CHAPTER 4 RESULTS AND DISCUSSION

4.1 Density

Density of a cat-litter pellet could be evaluated by weight and volume of the small cylindrical pellet. Volume of the pellet was calculated from its diameter and length which were measured by a vernier caliper. Average density of 100 cat-litter samples produced from different compositions were shown in Figure 4.1.

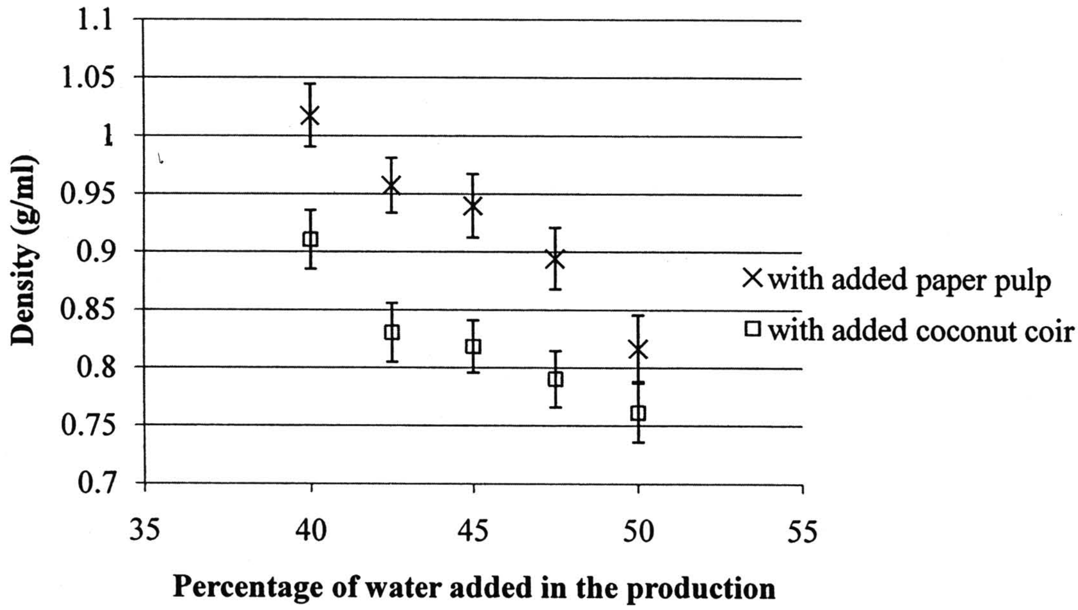

Figure 4.1: Relationship between density of cat-litter and water content in the cat-litter production

From Figure 4.1, the density of cat-litter is lower when the water content in cat-litter production is increased. This result is the same as that in US Patent 4163674 [8] which showed that the density of plaster pellet was lower while more water was added during the production. The density range of cat-litter sample with added coconut coir is 0.8618-1.0174 g/ml which is lower than density of the sample with added paper pulp which is 0.7613-0.9106 g/ml. The samples with added coconut coir have lower density because coconut coir density is lower than paper pulp.

The density of solid mixture can be estimated from the density of plaster, paper pulp/coconut coir and their mass compositions. The density of plaster, paper pulp, coconut coir, the mass composition of plaster and paper pulp/coconut are 2.63 g/ml, 0.20 g/ml, 0.14 g/ml, 90 wt.% and 0.1 wt.% , respectively. Then the density of solid mixture can be calculated. From the estimation, the density of the cat-litter with added paper pulp is about 1.1876 g/ml, while the density of the cat-litter with added coconut coir is about 0.9469 g/ml. In addition, total pore volumes of the samples were observed by gas adsorption technique and were shown in Figure 4.2.

