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Broiler litter pelleting using Siriwan model machine

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Broiler litter (BL) is an effective material for improving the physical and chemical condition of soil, including for the fattening ruminant. However, there are three factors that limit the application of fresh broiler litter (FBL). The first problem is that BL usually has high moisture content and high volume per unit of weight. As a result, it is difficult and costly to transport. The second problem is that the quality of the BL and its nutrient contents is not constant. The third problem is that safety for utilizing BL as feed ingredient and impact to environment from pathogens. These are also limited the efficient use of BL. The pelleting technology is an effective method to solve almost all problems. A Siriwan model machine is used to make BL into pellets. The moisture content of BL and the rate at which BL is supplied to the die part in the chamber that very important in pelleting processes. After processing, the pelleted BL has a volume of only 60.0-90.0% of the FBL and retains their form during storage and distribution. When the pellets are scattered, they generated less dust than FBL.

Key words: animal waste, invention, machine, pelleting, recycle

Introduction

Broiler chicken (*Galllus gallus domesticus*) production has undergone steady growth both in developed and especially in developing countries during the past 40 years (Sims *et al*., 2005). In Thailand, the production of broiler meat is expected to further increase in response to increase domestic consumption and export (Suppadit, 2009). The total census of broiler chickens in 2008 was about 1,250 million (Department of Livestock Development, 2009), which results in an estimated annual production of 3.50-4.50 million mt of broiler litter (BL) (1,000 birds produce 3.52 mt of litter) (Suppadit, 2009). BL is typically a mixture of manure, feathers, spilled feed and bedding material (e.g. rice husk or sawdust); the high organic matter (OM) and nutrient content

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it holds, along with the positive effects of it applications on soil texture, have encouraged it exploitation on agricultural soils (Moral *et al*., 2005; Lopez-Mosquera *et al*., 2007; Bernhart and Fasina, 2008; Suppadit *et al*., 2008b) since it is not only improve soil fertility and aeration, but also increases the water-holding capacity of the soil (Gupta and Gardner, 2005; Suppadit *et al*., 2008c). In addition, BL is known as the feed ingredient source for ruminants (Davis *et al*., 2002; Suppadit *et al*., 2002a, Suppadit *et al*., 2002b; Jeremiah and Gibson, 2003; Jackson *et al*., 2006; Suppadit *et al*., 2008a), ruminants can metabolize into essential amino acids for growth and maintenance (Suppadit, 2005).

Litter from broiler houses is periodically removed and stored in covered facilities or outdoors until transportation and field application, what is usually done in the winter or dry season prior to ploughing, although fertilizing of BL can be also applied successfully in the rainy season (Suppadit, 2009). The fertilizer requirements are seasonal, BL is produced at a roughly constant rate throughout the year. Thus litter often accumulates and either must be stored or results in incorrect timing or excessive land application (Lopez-Mosquera *et al*., 2007). Storage is often problematic so that the litter is dumped as waste. Inadequate storage or field application of fresh broiler litter (FBL) may lead to contamination problems such as nitrogen emission to the atmosphere, chemical and microbial contamination of water bodies, carrier insect, and odor nuisance (Sims and Wolf, 1994; Hara, 1998; Lopez-Mosquera *et al*., 2007; Suppadit *et al*., 2008a), including transportation cost, handling, and dust problems, etc. (Gilbert *et al*., 2009). In Thailand, for example, an estimated 20.0% of agricultural N emissions (Suppadit *et al*., 2008b) and 23.0% of cases of agricultural odor nuisance (Suppadit, 2009) are due to BL. The inefficient use of BL has led to the viewing of manure by many people as a bad waste (Guru and Goodwin, 2002; Suppadit *et al*., 2008a).

A promising approach for reducing these problems or restrictions of BL is pelleting method. The reduced moisture content of the pelletized organic wastes mean that they are easier to store, transport, and apply to soil (John *et al*., 1996) or feed ingredient (Suppadit, 2004). This technique may help to obtain a readily stored product that neither leach nor have bad odor, thus increasing its environmental acceptability and financial value. In addition, pelleting could reduce the significant pathogen load and antibiotic residue content of FBL (Suppadit *et al*., 2008a). The purpose of this paper is to show the processes and performances of BL pelleting machine. The prototype pelleting machine worth 17,500 USD was invented in 1997 by our team and called “Siriwan Model”, and its commercial production rolled out in 1998. Later, this model machine is modified in 2008 in order to increase productivity capacity. The outputs from this machine, we hope to establish proper method,

contribute to optimized BL efficiency and application targeting at sustainable agriculture production.

Materials and methods

Machine compositions and pelleting processes: the pelleting technology is to mold BL into a pellet form that produces cylindrical pellets 6.00 mm in diameter and 1.50-2.00 cm in length. The pelleting machine is the roller-and-die pellet press which one kind of roller ring die type. This type has a basic structure of a die with many holes and three rollers. FBL is sent into a screw conveyer and moved into a receiving elevator, next is sent into the pelleting chamber. The litter is fed between the die and rollers, and as the rollers turn, the litter is forced into the holes, producing the pellets. The machine uses truck engine to drive the roller axis. The processing speed is adjustable. The machine is fitted with a variable gearbox where the speed is adjustable between 150-250 rounds per minute (RPM) depending on moisture content of the FBL.

