

# The Pelleting Sawdust for Using as Litter in Pet Cages

Suphan Yangyuen<sup>1,\*</sup>, Songchai Wiriyumpaiwong<sup>1</sup>, Juckamas Laohavanich<sup>1</sup>,  
Cherdpong Chiawchanwattana<sup>2</sup> and Phongkorn Ketmala<sup>3</sup>

<sup>1</sup> Post-Harvest and Agricultural Machinery Engineering Research Unit, Faculty of Engineering, Mahasarakham University, Kantarawichai, Maha Sarakham 44150, Thailand

<sup>2</sup> College of Industrial Technology, King Mongkut's University of Technology North Bangkok, Bangkok 10800, Thailand

<sup>3</sup> Department of Basic Technique Technology, Maha Sarakham Technical College, Maha Sarakham 44150, Thailand

yangyuen@yahoo.com\*

**Abstract.** *The objective of this research is to study the pelleting process for the pet cages. The materials were eucalyptus sawdust, rice straw and coconut fiber without using a binder. Factors in this study were material formulas, which varied in five formulas (U, UR1, UR2, URC and UC) and the rotation speed of pelleting mold 3 levels of 120, 150 and 200 RPM. These were compared with two reference samples (Ref.1 and Ref.2). The results showed that the durability index ranged from 90.07-98.18 %, water absorption ability ranged from 309.46-548.00 %, apparent density ranged from 0.52-0.69 g/cm<sup>3</sup>, moisture content ranged from 3.08-5.63% db., the average of diameter and length were 6.08 and 21.43 mm and pH ranged from 6.69-7.75. The results were not significantly different between the reference samples. For the satisfaction assessment on the overall quality, three formulas of U, UR1 and UC were tested by the user and compared with reference samples Ref.1 and Ref.2. The point were similar to the results of reference samples of 7.77 ±0.72 and 7.47 ±0.91. The results of this study indicated that developed material formulas for pet cage of U, UR1 and UC were satisfied by the user and this might be the alternative ways for the animal husbandry industry.*

## Keywords:

Pet cages, litter, mold pellet

## 1. Introduction

Biomass and agricultural waste materials usually have low bulk density which results in high volumetric storage. Densification classify with respect to final product feature, pellet or briquette, cubing, extruded log and baling, but if considered by mechanism, it consists of piston press, screw

press, roll press, ring die pellet and flat die pellet. Pelleting is a densification method to increase bulk density under high pressure compression which can reduce storage area and save transportation cost. However, biomass and agricultural waste is first reduced size prior to pelleting. An advantage of flat die pellet mill is density level controlling of pellet by adjusting mixed ratio and feed and compression rates [1]. The mechanism of operation: raw material is fed into rotary wheels which is a tool to press raw material passed through flat die plate. This mechanism widely uses in ago-industries, cassava pelleting, animal feed, wood pelleting, biomass pelleting and etc.

Biomass pellet mostly uses as renewable energy application which has low cost per million Btu [2]. Recent researches in several applications: wood pellet is an alternative fuel for convective and irradiative heating within home in the winter Japan [3], switch grass pelletizing process and energy analysis [4], sawdust, residue log and bark quality properties [5], durability test methods for pellets and briquettes [7] and wood water absorption characteristics [6]. Wood pellet production divide into 7 steps: pretreatment, drying, grinding, conditioning, pelleting, cooling and sieving [8]. Effect of moisture content in quail litter on the physical characteristics after pelleting using a Siriwan model machine, which bulk and particle densities of quail litter pellets decreased and increased, respectively, following by increase in moisture content of material. Porosity, durability, rupture force and decomposition were also affected by moisture content [9]. Stark (2004) studied the effect of die thickness and pellet mill throughput on pellet quality in pelleting step. The aims of this work are to study the sawdust base in pelleting processing for pet cages. Five formulas (U, UR1, UR2, URC and UC) and 120-200 rpm rotary wheels speeds are varied to compare with two reference samples (Ref.1 and Ref.2).

## 2. Materials and Methods

Specific characteristics of small pet cage litter survey, totally 25 sources from 5 stores in Maha Sarakham province and adjacent provinces in Thailand, 5 foreign manufacturer websites and 15 domestic and foreign distributors. Details of characteristic are water absorption capacity, smell, pelleting raw materials and price.

