Economical Cat Litter from Biomass using Eggshell

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Abstract - **Most commercially produced clay cat litters such as bentonite clay cat litter nowadays have raised issues to pet owners since they are toxic, non-biodegradable and have no natural odor controlling features. Thus, a study to develop litter from biomass was carried out to produce a cat litter from biomass that is biodegradable, scoopable, odor control and economical properties in order to overcome those problems. In this study, biomass materials; esgghell were processed into cat litter formulations and the results were compared . Firstly, the eggshell were cleaned properly and dried to remove moisture content and grinded to reduce their particle size. Then, the grinded eggshells were then mixed with xanthan gum as clumping agent, sodium bicarbonate as deodorizer, and glycerol as dust retardant to form mixtures of cat litter. For the purpose of enhancing the adsorptivity of the cat litter and flushability, hydrogel is added into cat litter formulations. Two types of hydrogel were used into this eggshell cat litter where a superabsorbent (carboxymethylcellulose/starch hydrogel) and a consecutive hydrogel biochar products were added into 2 different samples of eggshell cat litter. The samples were tested to compare with all of those raw materials in terms of their clumping activity, absorption capacity and dust formation.**

Keywords—Eggshell, Hydrogel Biochar, Carbomexymethylcellulose/starch Hydrogel, Absorption, Odor, Clumps.

I. INTRODUCTION

Generally, it can be said cats are among the popular domestic animals that are mostly kept as pets in many households. The main concern for pet owners is the disposal of their waste and covering any disturbing odors from the waste [1]. Therefore, most cat owners would provide litter boxes containing absorbent materials that could cover and absorb the cat's waste until it is disposed [2]. Nowadays, there are many products already invented and each of the products contributed well on the performance of cat litter such a clay, silica, natural base from biomass, and etc. It has their own specialties like the capability of odor absorbance, clumping ability, effective moisture, dust-free and biodegradable. The most commercialize cat litter currently is Bentonite clay cat litter. It has good absorption properties and is commonly used as absorbent material of cat litter [3]. Unfortunately, there are several negative impacts of using clay as cat litter since it is non-biodegradable and therefore, would lead to sewage piping blockage upon discharge through the toilet system [4]. Moreover, bentonite clay contains mica that is carcinogenic and current studies show that the use of such a compound raises health concerns for animals as well as for the owner who changing the litter [5] [6]. Dusting also one of the problems that cat owners frequent complain about as clay litter usually produced dust that cat often left around their house. Scooping up clay litter also will often scatter clay dust into air which can easily be inhaled in by pet owners during cleaning process [7]. Thus, concerns have been raised about potential health problems for both pets and owners from inhaling clay litters [8].

For this research, natural based cat litter from biomass is to be considered to make the cat litter as it can contribute to environment, economics and health of the surrounding. Currently, the world is facing exhaustion of fossil fuel as the main source of energy and the alarming global warming problem caused by the exploitation of fossil fuel. Therefore, biomass as an optional and reliable source of energy is gaining the attention of researchers to widen the methods of utilizing them. In addition, the utilization of biomass rather than fossil fuel could reduce the carbon dioxide emission to the atmosphere thus gives no significant contribution to the greenhouse effect [9]. Biomass is defined as the biodegradable products, waste and residues from agricultural activities, forestry industries, as well as municipal waste [10]. Biomass also is the better alternative as an absorbent material because unlike clay material, it is biodegradable and can easily be flushed down the toilet without causing serious blockage in the sewer system [3], [11], [12]. Other than that, biomass are also cheap and abundant as most of the biomass is just thrown away. By that, to have cheap and abundant resources as renewable sources is an innovation to the country. So, to reduce solid waste, biomass can be used as cat litter formulations. As for this research, in order to contribute to economic of the country that is Malaysia by using biomass materials; eggshell were processed into cat litter

formulations.