The rollers movement and die during the compression process generates heat over 90.0°C. The temperature can be controlled by adjusting the pressure. The pelleted broiler litter (PBL) is cut with blades where the length is adjustable, depending on customers' orders. The PBL is carried through a rail conveyor to store in a bin to cool down before bagging. Dust is collected in the adjacent bin for subsequent recycling. The machine has 60.0 t/day capacity (Figs. 1-18).

Results and discussion

Conditions of pelleting

BLP gave a high-grade product with desirable qualities. For example, they should be durable enough to maintain their shape when being transported to distance areas. They should be easily used by sowing or feeding machines. The quality and the nutrient should be constant. They should not deteriorate during prolonged storage. The quality of the pellet is determined by the character of the BL which is the raw material, by the size of the apertures and the power of the pelleting machine, and by moisture management during the pelleting process. The production of BLP should be seen as a system which begins with the making of the BL, and which ends with the packaged and distributed pellets. It is necessary to understand how to manage the litter as a raw material, in order to produce the best possible pellets. The operating condition of the machine influences the processing speed, and thus the strength of the pellet. The speed

with which the BL is fed to the die is important. Which pelleting condition is the best depends on the ingredients and maturity of the FBL.

Fig. 1. BL.

Fig. 2. Mixture agitator.

Fig. 3. Elevator.

Fig. 4. Screw conveyer.

Fig. 5. Pelleting machine.

Fig. 6. Pelleting chamber and cutter.

Fig. 7. Die.

Fig. 8. Rollers.

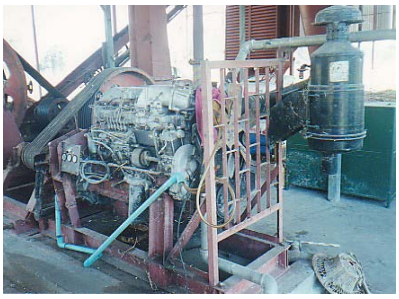

Fig. 9. Truck engine as primary power source.

Fig. 10. Cooling system.

Fig. 11. Adjusting speed.

Fig. 12. Machine belt to reduce the speed.

Fig. 13. Broiler litter pellets (BLP).

Fig. 14. Rail conveyer.

Fig. 15. Cooling in a bin.

Fig. 16. Bagging.

Fig. 17. Storage.

Fig. 18. Distribution.

Characteristics of the BL

The moisture content of the FBL is the most important factor. This greatly influences the strength and the processing speed of the pellet. Which method is suitable for raw material which has a comparatively low moisture content of 20.0-30.0%. The fluidity of FBL falls with a lower moisture content, and friction resistance increases as the litter passes through the hole of the die. Therefore, damage to the extrusion screw may also increase, and so may power load. The processing performance falls by 30.0-50.0% if the moisture content of the compost is only 5.00% higher or lower than its optimal level. The die of machine tends to block if the moisture content is too low. An electric drill is needed to remove the blocked litter, requiring considerable time for repairs. It is therefore important to make sure before processing that the moisture content of the litter is optimum (Figs. 19-20).

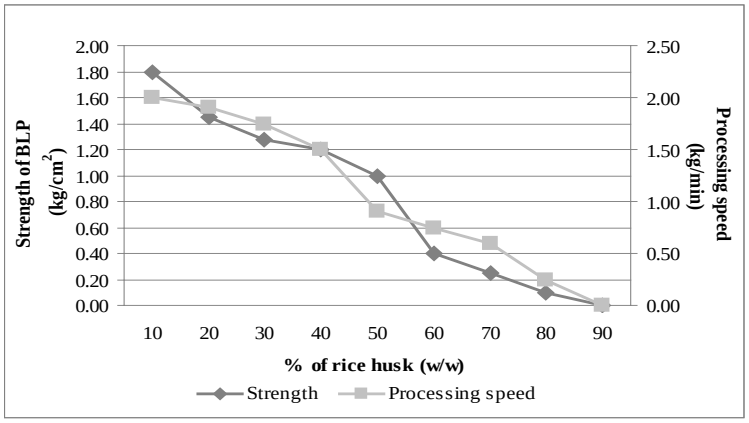

Fig. 19. Effect of change in rice husk percentage of BL on strength and processing speed of pellets.

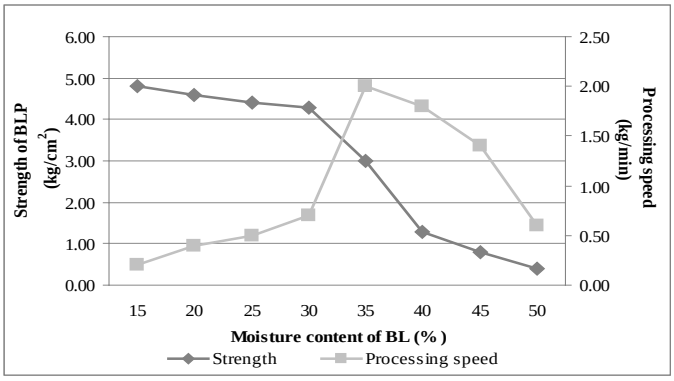

Fig. 20. Effect of a change in moisture content of BL on strength and processing speed of pellets.

