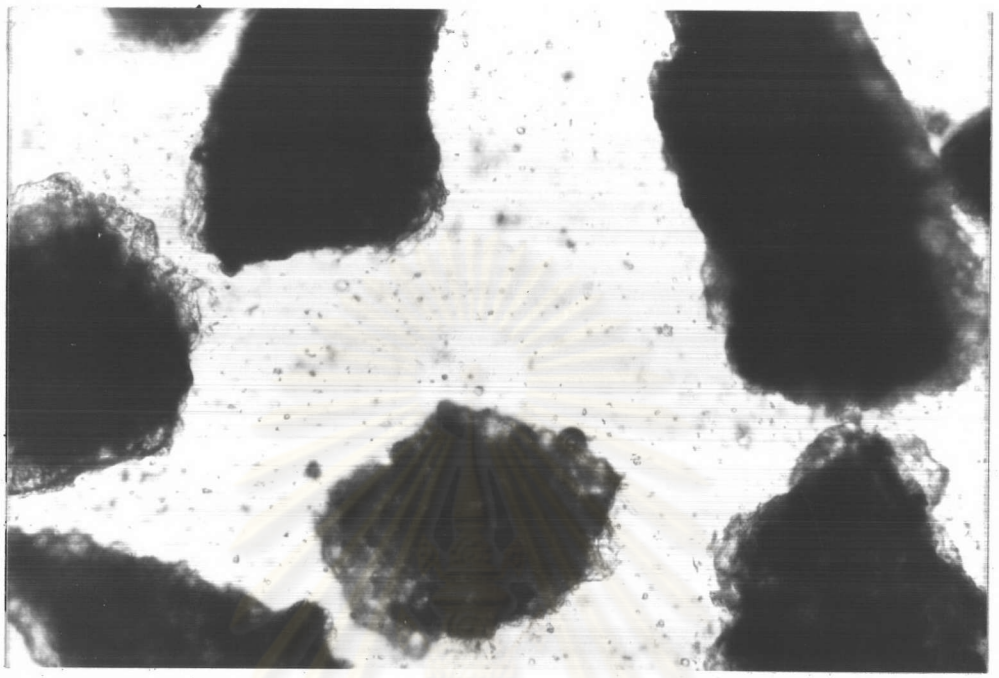


A: 20-40 mesh (601 μm)

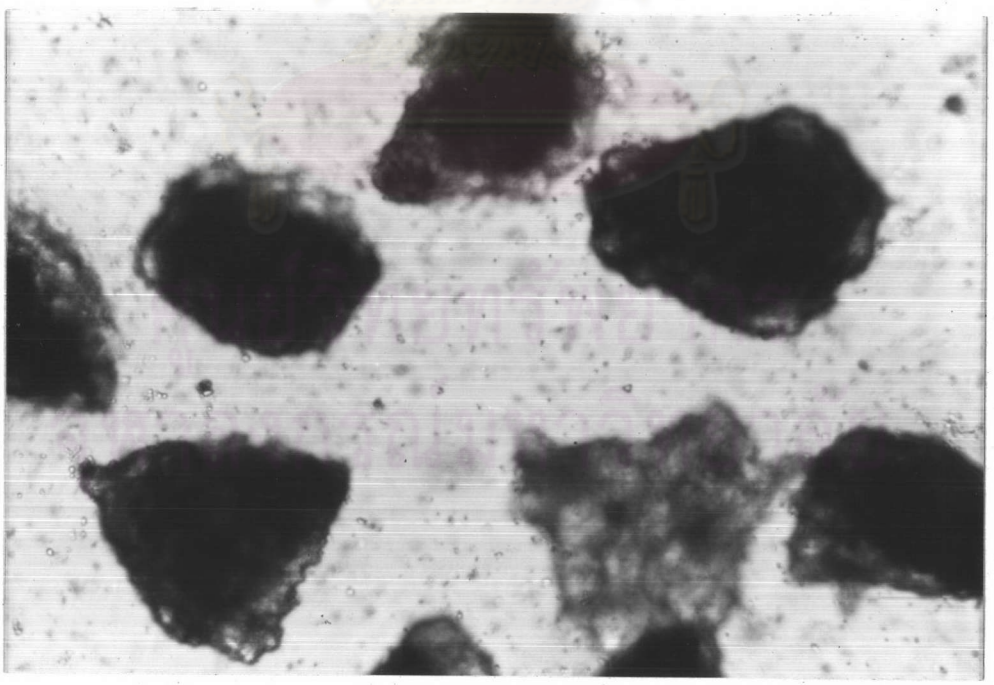


B : 40-60 mesh (326 μm)