Next, one of the important properties of cat litter is to make them a flushable products as they should be able to hold enough wet strength for their main functionality but will lose their integrity once contact with huge amount of water [13]. Thus, hydrogel was used to ensure that the cat litter will be able to absorb water and swell thus lead to disintegration of the litter sand. Superabsorbent material will swell greatly when they absorb the moisture and tend to force the litter sand formation apart [13]. Two types of hydrogel were used to test the enhancement of each cat litter which is a consecutive biomass hydrogel biochar and a carboxymethylcellulose/starch hyrogel. The consecutive biomass hydrogel biochar were produced by cross-linking copolymerization of each biochar material with non-ionic monomer. For carboxymethylcellulose/starch hyrogel, a study have found that hydrogels with superabsorbent characteristics can be prepared from the gamma irradiation of carboxymethylcellulose/starch solutions without any used of crosslinking agents [14]. The swelling of superabsorbent material will break down the integrity of litter sand thus, make it be able to flush down into the toilet without able to clog the toilet.

Thus, the objective this study is to produce a cat litter that is high in capability of an adsoprtion and to analyze and characterize the practicality the ability of eggshell in order to be used as cat litter based on the characteristics of clumping ability, odour control, dust control and adsorptivity alongside with embedded it with hydrogel biochars or carboxymethylcellulose/starch hydrogel. A commercial bentonite clay cat litter was tested alongside the biomass materials in order to compare their performance effectiveness.

II. METHODOLOGY

A. Preparation of Cat Litter from Biomass

An amount of eggshell were dried under the sun for a week. After a week, further drying was carried out using drying oven with temperature 80◦C for 24 hours to ensure the moisture is eliminated from the material. After drying process, the dried biomass is then subjected to grinding process by using the cutting mill and in order to obtain a proper size distribution, it was screened through a 6-mesh sieve to obtain a proper size distribution. Then preparations of biomass cat litter begin from mixing of raw material, in which certain amount of treated biomass is pour into beaker. Then other material was added with biomass by adding 20% w/v glycerol. Glycerol was used in the mixing to help adhere the raw material to the gum besides acting as a dust suppressant [3], [15]. Next, 20% w/v xanthan gum which is a type of natural polysaccharide industrial gum that is commonly used as cat litter clumping agent was added into the mixture [14]. After that, 10% w/v sodium bicarbonate act as agent that helps neutralize and regulate the pH levels of material, thus reduces odor from cats' waste was added into the solution and the stirring was continued.

B. Cat Litter Formulation with Hydrogel Preparation

Two sample mixtures of eggshell then was added differently with 2% w/v of CMC/Starch hydrogel and their consecutive hydrogel biochar that were produced by cross-linking copolymerization of each biochar material with non-ionic monomer, acrylamide, AAm (Merck), a small amount of cross-linking agent, N,N'-methylenebis(acrylamide), MBAAm (Merck), and an initiator, ammonium persulfate, APS (R & M Chemicals) [17], [18]. Then the mixture was stirred continuously to form a homogenous suspension and the soft clumps formed were dried again before before they were cut into smaller cubic-like pieces. The mixture products, as well as their respective pure hydrogel biochar were then set for further testing.

C. Clumping of litter formulation test

The clumping rate was studied by placing 20.0 g of each sample into petri dish, then dropping 5.0 ml of water into each plate. The plates were then set aside for absorption and clumping to occur, before they were placed in the drying oven set at 40℃ for 6 hours. The contents of each plate were sieved using a 6-mesh sieve and placed in the orbital shaker set at 250 rpm for 60 seconds. The clumping percentage of each litter was calculated as follows [3]:

Clumping percentage

$$= \left(\frac{\text{Weight of clumps remained on the sieve}}{\text{Initial weight of mixture before clumping}}\right) \times 100$$

D. Absorption test of cat litter

The ability of the cat litter formulations as absorbent material was tested by a simple test to observe the amount of water being absorbed by each material. 20.0 g of each sample were placed in beakers, while 10.0 ml of water was poured into each beaker. The treatments were allowed to rest for 10 minutes for absorption to occur, before each content was filtered using filter paper in the filter funnel. The absorption rate of each sample was calculated as follows:

Absorption rate

$$= \left(\frac{\text{Weight of filtered litter sample}}{\text{Initial weight of litter before absorption}}\right) \times 100$$