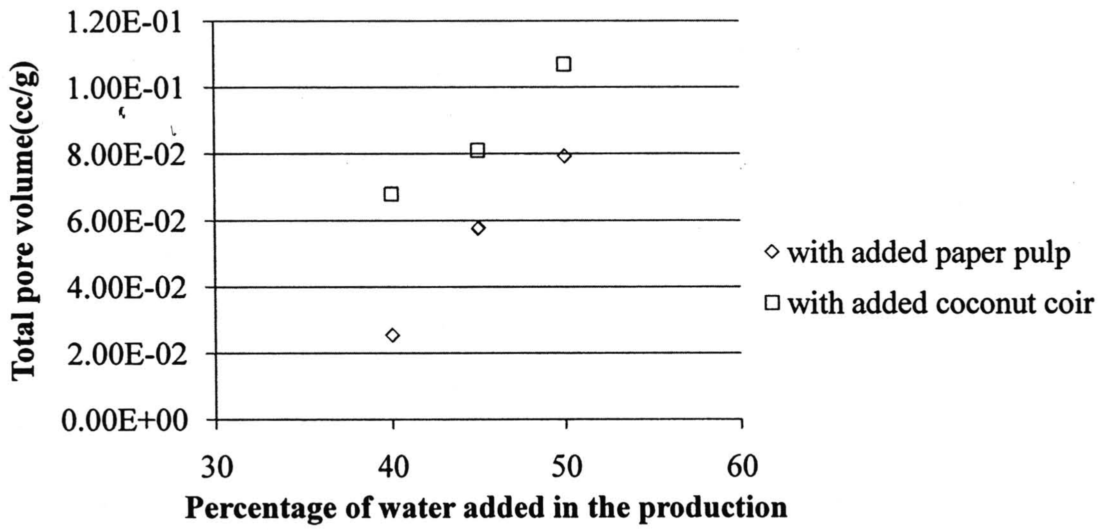

Figure 4.2: Relationship between total pore volume and water content in the cat-litter production

According to Figure 4.2, if added water was increased, the pore volume in the cat-litter will also be increased. Figure 4.2, it is indicates that the increasing of added water increases the total pore volume and then decreases the density of the cat-litter.

4.2 Abrasion resistance

Dusty cat-litter is not good to the cats. Hence, most of the users consider amounts of dust which are generated from cat-litter. Generally, abrasion resistance marks the ability of surface to resist wearing due to contact with another moved surface. The abrasion resistance of the cat-litter refers to amounts of attrition dust. Cat-litter which has higher abrasion resistance creates less dust. Abrasion resistance of the cat-litter samples which were produced from different composition were shown in Figure 4.1.

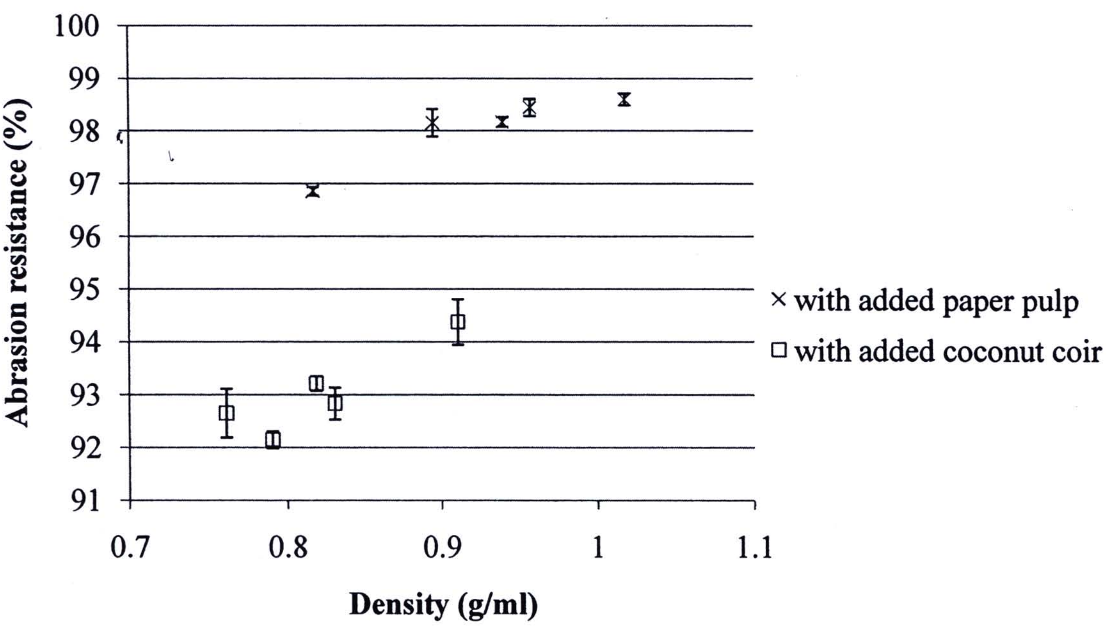

Figure 4.3: Relationship between abrasion resistance and the density of cat-litter