### 2.1 Preparation before pelleting

Raw materials consist of eucalyptus wood sawdust, coconut fiber and rice straw which are collected around Maha Sarakham. They were dried to reduce moisture content down to 10% wet basis by batch hot air dryer and performed size reduction by hammer mill. Fine particle was then found size distribution by standard sieve analysis and kept in plastic bag to protect moisture in air. Fine samples were measured an initial moisture content by moisture analyzer and apparent density by free fall tester.

### 2.2 Mixing ratio in each formula

Five formulas have the different mixing ratios of eucalyptus wood sawdust, coconut fiber and rice straw as shown in Table 1.

Formulas	Weight percentage of samples (%)		
	sawdust	coconut fiber	rice straw
U	100	-	-
UR1	50	-	50
UR2	80	-	20
URC	40	20	40
UC	50	50	-

Table 1: Mixing ratio of samples in each formula

### 2.3 Pelleting methodology

Pelleting process is factorial in completed randomized design (CRD) with 3 replications. Factors and levels in a litter are 5 recipes: U, UR1, UR2, URC and UC and 3 press wheels speeds in a range of 120-200 rpm. An opening diameter of flat die and pelleting machine are fixed following the domestic and foreign product survey. Pelleting machine controls speed by inverter with a 5 HP electric motor drive.

### 2.4 Qualities determinations

Pellet characteristics in each formula compare with two reference samples which are imported from China and Japan. Detail of qualities determinations are depicted in Table 2.

## 2.5 User satisfaction evaluations

Selection of 3 formulas and two reference samples of sawdust pelleting for 40 users were satisfice evaluations. Ten items in satisfaction form, pellet size and shape, color, weight, water absorption speed and capacity, ammonia absorption capacity, durability, reduction amount per usage, and overall acceptance, used to point by 9-hedonic scale test.

Pellet Evaluation Parameters	Unit	Calculated equation	Standard/Reference
Mean diameter	mm	-	Modified from European standard of solid biofuels and ASTM E873 (pellet fuels institute)
Mean length	mm	-	Modified from European standard of solid biofuels and ASTM E873 (pellet fuels institute)
Apparent density	g/cm <sup>3</sup>	m/V	ASTM D1985
Moisture content	% db.	[(w-d)/d] x 100	ASAE S358.2 (2003)
Water absorption capacity (WAC)	% by weight	$WAC = \left[ \frac{m_{after} - m_{before}}{m_{before}} \right] \times 100$	ASTM D1037 (2004)
pH	-	-	Modified from International Union of Pure and Applied Chemistry (IUPAC 2002) and ASTM D1293-99 (2004)
Pellet durability index (PDI)	-	$PDI = \left[ \frac{m_2}{m_1} \right] \times 100$	Drop test according to ASTM D440-86 (2004) and modified from tumbler test according to ASAE S269.4 (1996)
Pelleting capacity	kg/min	m/Δt	-
Pelleting efficiency (PE)	%	$PE = \left[ \frac{m_c}{m_f} \right] \times 100$	-

Table 2: Pellet evaluation parameters, units, calculated equations and standard methods

### 3. Results and Discussions

Small pet cage litter pelleted products surveying are imported with the price of 48 baht/kg. Raw materials are cheap and available in Thailand. Water absorption capacity was not effect on pet and surrounding but important factors for small pet cage litter pelleted product was low price and easy procurement. Raw materials are normally used to produce such as: saw dust, wood peel, paper, other biomass and artificial sand. Total 25 survey sources from stores and manufacturer and distributor websites as shown in Fig 1, it revealed that pelleted saw dust is the best favorite as main component with 45% of market sharing, 20% for sawdust and wood peel, 16% for paper, 12% for other biomass and 7% for artificial sand, respectively. Fig. 2 shows the used amount and cost per day in each raw material. Used amounts per day of paper, artificial sand and pelleted saw dust rather lower than dried natural materials-saw dust and wood peel and other biomass. However, costs per day of pelleted saw dust, artificial sand and other biomass was lower in a range of 3.38-5.07 baht/day. Fig. 3 shows the sawdust pelleted on the different conditions, which were investigated pelleting efficiency. Moreover, various formula on similar the rotation speed of pelleting mold were effect on pelleting efficiency. At the U formula with 120 RPM of the rotation speed of pelleting mold (UR1@120 RPM) was a good efficiency at 80.97%.

