Evaluation of Physical Properties of Feedstuffs in Supporting the Development of Feed Mill at Farmers Group Scale

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***Abstract*—This study aimed to determine the nature or physical characteristics of the local livestock feed ingredients in order to collect baseline data that will be useful in the processing and handling of feed materials mechanically. The study was conducted in Livestock Farmers Group, Pinrang Regency, and in the Laboratory of Technology and Feed Industry Faculty of Animal Science, Hasanuddin University, South Sulawesi, Indonesia. The materials used were the samples of ten (10) types of animal feed ingredients, and each sample approximately 30 kg. The materials of feedstuffs used were divided into 4 (four) groups based on their function in the ration. In this study, the observed variables were the physical characteristics of the feed material including angle of repose, bulk density and compacted bulk density. Measurements of physical properties of the each feedstuff were conducted and repeated 20 (twenty) times. This study concluded that the angle of repose of feedstuffs was influenced by particle size, surface characteristics of materials, density, moisture and fat. The bulk density and compacted bulk density was affected by particle size. Value of physical characteristics of feedstuffs such as angle of repose, bulk density and compacted bulk density is useful to improve the efficiency of feed processing mechanical.**

***Index Terms*—feedstuff, feedmill, farmers, physical properties, angle of repose, bulk density.**

I. Introduction

Feed is a crucial factor in the viability of farm businesses, because approximately 60% of production costs derived from the cost of feed. The existence of feedstuffs in Indonesia is quite a lot, but some of them contain a low nutritional value.

Efforts that can be done to improve the nutritional value of animal feed ingredients are the processing of both physical (mechanical), biological or chemical. Particularly in feed industry (feed mill) processing the feed material mechanically has a significant role as the size reduction (grinding), mixing and pelleting.

Characteristics or properties of the feedstuffs very influential in the processing of feed ingredients. Classify the nature of the material to be: a) the biological and physiological characteristics, the nature of which is closely related to the activity of the material as biological creatures like metabolism activity, photosynthesis, respiration, fermentation, climacteric and withering, b) physical characteristics, including dimensions shape, density, texture, hardness, bulk density, and angle of repose, color and appearance, specific heat, thermal conductivity and diffusivity. The physical properties are much related to the processing or handling of feed material mechanically [1].

The physical characteristics of alternative feeds are not the first thought in the mind of farmers, cattlemen, or feed professionals as they plan feed rations. It does however have an impact in the decisions that need to be made when planning and designing the on farm feed storage. A discussion of the basic terminology and physical properties of alternative feeds should help the fanner or feed professional recognize the important considerations such as volume of storage required and handling options that need to be addressed in planning for storage [2].

The physical properties of the feed are a very important factor to note in feed processing. The efficiency of a process of handling, processing and storage of feed in feed mills not only requires information about the chemical nature and nutritive value, but the physical properties of the feed should also be known that the loss due to the handling of feed can be avoided [3]. Knowledge of the physical properties of the feed is important to note that affect the storage, drying and processing of feed materials [4].

The design of storage, handling and processing systems for bulk materials requires data on bulk and handling properties namely, size dimensions, bulk and particle densities, and friction coefficients of bulk materials on most commonly used structural surface materials. Theories used to predict the pressures and loads on storage structures require bulk density, angle of repose and friction coefficients against bin wall materials. Also the design of hoppers for processing machinery requires data on bulk density and angle of repose. Bulk density is used in design of drying and aeration systems because it affects the resistance to airflow of a stored bulk [5].

Bulk density and angle of repose are important physical parameters for free flow behavior during

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processing. Bulk density and angle of repose are useful characters for determining the capacity of withering troughs and bins and also performance characteristics of conveyors such as screw or belt type. Further, high variation in angle of repose may bring differential internal friction, higher angle means higher internal friction and vice versa. This character decides the power requirement of the conveyor system [6]. The design of storage and handling systems for bulk materials requires data on bulk and handling properties namely, emptying and filling angles of repose, bulk and particle densities. Also the design of hoppers for processing machinery requires data on bulk density and angle of repose [7].

To our knowledge, data about the physical characteristics of the local animal feed ingredients so far is quite low. Therefore, it is necessary to evaluate the physical properties, which will be required as a baseline in designing or designing the processing or handling of feed material mechanically precisely in order to develop the feed mill. This study aimed to determine the nature or physical characteristics of the local livestock feed ingredients in order to collect baseline data that will be useful in the processing and handling of feed materials mechanically.