If BL with low fluidity and a high percentage of a bulking agent such as rice husk is used, the processing speed is slow and the pellets lack strength. It is preferable to use BL with 40.0% or less rice husk mixed in. This gives a pellet which has enough strength to maintain its form when it is stored and distributed. It is also important to use BL which does not contain metal debris or stones. BL with a lot of hard foreign bodies is used in the machines damage to the die and roller is severe. These damage the machines, and the repairs and replacements add to the production cost.

Quality control of the BLP

It is important to prevent the deterioration in quality if BLP are stored for a long time. BLP become moldy if they are packed and stored without drying. Therefore, it is necessary to reduce the moisture content of the pellets to 15.0% or less. BLP generate more molds on the surface than ordinary BL, even if the BL has the same moisture content. If the BL used to make the pellets is immature, deterioration is very noticeable.

Advantages of BLP

Transforming BL into pellets makes them much more suitable for long-distance transport. The volume of pellets 6.00 mm in diameter is only 60.0-90.0% of the FBL (Table 1). BL with a high percentage of rice husks makes pellets lower in volume. By compressing the pellets and reducing their volume, the pellets become better suited to transport over a long distance, so that recycling becomes extremely cost effective. Another benefit is that the compactness of the pellet requires less storage space during the off season and protects the laying of house flies or other insects and bad smell.

Table 1. Improved ease of distribution after pelleting.

FBL 750 kg (100%)	PBL (Ø 6.00 mm) 675 kg (90.0% from beginning)
Water 188 kg (25.0%)	Water 113 kg (15.0%)
Solids 562 kg (75.0%)	Solids 618 kg (75.0%)

For transportation of 1.00 mt of BL			
	Moisture content	**Solids**	**Water**
FBL	25.0%	750 kg	250 kg
PBL	15.0%	850 kg	150 kg
Pellet : Fresh ratio		1.13 : 1.00	1.00 : 1.67

The BLP are comparatively uniform in size and quality. They can be applied by various kinds of machinery which crop or animal farms already possess. They are strong enough to be applied by a machine without disintegrating (Table 2). Machines such as the Broadcaster or the Limesower make precision application possible. If farmers use a Blendcaster, it is possible to apply chemical fertilizer at the same time. A further benefit is that the pellets can be spread near residential areas, because they do not generate dust.

Table 2. Physical properties of BLP.

Shape	% Rice husk	Compressibility[1] (%)	Cutting strength (kg)	Collapsibility[2] (%)	Bulk density (kg/mt)
Pellet (Ø 6.00 mm)	30.0	70.0	3.80	97.0	0.600

Note: Moisture content of sample is 15.0%. Length of BLP is 2.00 cm.
[1]Compressibility: Volume of pellet (1.00 mt dry matter (DM))/Volume of FBL (1.00 mt DM)
[2]Collapsibility: Conforms to the strength measurement used for pelleted animal feed. Pieces 4.00 mm or less in diameter are assumed to be from pellets which have disintegrated. Criteria value is 95.0% or more.

The BLP can be applied to crops according to the standard application rates for organic fertilizer. The shape of the pellet persists in upland soils for a comparative long time (Fig. 21). The breakdown of BLP in upland soils is slower than that of FBL. Therefore, even if the BL used as the raw material is immature, the negative effect on the plant caused by the rapid decomposition of easily decomposable OM is limited.

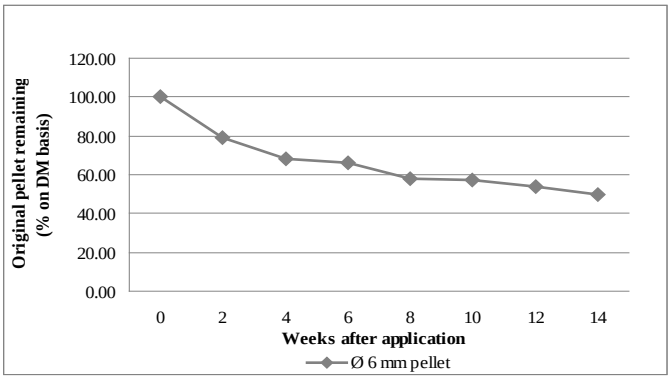

Fig. 21. Breakdown of BLP (Ø 6.00 mm) over time in upland soil.

In conclusion, the following two points are important in supporting the recycling of BL as organic fertilizer or ruminant feed. The first point was to create new technology for pelleting litter from broiler farms which meets the demands of crop cultivators or ruminant farmers. The second was to create a method of fertilizing crops or feeding animals which takes into account the needs of the environment. Pelleting FBL into pellets can solve both problems. However, before it can come into widespread use, there are still problems remaining to be solved.

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