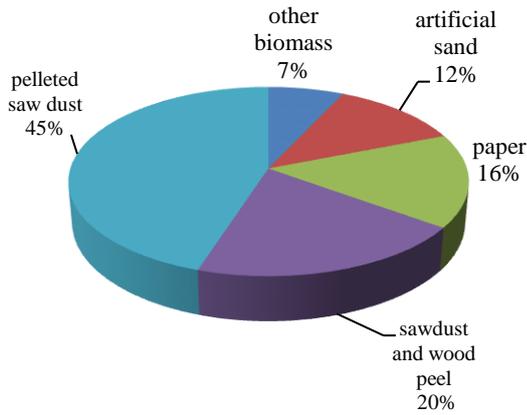


Fig. 1: Market sharing of various small pet cage litter pelleted in Thailand

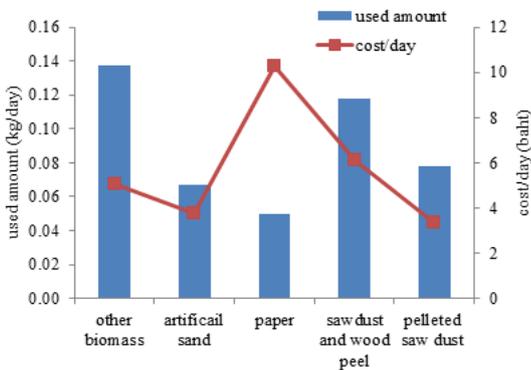


Fig. 2: The amount and cost per day in each raw material for small pet cage litter

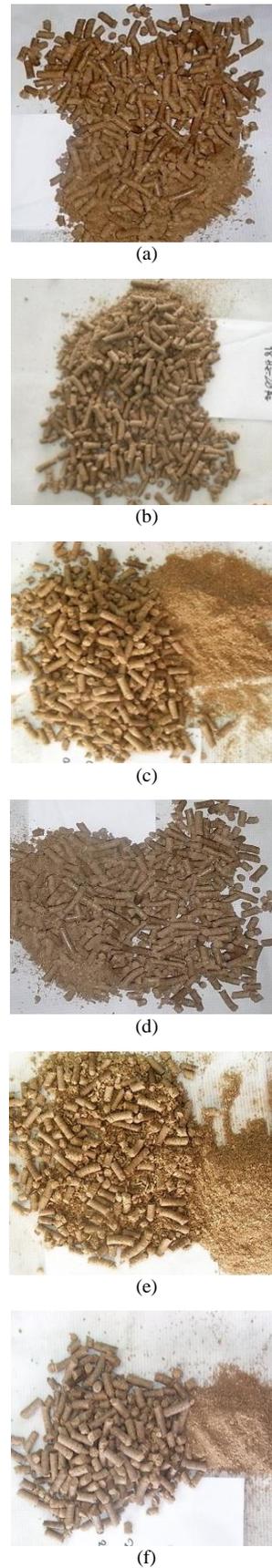


Fig. 3: Small pet cage pelleted at various formula material and die shaft speed: (a) UR1 120 RPM; (b) UR2 120 RPM; (c) URC 150 RPM; (d) UR1 150 RPM; (e) URC 200 RPM and (f) U 200 RPM

Moisture content and apparent density of pelleted saw dust in this study was comparing before and after pelleted. The result found the moisture content and apparent density range from 5.36 to 6.38% db. and about 0.17 to 0.27 g/cm<sup>3</sup> of before pelleted, and after pelleted that the moisture content ranged from 3.08-5.63% db., apparent density ranged from 0.52-0.69 g/cm<sup>3</sup>, respectively. The moisture content and apparent density changing between -23.51 to -73.55 % and 121.33 to 286.27 % base on before pelleted, respectively (Table 3 & Table 4). Pelleting capacity and pelleting efficiency ranged from 0.39-0.56 kg/min and 73.17-84.13%, respectively.