According to Figure 4.2, the higher density sample has better abrasion resistance. For different added material, abrasion resistance values of the cat-litter with added paper pulp are higher than added coconut coir at every density. That means the cat-litter which are produced by adding tissue paper will generate less dust.

Furthermore, the results show that all samples with added coconut coir has lower abrasion resistance than the sample with added paper pulp because coconut coir in this study was used in the form of small particle and the length to diameter ratio of coconut coir is clearly less than paper pulp. Moreover, microscopic photo of paper pulp and coconut coir are shown in Figure 4.3.

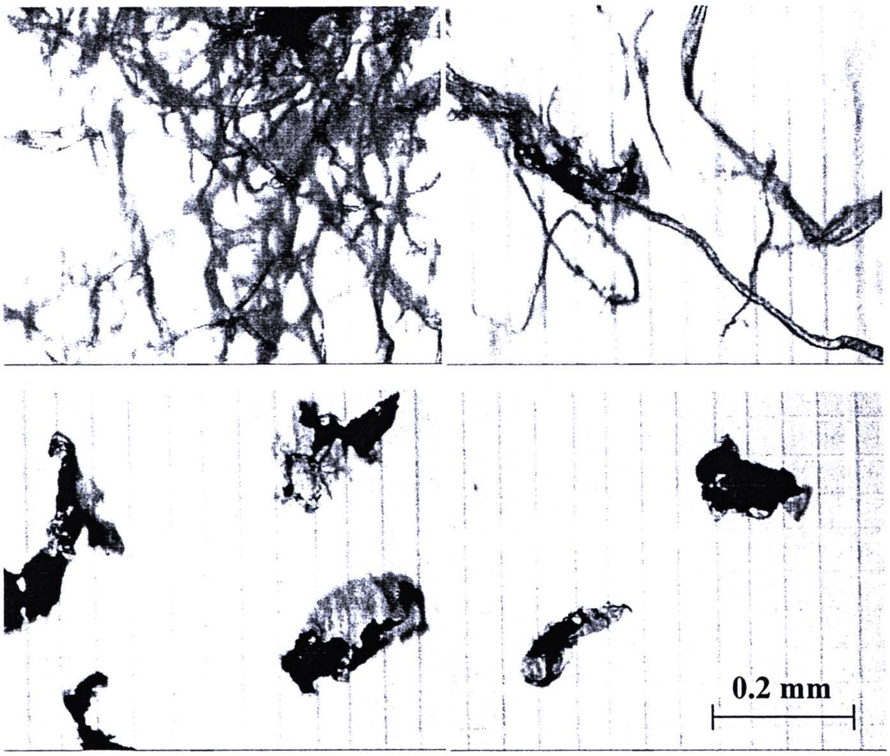

Figure 4.4: a) Microscopic photo of paper pulp
b) Microscopic photo of coconut coir

According to Figure 4.3, paper pulp has higher length to diameter ratio than coconut coir. L.A.Carlsson, *et al.* [24] proved that longer fibers of paper pulp resulted in the higher tensile strength of the paper. H.Zhang, *et al.* [25] studied the effect of fiber length on the wear resistance of short carbon fiber reinforced epoxy composites and concluded that the longer fiber composites exhibited better wear resistance compared to the shorter fiber. D.J.Callaghan, *et al.* [26] studied about the wear characteristics of glass fiber-reinforced dental composites, they found that the wear rate in composites with longer fibers was lower compared to that of shorter fiber at the same weight percent and claimed longer fibers generally provide better strengthening mechanisms compared to that of short fibers thus more wear resistance. With the mentioned researches above, the higher length of fiber results in the better abrasion resistance of the obtained cat-litter. In addition, paper pulp is obtained from purified cellulose from plants so that paper pulp has more fiber composition than coconut coir which is natural material without any pretreatment. Consequently, the material with more fiber percentage has more effective to improve strength of the obtained cat-litter.