Figure 3.4 Comparison of ocimum seed powder fraction from microscope, X 100

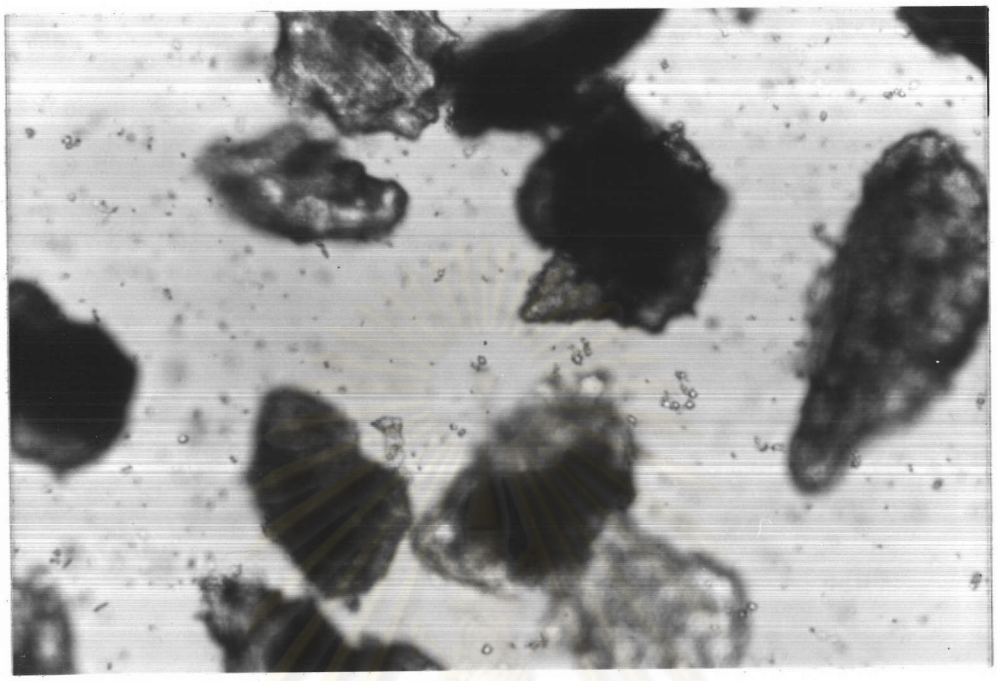


C : 60-80 mesh (212 μm)