The average of diameter and length ranged from 6.05 to 6.12 (average at 6.08 mm) and 20.19-13.13 (average at 21.43 mm) and pH ranged from 6.69-7.75 (Table 5). The results were not significantly difference with the reference samples. (p< 0.05). The reference sample, Ref. 1 and Ref.2 had pH about 3.74 and 5.41, respectively. Thus, the samples of this study had in range nearly 7 pH scales that shown the pelleted saw dust were safe for the cage litter (Table 6).

Fig. 4 showed that the water absorption ability varying by time soaking about 150, 300, 600, 1800 and

7200 seconds, that found the water absorption ability for the best absorption ability was 286.58, 289.86, 343.98, 391.88 and 461.51% , respectively. The overall of formula ranged from 309.46-548 % after 120 seconds, which the UR1@120 RPM was highest water absorption ability. For the Ref. 1 and Ref. 2, the Ref. 1 was highest water absorption ability but Ref.2 was non-significant that in group of low water absorption ability.

40 users were evaluating of satisfaction on the overall pelleted quality as shown in Table 7. It is noted that the 9-point hedonic scale: 1 is extremely dislike, 2 is very much dislike, 3 is moderately dislike, 4 is slightly dislike, 5 is neither like nor dislike, 6 is like slightly, 7 is moderately like, 8 is very much like and 9 is extremely like.

Three formulas of U, UR1 and UC were tested by the users and compared with reference samples Ref.1 and Ref.2. The points were 7.77 ±0.68 7.44 ±0.68 and 7.42 ±0.86, respectively, which were similar to the results of the reference samples of 7.77 ±0.72 and 7.47 ±0.91. UR1 had the highest point about 7.94±0.59, which was closely 8 points. With this obtained results, the users were very satisfied.

formula	120 (RPM)		150 )RPM)		200) RPM)	
	apparent density (g/cm <sup>3</sup> )	moisture content (% db.)	apparent density (g/cm <sup>3</sup> )	moisture content (% db.)	apparent density (g/cm <sup>3</sup> )	moisture content (% db.)
U	0.52	3.60	0.57	3.70	0.59	4.01
UR1	0.68	3.70	0.60	4.05	0.52	4.52
UR2	0.61	3.84	0.55	5.29	0.52	5.63
URC	0.66	3.48	0.58	3.59	0.59	4.65
UC	0.69	3.08	0.56	3.34	0.53	3.37
Ref.	apparent density (g/cm <sup>3</sup> )			moisture content (% db.)		
1	0.67			4.01		
2	0.57			5.21		

**Table 3:** Moisture content and apparent density of pelleted saw dust at various shaft speeds

formula	% difference of apparent density			average	% difference of moisture content			average
	120 RPM	150 RPM	200 RPM		120 RPM	150 RPM	200 RPM	
U	148.10	175.49	182.14	168.58	74.47	66.60	56.62	65.90
UR1	329.41	294.12	235.29	286.27	46.05	33.48	19.58	33.04
UR2	250.00	238.89	205.56	231.48	53.79	11.78	4.97	23.51
URC	172.00	112.00	80.00	121.33	54.15	49.25	15.28	39.56
UC	250.47	215.00	173.62	213.03	83.52	69.18	67.95	73.55
average	219.47	191.82	180.04		62.40	46.06	32.88	