4.3 Water adsorption

The most important property being a good cat-litter is the ability for water adsorption. Good cat-litter should be good at adsorbing moisture or water from cat's excretion. For this aspect, the objective of this section is to study the water adsorption behavior of cat-litter which are produced from different amount of added water during the production and also different raw materials. The water adsorption of the obtained cat-litter was performed by soaking the obtained cat-litter in the water. The plaster slightly dissolves in the water while the paper pulp and coconut coir cannot dissolve. So, the obtained cat-litter does not dissolve in the water and it can be assumed that the increased weight after adsorbing is the weight of adsorbed water. Percentages of water adsorption at steady state of the samples are shown in Figure 4.4.

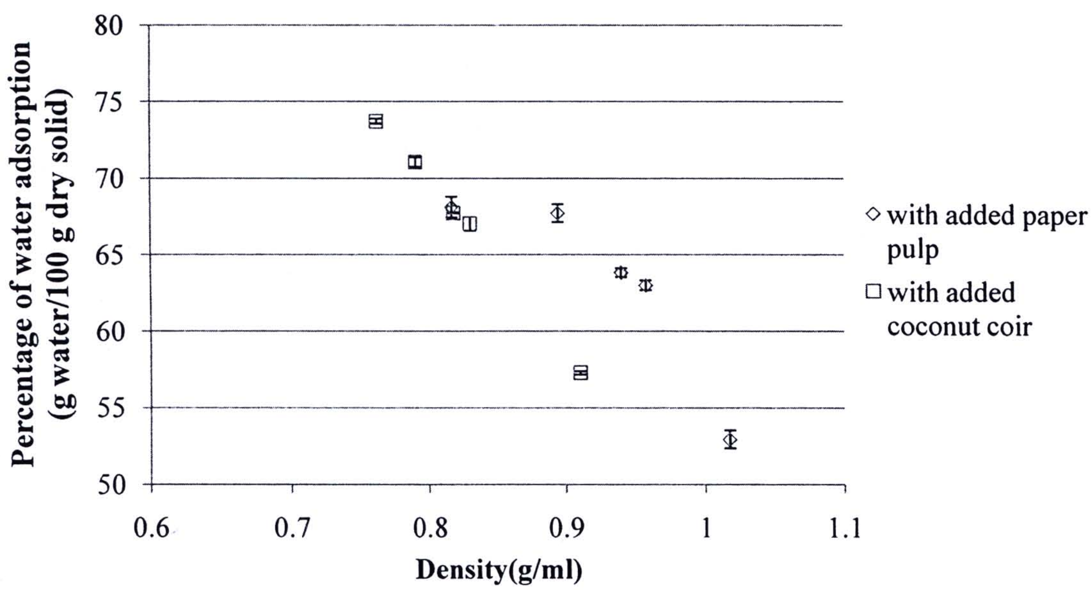

Figure 4.5: Relationship between percentage of water adsorption and the density of cat-litter

According to Figure 4.4, the cat-litter adsorbs less water while density is increased. This results are in the same way as US Patent 4163674[8] which reported that the plaster pellets which have lower density adsorbed more water. Furthermore, for different added material, the samples with added paper pulp have higher water adsorption ability than the samples with added coconut coir. However, the water adsorption trends of both samples are similar. It means that the mechanism of water adsorption of both samples could be ruled by something which both of them similarly have. Therefore, the water adsorption of plaster, paper pulp and coconut coir would be determined separately and shown in Figure 4.5.