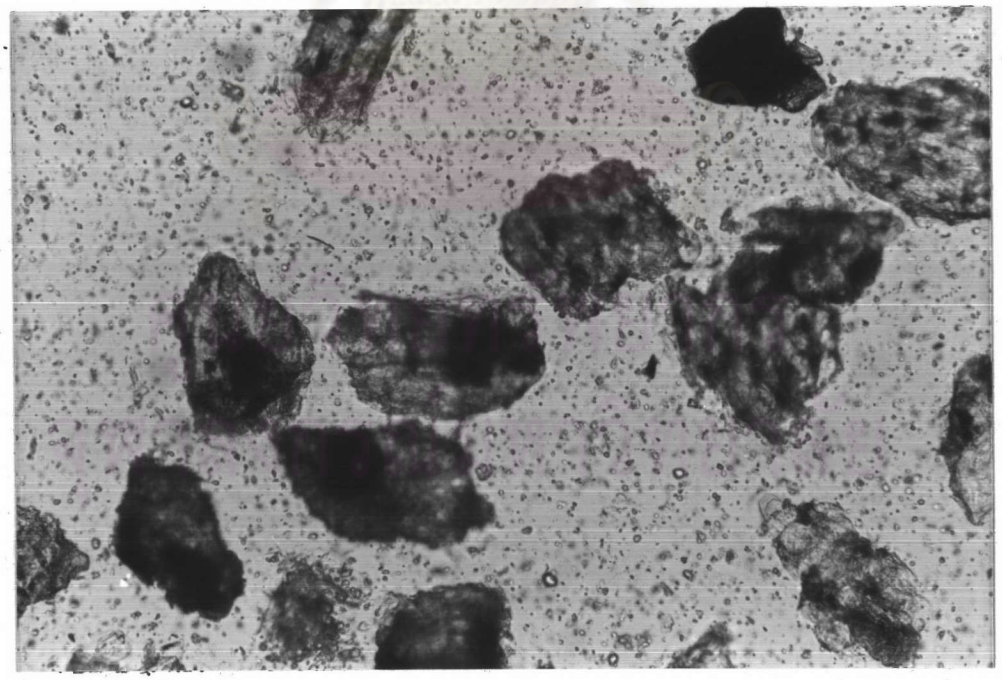


D : 80-100 mesh (164 μm)

Figure 3.4 (continue)

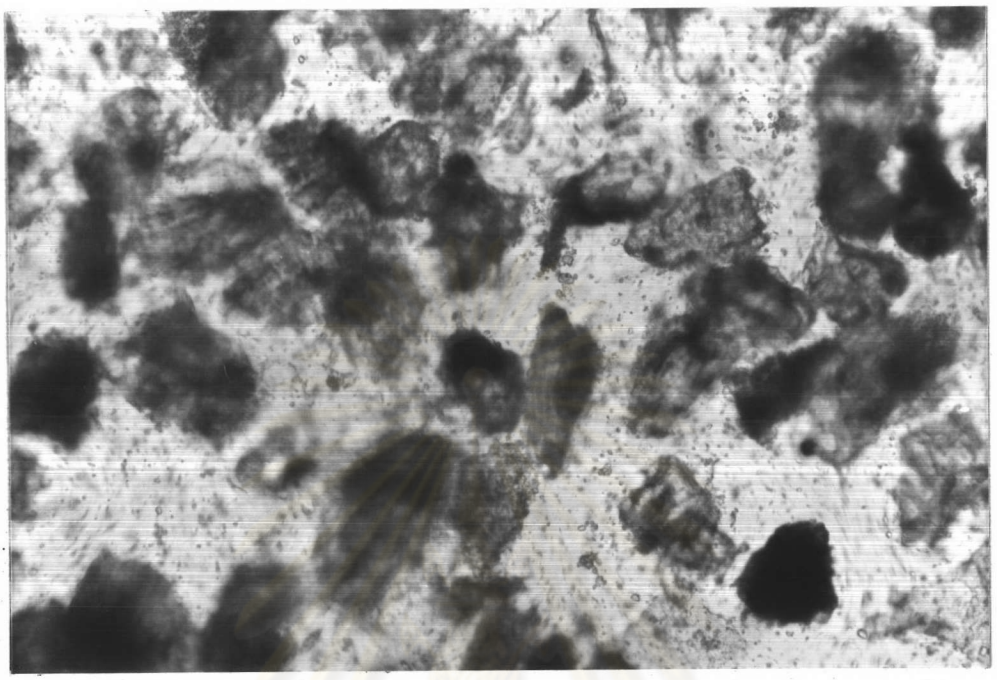


E : 100-120 mesh (136 μm)