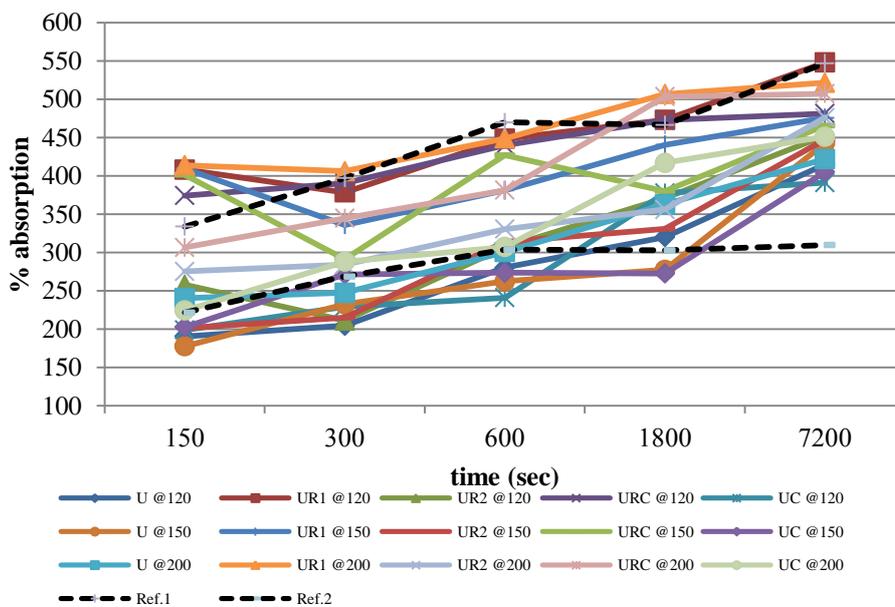
**Table 4:** The difference of characteristic changing of moisture content and apparent density at various shaft speeds (before and after pelleted)

formula	Diameter) mm)			Length (mm)		
	120RPM	150RPM	200RPM	120RPM	150RPM	200RPM
U	6.05	6.06	6.19	23.63	21.06	24.69
UR1	6.25	6.01	5.98	19.30	19.94	21.34
UR2	6.14	6.09	6.03	24.12	20.19	20.25
URC	5.99	6.16	6.04	21.09	22.38	21.23
UC	6.17	6.11	6.02	20.25	22.44	19.47
average	6.12	6.08	6.05	21.68	21.20	21.40
Ref.1	6.13			20.85		
Ref.2	6.02			21.55		

**Table 5:** The average of diameter and length pelleted of saw dust at various shaft speeds

formula	pH			Durability index, (%)		
	120RPM	150RPM	200RPM	120RPM	150RPM	200RPM
U	6.72	7.08	7.75	97.62	96.73	95.46
UR1	7.26	7.38	7.33	96.41	95.84	94.50
UR2	6.67	6.98	7.16	96.41	93.38	96.02
URC	7.52	6.68	7.00	97.23	93.46	90.07
UC	7.05	6.69	7.05	98.16	96.95	96.88
Ref.1	3.74			97.33		
Ref.2	5.41			96.44		

**Table 6:** The average of pH of pelleted saw dust at various shaft speeds



**Fig. 4:** Water absorption ability at various formula materials and die shaft speed

Items	U	UR1	UC	Ref. 1	Ref. 2
size and shape	7.6±0.49	7.8±0.40	8.0±0.63	7.4±0.80	7.6±0.49
color	6.6±1.02	8.0±0.63	8.0±0.63	6.8±1.17	6.6±1.02
weight	6.8±0.75	8.2±0.40	7.2±1.17	7.0±0.89	6.8±0.75
water absorption speed	7.8±0.98	7.8±0.40	7.8±0.98	7.8±0.98	7.8±0.98
water absorption capacity	7.2±0.75	7.4±1.02	7.4±0.80	7.2±0.75	7.2±0.75
ammonia absorption capacity	7.8±0.40	8.2±0.98	7.8±0.40	7.4±0.80	7.8±0.40
Safety (user and pets)	7.6±0.80	7.8±0.40	7.6±0.80	7.4±0.80	7.6±0.80
durability	7.4±0.49	8.0±0.63	7.4±0.80	7.0±0.63	7.4±0.49
reduction amount per usage	7.8±0.40	8.2±0.40	7.4±0.49	7.4±0.49	7.8±0.40
overall acceptance	7.8±0.75	8.0±0.63	<u>8.4±0.49</u>	7.2±0.75	7.8±0.75
Average	7.44±0.68	7.94±0.59	7.7±0.82	7.26±0.81	7.44±0.68

**Table 7:** User evaluation of satisfaction with overall quality by 9- point hedonic scale

## 4. Conclusions

The difference of mixing ratio for 5 formulas were affected to durability index, which UC was the most appropriate at an average 97.33% in the equivalent samples from five formulas by Ref.1 at 97.33% was the highest as well. The pelleting capacity ranged from 0.39-0.56 kg/min, and pelleting efficiency ranged from 73.17-84.13%. The water absorption ability ranged from 309.46-548 %, apparent density ranged from 0.52-0.69 g/cm<sup>3</sup>, moisture content ranged from 3.08-5.63% db., the average of diameter and length were 6.08 and 21.43 mm and pH ranged from 6.69-7.75. Three formulas of U, UR1 and UC were tested by the user and compared with reference samples Ref.1 and Ref.2. The points were similar to the results of reference samples. UR1 formula was got the highest point by closely the like very much scale.