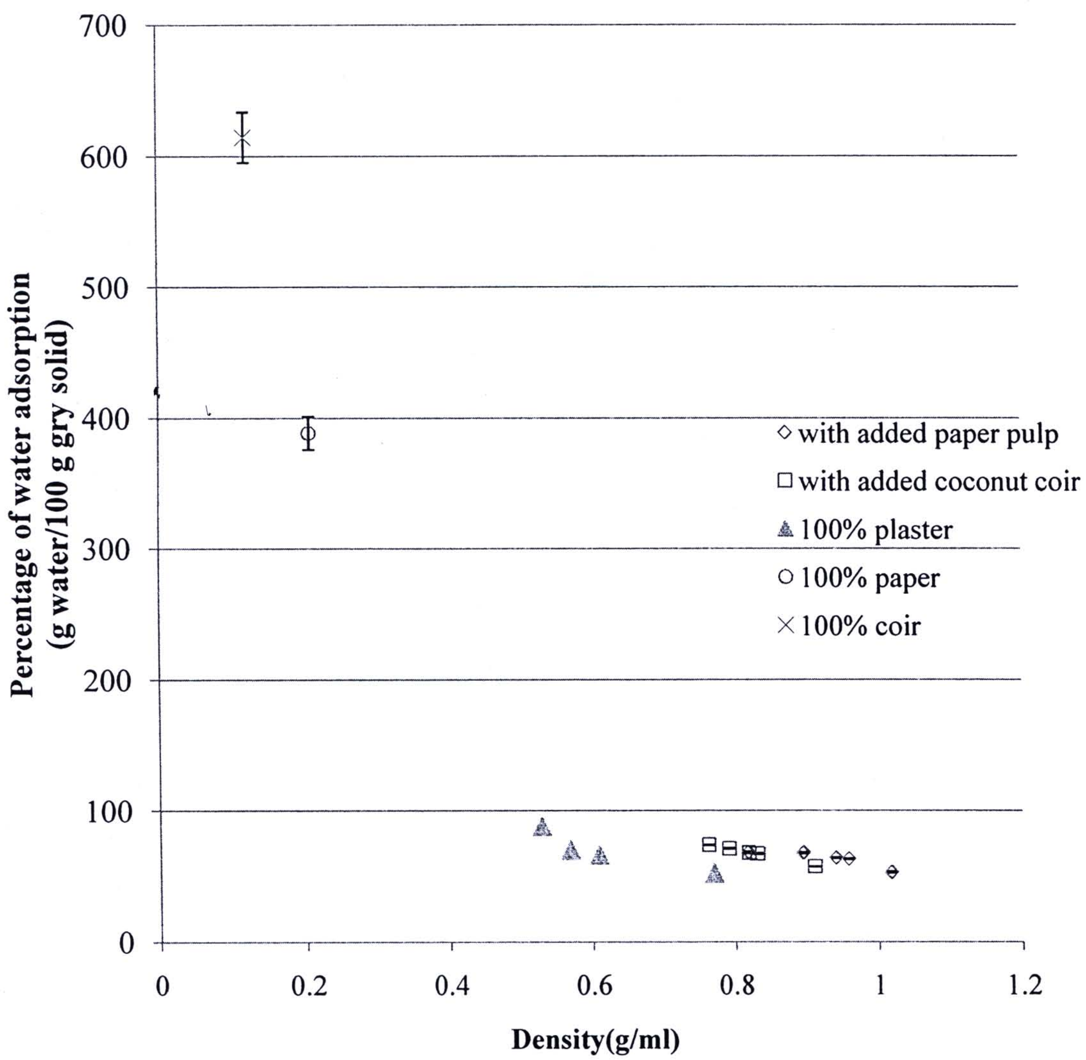

Figure 4.6: Relationship between percentage of water adsorption and the density of cat-litter

Figure 4.5 explains the effect of different raw material on the water adsorption. Individually, coconut coir is better adsorbent that paper pulp. It means that the obtained cat-litter with added coconut coir to be the better adsorbent than the obtained cat-litter with added paper pulp. However, when comparing the ability for adsorbing water, the obtained cat-litter with added paper pulp has better water adsorption than the obtained cat-litter with coconut coir. Figure 4.5 illustrates the water adsorption of the obtained cat-litter, plaster, paper pulp and coconut coir. Paper pulp can adsorb water about 400%

of their weight while coconut can adsorb water about 600% of their weight. The adsorption abilities of plaster without added material which are obtained from US Patent 4163674 [8] are shown as well. In addition, the densities of paper pulp and coconut coir are about 0.2 g/ml and 0.14 g/ml, respectively. The adsorption trend of the plaster with no added material is similar to the obtained cat-litter with paper pulp's and coconut coir's. That means the water adsorption of β-plaster dominates over the adsorption which is affected by added material because the weight of β-plaster in cat-litter is 9 times more than the addition materials. In addition, the sample with added paper pulp has slightly better adsorption than the sample with added coconut coir even though the coconut coir has better adsorption ability than the paper pulp.