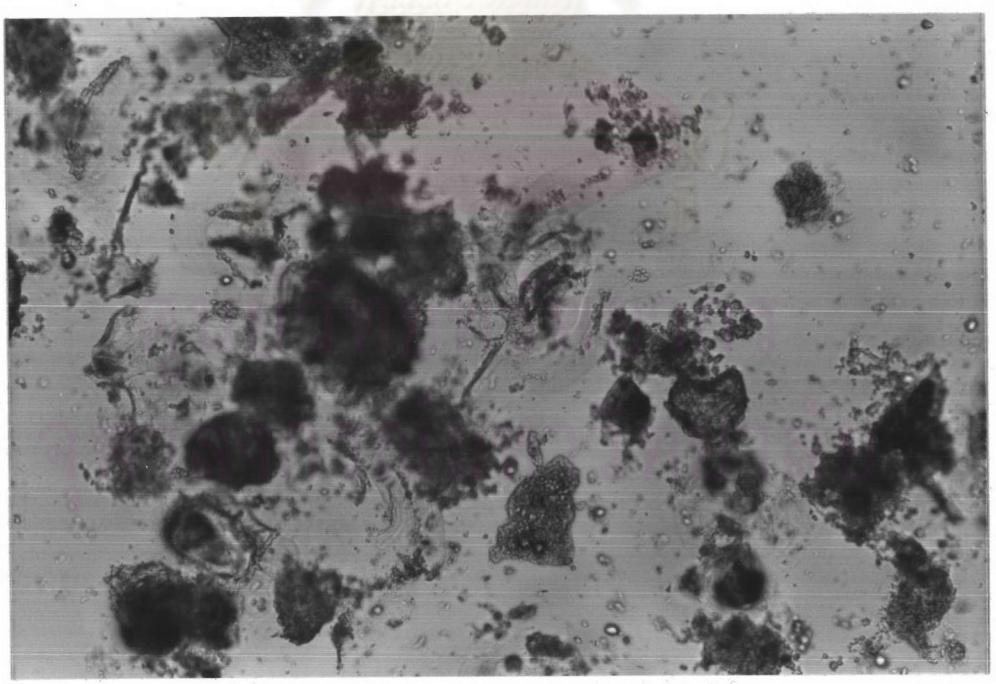


F : 120-140 mesh (114 μm)

Figure 3.4 (continue)

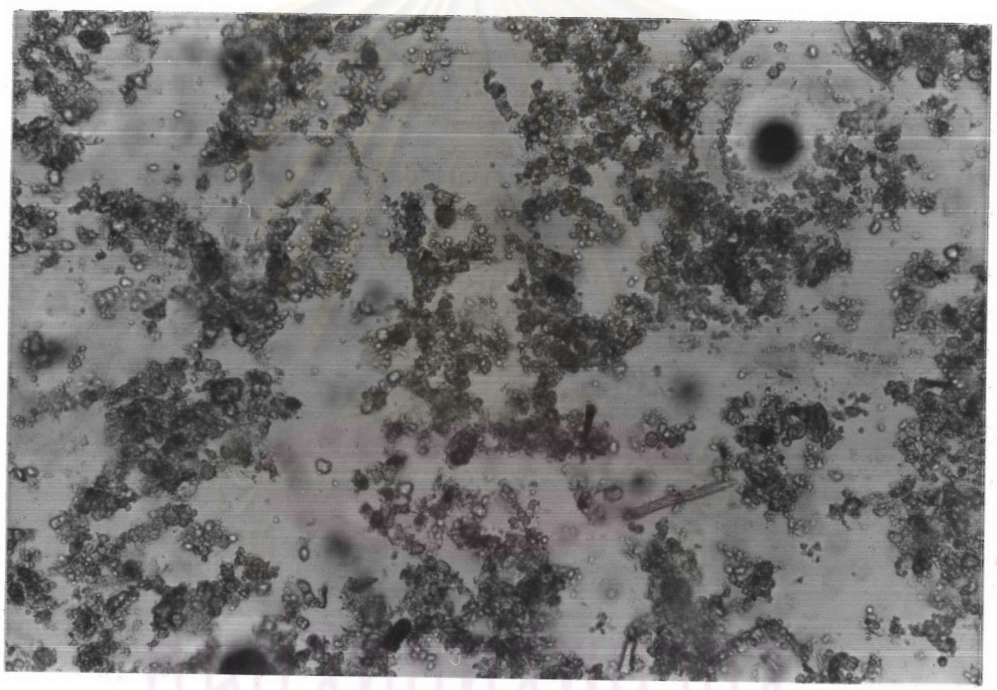


G : 140-200 mesh (88 μm)



H : 200-325 mesh (57 μm)

Figure 3.4 (continue)



I : 325- mesh (22 μm)

Figure 3.4 (continue)

3.5). Plot of weight frequency versus particle size from above data, Figure 3.5, shown that the ground mixture falls into the trimodal distribution in size, is 40-60 mesh, 100-120 mesh and 325 mesh or smaller in size. This may be due to mixed particle size distribution according to unique nature of this ground material. The results were the average of four determinations.