E. Dust control test of cat litter

The dust control test was conducted to determine the amount of dust produced by the final cat litter products. 50.0 g of each sample was placed into beakers and let sit for 2 hours. The contents were then sieved onto the 6-mesh sieve before being placed in the orbital shaker set at 250 rpm for 60 seconds. The dust content is determined using the equation:

Percentage of dust content

$$= \left(\frac{\text{Initial weight of sample} - \text{Weight of sieved sample}}{\text{Weight of sieved sample}}\right) \times 100$$

III. RESULTS AND DISCUSSION

A. Clumping percentages of cat litter formulations

One of the characteristics of economical cat litter is to have the ability to clump whenever it come contacts with cat waste. Ability of the cat litter to clump can be one of the advantages, it will make the cleaning process easy whereby the cat owner can easily scoop the clump litter without spoiling the unsoiled litter [17]. According to Vaughn (2011), the acceptable clumping rate for animal litter products would have to be higher than 40% [3]. The results obtained show a high clumping rate in all formulations being tested. . For precise result, the analysis was repeated three times and the average clumping percentage was calculated and tabulated in the Tables below.

Table 1 : Percentage of Clumping of Eggshell cat litter without hydrogel

No of Testing	W_0, Initial Weight of Mixture before Clumping (g)	W_i, Weight of Clumps Remained on the Sieve (g)	W%, Percentage of Clumping (%)
1	30.0	19.10	63.7
2	30.0	19.80	66.0
3	30.0	19.60	65.3

Table 2 : Percentage of Clumping of Eggshell cat litter with CMC/Starch hydrogel

No of Testing	W_0, Initial Weight of Mixture before Clumping (g)	W_i, Weight of Clumps Remained on the Sieve (g)	W%, Percentage of Clumping (%)
1	30.0	20.05	66.8
2	30.0	19.85	66.2
3	30.0	20.18	67.3

Table 3 : Percentage of Clumping of Eggshell cat litter with hydrogel biochar

No of Testing	W_0, Initial Weight of Mixture before Clumping (g)	W_i, Weight of Clumps Remained on the Sieve (g)	W%, Percentage of Clumping (%)
1	30.0	19.05	63.5
2	30.0	18.76	62.5
3	30.0	18.80	62.7

From the result obtained, all formulation tested show a clumping percentage that is more than 40% with the percentage of clumping of the cat litter ranges was noticeably from 62.5% to 66.8% with the average percentage of Eggshell cat litter without hydrogel is 65.0% and meanwhile for average percentage of Eggshell cat litter with with CMC/Starch hydrogel and hydrogel biochar is 66.8% and 62.9% consecutively. The clumping agent used in the mixture is Xanthan Gum, is indeed giving the best performance towards the clumping activity of the cat litter as the combination of the gum with the eggshell result in hydromulch. The hydromulch has a strong binding factor, thus increasing the strength of bindings in clumping activity. Although there is an addition of hydrogel into the samples, the results is not much different with the samples without hyrogel. By the result, it shows that the performance of xanthan gum toward cat litter formulations quite excellent.

B. Absorption percentages of cat litter formulations

The ability of cat litters to absorb cat's urine is considered to be one of the significant properties of an economical cat litter. Absorptive test was done in order to experiment on how much the

produce cat litter can absorb the moisture of the cat's urine. The absorption rates for each material to absorb water are shown in tables below.

Table 4.4 : Hydration Capacity of Eggshell cat litter without hydrogel

No of Testing	W_O , Weight of Wet Sample (g)	W_i , Weight of Samples After Filtered (g)	C_H, Hydration Capacity (%)
1	30.0	23.25	77.5
2	30.0	23.10	77.0
3	30.0	23.50	78.3

Table 4.5 : Hydration Capacity of Eggshell cat litter with CMC/Starch hydrogel

No of Testing	W_O , Weight of Wet Sample (g)	W_i , Weight of Samples After Filtered (g)	C_H, Hydration Capacity (%)
1	30.0	25.08	83.6
2	30.0	24.90	83.0
3	30.0	25.20	84.0