If it is assumed that there is no interaction between the plaster and added material during water adsorption, the amount of water adsorption could be predicted by the summation of water adsorption capacity of pure plaster and from pure paper pulp or coconut coir at each density. Adsorption capacity of plaster portion was estimated from the data which were quoted from US Patent 4163674 [8]. Table 4.1 shows the difference between water adsorption capacity of the individual raw materials and the combined materials. The water adsorption capacities of the obtained cat-litter are compared with the water adsorption capacity of solely plaster and paper pulp/coconut coir and are shown in Table 4.1.

Table 4.1 Water adsorption comparison between the obtained cat-litter and the summation of plaster and paper pulp/coconut coir

Cat-litter	Adsorption capacity (g water/100 g dry cat-litter)				% Difference (based on the obtained cat-litter)
	Adsorption by plaster	Adsorption by paper pulp/coconut coir	Adsorption by plaster + adsorption by paper pulp/coconut coir	Adsorption by obtained cat-litter	
A1	15.89	38.86	54.75	52.95	-3.28
A2	22.85	38.86	61.71	63.02	2.12
A3	24.89	38.86	63.75	63.84	0.14
A4	30.13	38.86	68.99	67.73	-1.83
A5	39.15	38.86	78.01	68.12	-12.67
B1	28.28	61.44	89.72	57.28	-36.16
B2	37.57	61.44	99.01	67.04	-32.29
B3	38.96	61.44	100.40	67.75	-32.52
B4	42.21	61.44	103.65	71.06	-31.44
B5	45.57	61.44	107.01	73.73	-31.10

In accordance with Table 4.1, it can be summarized that when the plaster and coconut coir are combined into the cat-litter, the obtained cat-litter is the worse adsorbent than when they are individual. As mentioned in Table 3.1, A and B stand for the obtained cat-litter with paper pulp and obtained cat-litter with coconut coir, respectively. The number 1, 2, 3, 4 and 5 after A and B represent the weight percentage of water in mixture which are 40, 42.5, 45, 47.5, and 50, respectively. The summation of water adsorption by plaster and paper pulp were close to the water adsorption by the obtained cat-litter with added paper pulp. But the obtained cat-litter with added coconut coir adsorbs water less than when the individual raw materials. The results state that there is no effect on the adsorption capacity of plaster and paper pulp when they are integrated. Nevertheless, the adsorption capacity of plaster and coconut coir is decreased when they are combined into the cat-litter. This is because the cross-linkage in PVA molecules may obstruct the adsorption of coconut coir in the obtained cat-litter. The swelling of paper pulp and coconut coir during the adsorption were also observed. The swelling data of paper pulp and coconut coir are shown in Appendix C. The paper pulp is slightly swelled, while the swelling of coconut coir increases its volume to 120% of dry solid volume. So, paper pulp in the cat-litter pellet adsorbed water in full capacity, as shown in Table 4.1. On the other hand, coconut coir needs more space to expand itself and adsorb water 6 times of its weight. But the space in the cat-litter pellet is fixed by plaster and PVA cross-linkage and then the coconut coir cannot freely swell. Therefore, the coconut coir in the obtained cat-litter cannot reach the maximum adsorption capacity.

In addition, the water adsorption was noticed by eye observation. The obvious thing is that the cat-litter pellet ejected air bubbles while the water was adsorbed which means that there are pores in the pellet of cat litter, absolutely. It is also observed during the water adsorption that there are two types of bubble ejection of the obtained cat-litter. The first type is the large bubble with low ejection frequency. The second type is the small bubble with high ejection frequency. During adsorption, pore space is substituted by the water. If the pore has only one exit, it is hard for the water to pass into the channel that has air in the pore with no other outlets. Beside, air substitution is easier if the pore has other outlets that the air can exit. So, the pores in the obtained cat-litter can be classified for each type of the bubble. In the first type, air is ejected from the pore which has only one outlet. For the second type, air is ejected from the pore which has more than one outlet.