3.2.2.3 Particle shape factor

According to the definitions of particle shape in British Standard 2955 (29), ocimum seed powder from microscopic observation (Figure 3.4) in the size range of 20 to 325 mesh cut size could be defined as moderately-irregular particle. Owing to this particle shape, shape factor might be calculated from the equivalent volume diameter (d_V) of 1 , and surface diameter (d_S) of 1.2 obtained from Table 11 in British Standard 4359 (30) as follow;

$$\text{Shape factor} = \left(\frac{d_V}{d_S}\right)^2$$

$$= \left(\frac{1}{1.2}\right)^2$$

$$= 0.6944$$

The particles smaller than 44 μm group is assumed to be sphere since it is granular shape and very fine by nature.

3.2.2.4 Swelling properties

All fractions of particle cut size, except for the finest group extensively swelled in distilled water. Swelling capacity increases with reduction of particles size. Volume expansion of particles in the first 3 groups seems to be similar and lower than groups of intermediate-size particles. This might be related to the composition of each class as mentioned in 3.2.2.1. The first 3 groups of particles primarily consists of particles of core of seed coat whereas particles of intermediate

Table 3.4 Particle size analysis of ground ocimum seed powder

Exp No 901

particle in mesh	dpi (micron)	Ln(dpi)	weight of F+S (gm)	weight of F (gm)	weight of S (gm)	Xi	cum. % under size	XiLn(dpi)
20-40	601.040	6.399	425.57	422.12	3.45	0.0863	8.6293	0.5522
40-60	325.960	5.787	360.15	348.93	11.22	0.2806	36.6933	1.6240
60-80	212.130	5.357	412.94	406.28	6.66	0.1666	53.3517	0.8924
80-100	163.770	5.098	399.88	397.37	2.51	0.0628	59.6298	0.3201
100-120	136.470	4.916	261.51	258.04	3.47	0.0868	68.3092	0.4267
120-140	114.560	4.741	308.24	305.46	2.78	0.0695	75.2626	0.3297
140-200	88.150	4.479	327.50	326.48	1.02	0.0255	77.8139	0.1143
200-325	57.450	4.051	329.09	326.56	2.53	0.0633	84.1421	0.2563
325-	22.000	3.091	377.63	371.29	6.34	0.1586	100.0000	0.4902
mean particle size =		149.28012	micron	| total	39.98	1.0000		5.0058

Exp No 902

particle in mesh	dpi (micron)	Ln(dpi)	weight of F+S (gm)	weight of F (gm)	weight of S (gm)	Xi	cum. % under size	XiLn(dpi)
20-40	601.040	6.399	425.72	422.12	3.6	0.0895	8.9485	0.5726
40-60	325.960	5.787	360.17	348.93	11.24	0.2794	36.8879	1.6168
60-80	212.130	5.357	413.44	406.28	7.16	0.1780	54.6856	0.9535
80-100	163.770	5.098	399.89	397.37	2.52	0.0626	60.9495	0.3194
100-120	136.470	4.916	261.42	258.04	3.38	0.0840	69.3512	0.4130
120-140	114.560	4.741	308.08	305.46	2.62	0.0651	75.8638	0.3088
140-200	88.150	4.479	327.33	326.48	0.85	0.0211	77.9766	0.0946
200-325	57.450	4.051	328.74	326.56	2.18	0.0542	83.3955	0.2195
325-	22.000	3.091	377.97	371.29	6.68	0.1660	100.0000	0.5133
mean particle size =		150.11488	micron	| total	40.23	1.0000		5.0114

Note : S = sample, F = reservior of sieve frame

mean particle size = $\exp[\Sigma(XiLn(dpi))]$

Table 3.4 (continue)

Exp No 903

particle in mesh	dpi (micron)	Ln(dpi)	weight of F+S (gm)	weight of F (gm)	weight of S (gm)	Xi	cum. % under size	XiLn(dpi)
20-40	601.040	6.399	425.79	422.05	3.74	0.0922	9.2232	0.5902
40-60	325.960	5.787	422.86	411.71	11.15	0.2750	36.7201	1.5912
60-80	212.130	5.357	413.29	406.24	7.05	0.1739	54.1060	0.9314
80-100	163.770	5.098	400.11	397.37	2.74	0.0676	60.8631	0.3445
100-120	136.470	4.916	261.53	258.03	3.5	0.0863	69.4945	0.4243
120-140	114.560	4.741	308.05	305.47	2.58	0.0636	75.8570	0.3017
140-200	88.150	4.479	327.46	326.55	0.91	0.0224	78.1011	0.1005
200-325	57.450	4.051	328.8	326.59	2.21	0.0545	83.5512	0.2208
325-	22.000	3.091	377.89	371.22	6.67	0.1645	100.0000	0.5084
mean particle size =	150.34967	micron		total	40.55	1.0000		5.0130