Table 4.6 : Hydration Capacity of Eggshell cat litter with hydrogel biochar

No of Testing	W_O , Weight of Wet Sample (g)	W_i , Weight of Samples After Filtered (g)	C_H, Hydration Capacity (%)
1	30.0	24.05	80.2
2	30.0	24.65	82.2
3	30.0	24.42	81.4

As shown in table and figure above, the result of absorptive test from cat litter formulations produced showed a trend of adsorbing water at a good performance rate, ranging from 77 % to 78.3 % of water with the average of 77.6 % hydration capacity because of its characteristics of the eggshell membrane makes it adsorption-able. Theoretically, the porous structure of the materials has good ability to absorb water, and the Eggshell has also been grinded to smaller particles, that increases the adsorption surface area. Meanwhile, it is found that the hydration capacity had an increment 3% to 6%, ranging from 80 % to 84 % with the average hydration capacity of 83.5 % for Eggshell cat litter with CMC/Starch hydrogel and 81.3 % for Eggshell cat litter with hydrogel biochar compared to the hydration capacity of the cat litter without hydrogel. The absoption capacity of the biomass is assisted by the hemicellulose contents in raw materials, which are considered as the main reason of a high moisture absorption ability of the raw materials [20]. The extra pores available from both types of hydrogel helped the water sip into the cat litter at a higher quantiy, thus resulting to an enhancement of absorptivity. This is because the addition of hydrogel enhances the adsoprtion activity, as more water sips through the porous structure of the hydrogel available in the mixture [21]. According to Bejenariu et al. (2008), the larger surface area of the pores in its dried matrix structure assist the increased amount of water adsorption as well.

C. Dust control analysis

Dusting problem from cat litter can lead to health's problem to the cat and whoever that exposed to the fine particles from cat litter. Pet owner might be exposed to toxoplasmosis if they inhale the contaminated dust when they scooping the litter box in which scooping may stir up some of the dust formed from the cat litter [8]. In addition, it also carcinogen to cat itself as silica that contains in the cat litter can be ingested by cats once they lick their paws [22]. Therefore, dust control analysis was done in order to analyze whether the cat litter that has been produce have tolerance on controlling dust and tracking after cat done using it. The pelletizing process helped in reducing the amount of smaller sized particles and dust content [23], which could be harmful to cat's respiratory system by prolonged inhalation [24]. The analysis for dust control test is tabulated in tables below.

Table 4.7 : Percentage of Dust Control of Eggshell cat litter with CMC/Starch hydrogel

No of Testing	W_0, Weight Before Sieve (g)	W_i, Weight After Sieve (g)	W_D, Weight of Dust (g)	W%, Percentage of Dust (%)
1	50.0	49.80	1.20	2.4
2	50.0	48.78	1.22	2.44
3	50.0	48.45	1.55	3.1

Table 4.8 : Percentage of Dust Control of Eggshell cat litter with hydrogel biochar

No of Testing	W_0, Weight Before Sieve (g)	W_i, Weight After Sieve (g)	W_D, Weight of Dust (g)	W%, Percentage of Dust (%)
1	50.0	49.25	0.75	1.5
2	50.0	49.48	0.52	1.04
3	50.0	49.10	0.90	1.8

Based on the results above, the highest percentage of dust collected shows that Eggshell cat litter with CMC/Starch hydrogel has the highest dust percentage compared to the Eggshell cat litter with hydrogel biocaher which is at average 2.65% and 1.45% significantly. Basically, the dust percentage in eggshell cat littter can be said significantly low due to the presence of environmentally friendly, bio-degradable material and the dust suppressant. Dust suppressant is normally used to reduce the amount of fine particles airbone that suspended in the air. The dust retardant which is glycerol was added into the eggshell formulation that helps adhere the eggshell to the xanthan gum and acting as dust suppressant. Moreover, low production of dust increases the health safety of the cat and the owner, as the small dust particles can enter the respiratory system during the usage of the cat litter that can cause harm to health. According to Ng (2013), the high concentration of glycerol can act as dust retardant to ensure dermal protection of the living creature [25]. Thus, by the experiment, cat is ensure to be safe for using the experimented cat litter.

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