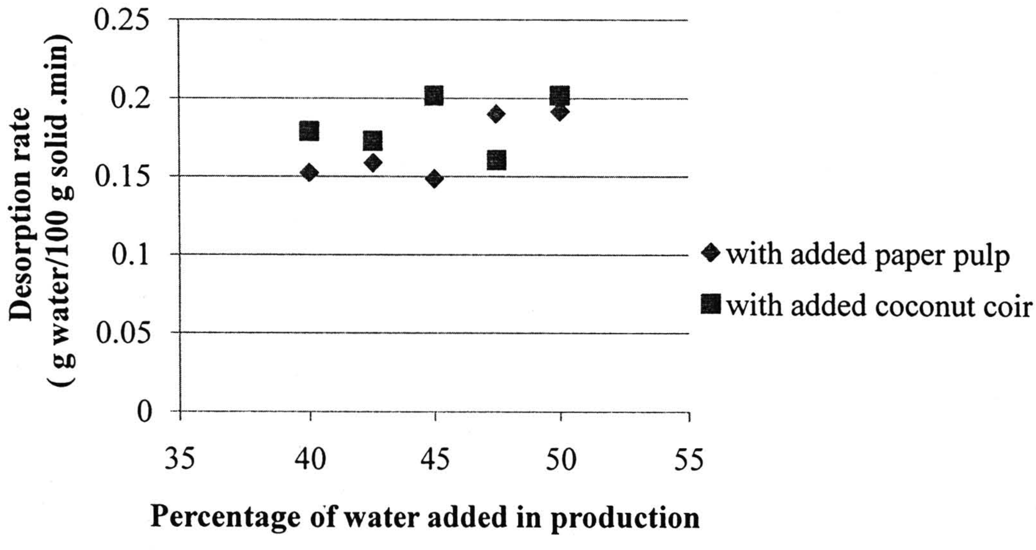

Figure 4.7: Relationship between desorption rate and percentage of water in production

Water desorption was performed in order to study the rate that the obtained cat-litter releases the adsorbed liquid. It is assumed that the less desorption rate is, the more urine odor are kept in the cat-litter. In accordance with Figure 4.6, the initial desorption rate (first 4 hours) of the two types of the cat-litter are in the same range which is about

0.15-0.2 g water/100 g solid·min. There is no significant relationship between desorption rate and percentage of water in the production. It means that there is no effect on reserving the adsorbed liquid when using different raw materials and different water added during the production.