Exp No 904

particle in mesh	dpi (micron)	Ln(dpi)	weight of F+S (gm)	weight of F (gm)	weight of S (gm)	Xi	cum. % under size	XiLn(dpi)
20-40	601.040	6.399	425.71	422.06	3.65	0.0901903	9.0190	0.5771
40-60	325.960	5.787	422.56	411.73	10.83	0.2676056	35.7796	1.5486
60-80	212.130	5.357	413.82	406.25	7.57	0.1870521	54.4848	1.0021
80-100	163.770	5.098	399.89	397.38	2.51	0.0620213	60.6869	0.3162
100-120	136.470	4.916	261.20	258.02	3.18	0.0785767	68.5446	0.3863
120-140	114.560	4.741	308.23	305.48	2.75	0.0679516	75.3398	0.3222
140-200	88.150	4.479	327.48	326.53	0.95	0.0234742	77.6872	0.1051
200-325	57.450	4.051	328.79	326.65	2.14	0.0528787	82.9750	0.2142
325-	22.000	3.091	378.11	371.22	6.89	0.1702496	100.0000	0.5262
mean particle size =	148.11856	micron		total	40.47	1.0000		4.9980

Note : S = sample, F = reservior of sieve frame

mean particle size = $\exp[\Sigma(XiLn(dpi))]$

Table 3.5 Average mean particle size and weight distribution of ground ocimum seed powder

particle in mesh	dpi (micron)	LnXmean	weight fraction of samples (gm) No.901	No.902	No.903	No.904	mean wt. (gm)	Xi	cum. % under size	XiLn(dpi)
20-40	601.04	6.3987	3.45	3.6	3.74	3.65	3.610	0.0896	8.9561	0.5731
40-60	325.96	5.7868	11.22	11.24	11.15	10.83	11.110	0.2756	36.5193	1.5950
60-80	212.13	5.3572	6.66	7.16	7.05	7.57	7.110	0.1764	54.1587	0.9450
80-100	163.77	5.0985	2.51	2.52	2.74	2.51	2.570	0.0638	60.5346	0.3251
100-120	136.47	4.9161	3.47	3.38	3.50	3.18	3.383	0.0839	68.9264	0.4125
120-140	114.56	4.7411	2.78	2.62	2.58	2.75	2.683	0.0666	75.5815	0.3155
140-200	88.15	4.4790	1.02	0.85	0.91	0.95	0.932	0.0231	77.8949	0.1036
200-325	57.45	4.0509	2.53	2.18	2.21	2.14	2.265	0.0562	83.5142	0.2276
325-	22.00	3.0910	6.34	6.68	6.67	6.89	6.645	0.1649	100.0000	0.5096
mean particle size = 149.4633 micron						total	40.308	1.0000		5.0071