U, UR1 and UC were satisfied by the user and this might be the alternative ways for the animal husbandry industry.

## Acknowledgements

The authors would like to thank the Faculty of Engineering, Maharakham University, Thailand for the financial Support.

## References

- [1] C.R. Stark. Effect of Die Thickness and Pellet Mill Throughput on Pellet Quality. North Carolina: Department of Poultry Science North Carolina State University; 2004.
- [2] Pellet fuels institute. <http://www.pelletheat.org/pfi-standards> ; 2016

- [3] Ken Ichiro Kojima. (2012). Overview of wood pellet Production and raw material in Japan. [online]. Available from <<http://www.bioenergytrade.org/downloads/tsukubawoodpelletproductiona.pdf>>
- [4] Jannasch, R., Quan, Y., Samson, R. (2010). A Process and Energy Analysis of Pelletizing Switchgrass. [online]. Available from <[www.reap-canada.com/online/11%20A%20Process.pdf](http://www.reap-canada.com/online/11%20A%20Process.pdf)>
- [5] Päivi Lehtikangas. Quality properties of pelletised sawdust, logging residues and bark. Journal of Biomass and Bioenergy, 2001(20), 351-360.
- [6] Khazaei, J. (2007). Water Absorption Characteristics of Three wood varieties. Available from <[www.uaiasi.ro/CERCET\\_AGROMOLD/CA2-08-01.pdf](http://www.uaiasi.ro/CERCET_AGROMOLD/CA2-08-01.pdf)>
- [7] Michaël Temmerman, Fabienne Rabier, Peter Daugbjerg Jensen. (2006). Comparative study of durability test methods for pellets and briquettes. Journal of Biomass and Bioenergy, 2006(30), 964-972.
- [8] Stefan Lescae. (2011). Wood Pellet Technology. [online]. Available from <[www.bepita.net/materiels/pellets/index.htm](http://www.bepita.net/materiels/pellets/index.htm)>
- [9] Tawadchai Suppadit. (2012). Effects of moisture content in quail litter on the physical characteristics after pelleting using a Siriwan Model machine. Animal Science Journal, (2012) 83, 350-357.

## Biography



**Suphan Yangyuen** received her Doctoral of Philosophy (Ph.D.) Department of Agricultural Machinery Engineering from Khon Kean University in 2009. She is a lecturer in Mechanical Engineering in Maharakham University, Thailand. Her research interest includes agricultural machinery and management, Post-harvest technology (drying technology), and Agro-process and industry.



**Songchai Wiriyapaisong** He is currently a lecturer in Mechanical Engineering in Mahasarakham University, Thailand. His research interest includes agricultural machinery and management, Post-harvest technology (drying technology), and Agro-process and industry.



**Juckamas Laohavanich** received his Doctoral of Philosophy (Ph.D.) from Department of Agricultural Machinery Engineering from Khon Kean University in 2009. He is a lecturer in Mechanical Engineering in Mahasarakham University, Thailand. His research interest includes agricultural machinery and management, Post-harvest technology (drying technology), and Agro-process and industry.



**Cherdpong Chiawchanwattana** received his Doctoral of Philosophy (Ph.D.) from Department of Mechanical Engineering from Khon Kean University in 2012. He is a lecturer in Department of Mechanical Engineering Technology College of Industrial Technology, King Mongkut's University of Technology North Bangkok, Thailand. His research interest includes agricultural machinery and management, Post-harvest technology (drying technology), and Agro-process and industry.

**Phongkorn Ketmala** He is currently a full time staff at Department of Basic Technique Technology, Maha Sarakham Technical College, Maha Sarakham Province, Thailand. His research interest includes agricultural machinery and management, Post-harvest technology (drying technology), and Agro-process and industry