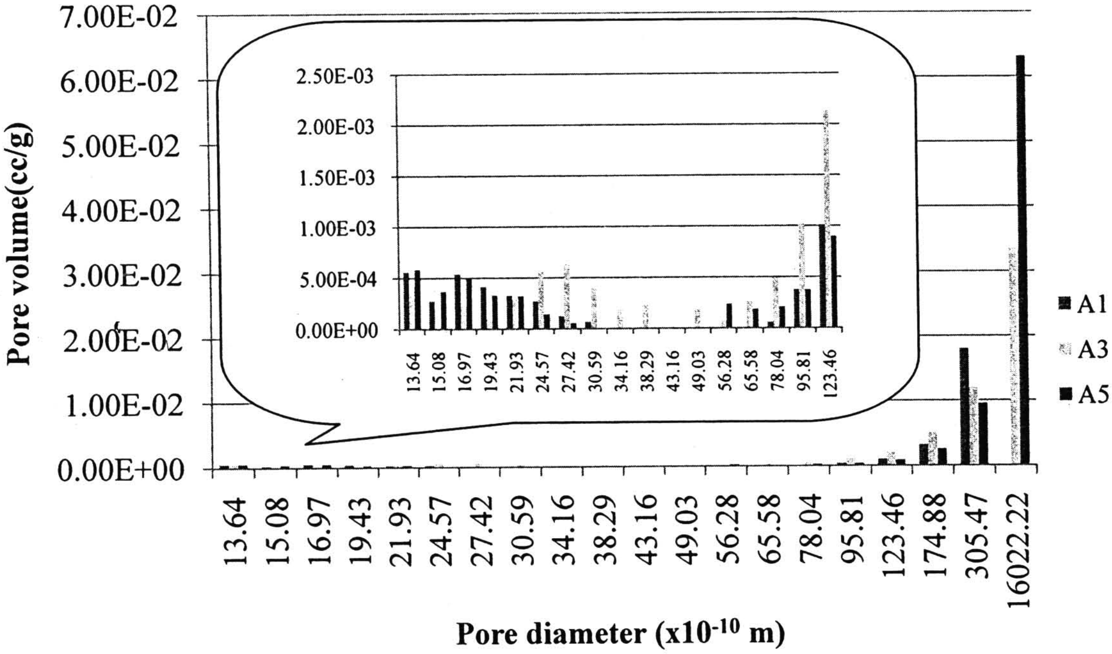

Figure 4.8: Pore size distribution of the cat-litter with added paper pulp

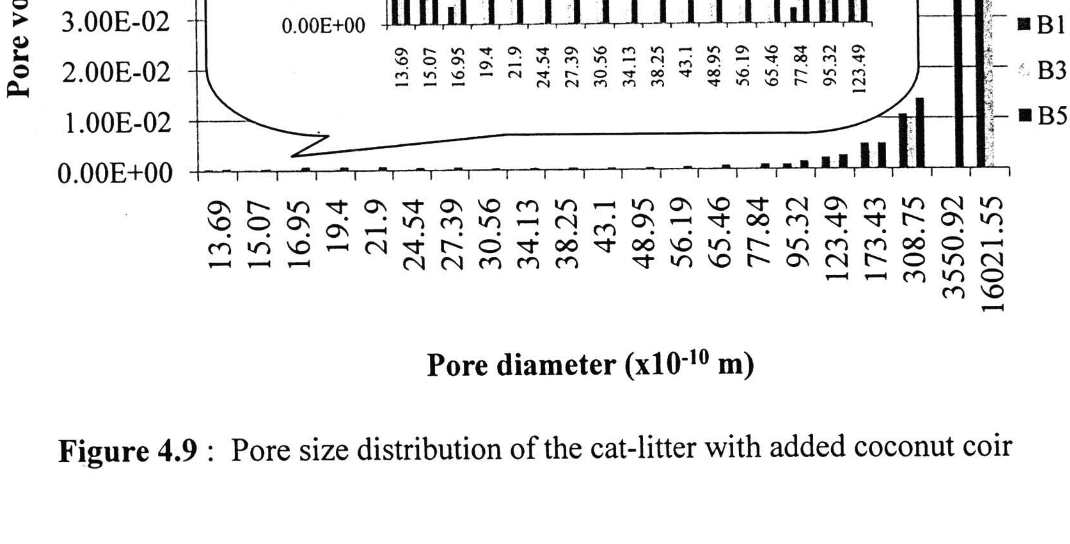

Figure 4.9 : Pore size distribution of the cat-litter with added coconut coir

Pore size distribution is mentioned because pore size may be the cause of lower the water adsorption capacity of the obtained cat-litter with added coconut coir. If the pore size is too small, the capillary action may occur and then the water cannot transfer through the pore. According to Figures 4.7-4.8, either the obtained cat-litter with added paper pulp or coconut coir has the similar shape of pore size distribution. For the obtained cat-litter pore size distribution, volume of macropore(D>500 Å) are more than mesopore(500>D>20 Å) and micropore(D<20 Å). It means that different material and different water added during production do not affect the pore size distribution. Therefore, pore size distribution is not the reason that makes the adsorption capacity of the obtained cat-litter with added coconut coir lower than that of individual plaster and coconut coir. Table 4.2 summarizes the characteristics of the obtained cat-litter when using different raw materials.

Table 4.2 : Summary of characteristics test

	The cat-litter with added paper pulp	The cat-litter with added coconut coir	100% paper pulp	100% coconut coir
Density	4	3	2	1
Abrasion resistance	2	1	n/a	n/a
Water adsorption	2	1	3	4

note : When comparing the characteristic of each material, the higher number represents the higher value of that characteristic. (eg. the obtained cat-litter with added paper pulp has the highest density)