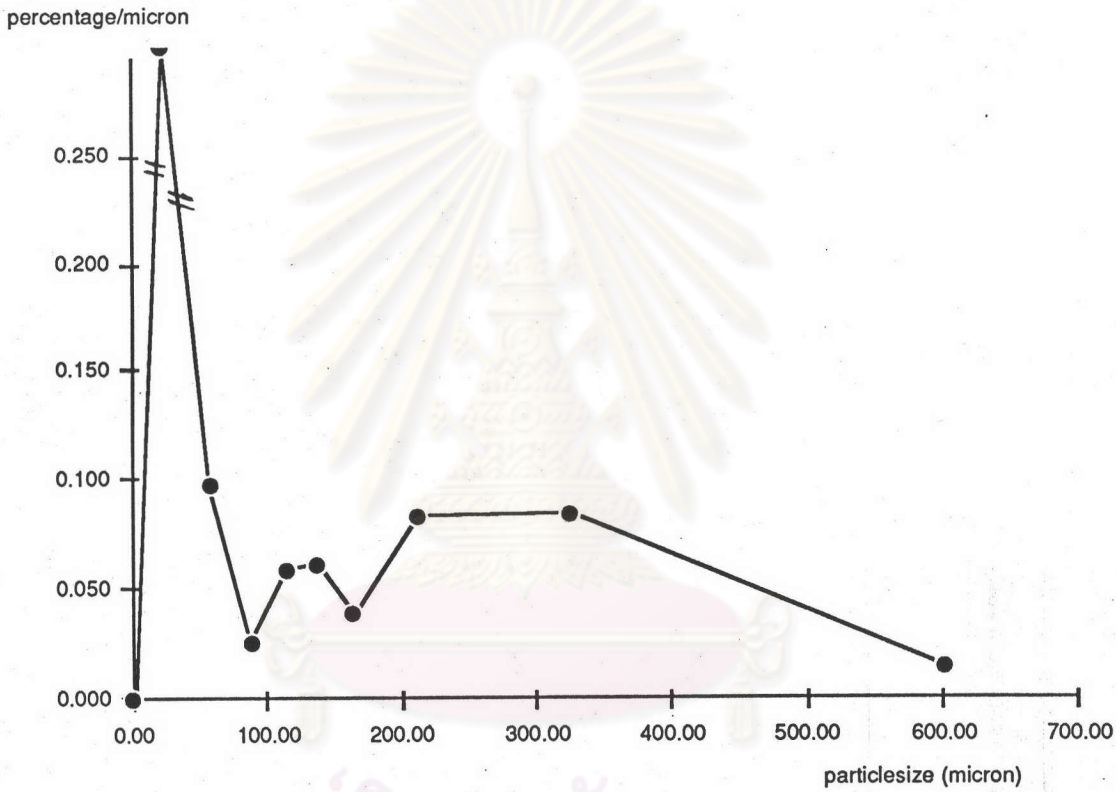


Figure 3.5 Trimodal distribution characteristic of ground ocimum seed powder

size with high volume expansion comprises swelling fractions in majority. For particle smaller than 44 μm, less volume expansion was observed (Figure 3.6) since it contains mainly the composition of seed core and trace amount of swelling fraction.

3.3 Density

Three kinds of particle density, that is, true density, dry-particle density (oven-dried at 70 °C for one hour) and whole powder bulk density were determined and studied.

3.3.1 True density

A considerably amount of ground ocimum seed powder was completely dried and 5 grams of sample were immediately weighed and poured in to 50 ml volumetric flask. Hexane, density of 0.665 g/cm^3 at room temperature (25-30 °C), was used in particle volume displacement since effective penetration of this liquid through ocimum seed powder were demonstrated in the previous study (26). The result is shown in Table 3.6, true density of ground ocimum seed powder was found to be 1.5257 gm/cm^3.

3.3.2 Density of dry particle

Because of the fact that powder used throughout this investigation was formerly dried at 70 °C for 1 hour, density of particles under this condition should also be investigated. Experimental procedure was the same as 3.3.1 and particle density of each particle cut size was examined, as shown in Table 3.7. It is interesting to note that all classes of particle have approximately the same density of about 1.4 gm/cm^3 though there are 3 different types of particles in these samples.

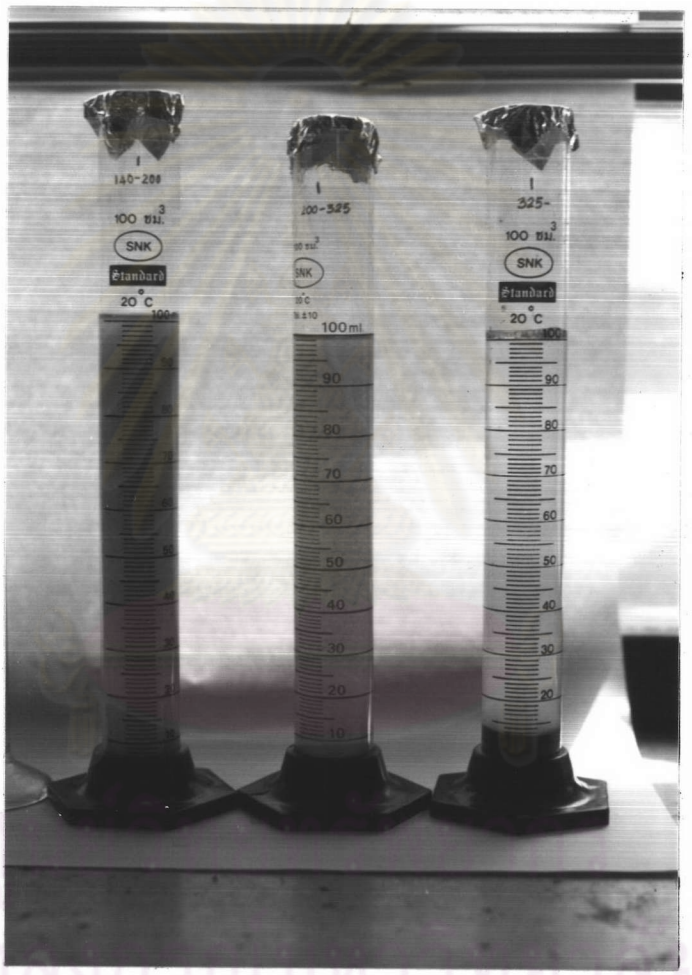


Figure 3.6 The swelling capacity of particles in smaller than 44 μm group, compared with other classes.

3.3.3 Bulk density

Whole mixture of ground ocimum seed was shaken in a suitable container, gently poured into 100 ml measuring cylinder to volume and then weighed with the cylinder had been tared. The bulk density were calculated and listed in Table 3.8.

Table 3.6 True density of ground ocimum seed powder

sample No.	weight of S+H+F(gm)	weight of S(gm)	weight of F(gm)	weight of H(gm)	volume of H(ml)	volume of S(ml)	density of S(gm/ml)
1	61.038	5.032	24.945	31.061	46.70827	3.29173	1.52868
2	65.908	5.051	29.81	31.047	46.68722	3.31278	1.52470
3	65.869	5.032	29.785	31.052	46.69474	3.30526	1.52242
4	62.343	5.015	26.262	31.066	46.71579	3.28421	1.52700
						mean =	1.52570

Note : S = sample, F = 50 ml volumetric flask and H = hexane

Table 3.7 Experimental result of dry-particle density of ocimum seed powder in each cut size

sample No.	weight of S+H+F(gm)	weight of S(gm)	weight of F(gm)	weight of H(gm)	volume of H(ml)	volume of S(ml)	density of S(gm/ml)	Mean density (gm/ml)
20-40 mesh								
1	68.95	5.006	33.07	30.874	46.42707	3.57293	1.40109	1.39860
2	62.047	5.005	26.176	30.866	46.41504	3.58496	1.39611	
40-60 mesh								
1	68.987	5.008	33.07	30.909	46.47970	3.52030	1.42261	1.43261
2	64.21	5.009	28.26	30.941	46.52782	3.47218	1.44261	
60-80 mesh								
1	65.599	5.002	29.704	30.893	46.45564	3.54436	1.41126	1.42918
2	60.81	5.005	24.855	30.95	46.54135	3.45865	1.44710	
80-100 mesh								
1	68.987	5.012	33.094	30.881	46.43759	3.56241	1.40691	1.40490
2	64.13	5.004	28.248	30.878	46.43308	3.56692	1.40289	
100-120 mesh								
1	68.954	5.008	33.086	30.86	46.40602	3.59398	1.39344	1.40247
2	60.759	5.005	24.862	30.892	46.45414	3.54586	1.41150	
120-140 mesh								
1	65.597	5.009	29.704	30.884	46.44211	3.55789	1.40786	1.41663
2	64.181	5.005	28.261	30.915	46.48872	3.51128	1.42541	
140-200 mesh								
1	68.999	5.009	33.092	30.898	46.46316	3.53684	1.41624	1.42094
2	64.172	5.008	28.25	30.914	46.48722	3.51278	1.42565	
200-325 mesh								
1	60.764	5.003	24.861	30.9	46.46617	3.53383	1.41574	1.41627
2	64.237	5.011	28.328	30.898	46.46316	3.53684	1.41680	
325- mesh								
1	64.172	5.004	28.25	30.918	46.49323	3.50677	1.42696	1.41269
2	62.06	5.007	26.184	30.869	46.41955	3.58045	1.39843	

Note : S = sample, F = 50 ml volumetric flask and H = hexane

Table 3.8 Bulk density of ocimum seeds powder

sample no.	weight of 100 ml powder (g)	bulk density (g/cm^3)
1	64.69	0.6469
2	65.42	0.6542
3	62.82	0.6282
4	62.56	0.6256
	mean =	0.6387