II. Materials and Methods

The present study was conducted in the Livestock Farmers Group, Pinrang Regency, and in Laboratory of Technology and Feed Industry Faculty of Animal Science Hasanuddin University, South Sulawesi, Indonesia. The materials used in the study were the samples of ten (10) types of animal feed ingredients, and each sample approximately 30 kg. The feedstuffs were then divided into 4 (four) groups based on their function in the ration, as shown in Table I.

In this study, the observed variables were the physical characteristics of the feed material including angle of repose [8], bulk density and compacted bulk density [9]. Measurements of physical properties of the each feedstuff was conducted and repeated for 20 (twenty) times. Method of measuring the physical properties of each feedstuff was done by the following procedures.

TABLE I. Groups and Types of Feedstuffs

No	Group of feedstuffs	Types of feedstuffs
1	Energy sources	Rice bran Corn grain Corn meal
2	Protein sources	Soybean meal Fish meal Meat and bone meal Coconut oil cake
3	Fiber sources	Gliricidia leaf meal Leucaena leaf meal
4	Mineral sources	Limestone

A. Angle of Repose

Angle of repose measurement of the feed ingredients was performed as in Fig. 1. By dropping or pour feedstuffs from a certain height through a funnel on a flat, circular with a diameter equal to two times the distance of the fall of the material. The material was poured reaches the edge of the circle of flat areas of known diameter. In this case the poster board will be used white as the base flat surface (floor). Angle of repose (^{o}) feed material will be determined by measuring the diameter of the base (d) and stack height (t). The magnitude of the angle of repose was calculated by the following formula.

$$\delta = Arctg\ \frac{t}{0{,}5d} = Arctg\ \frac{2t}{d}$$

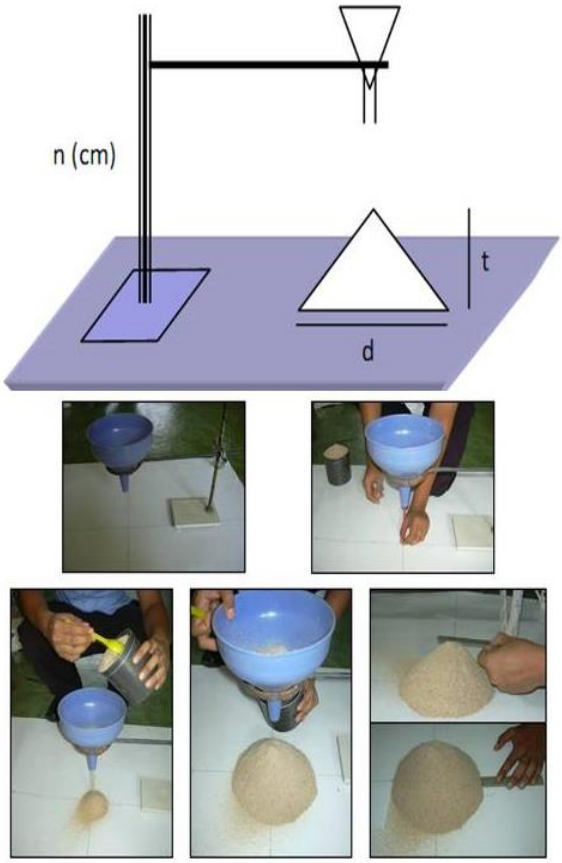

Figure 1. Measurement of angle of repose

B. Bulk Density

Bulk density was measured using a measuring cup. Feed materials incorporated into the measuring cup until a certain volume and then weighed heavy materials. Bulk density was calculated by dividing the weight of the volume of space they occupy. After weighing and measuring the results obtained were converted to kg/m^3 (Fig. 2)

C. Compacted Bulk Density

Compacted bulk density was determined by means such as bulk density. Only on the compacted bulk density, material volume was read after compaction by means of shaking the measuring cup by hand until the volume was not changed again. Same units as the unit bulk density pile.

Observation data from each measurement of physical properties of the feed material was analyzed descriptively by average and standard of deviation of each observation on each feedstuff to twenty repetitions.

Figure 2. Measurement of bulk density and compacted bulk density

TABLE II. AVERAGE OF ANGLE OF REPOSE OF FEEDSTUFFS

No	Feedstuffs	Angle of repose (^{O})	
		Average	Standard of deviation
1	Energy sources		
	Rice bran	45.82	4.8
	Corn grain	21.64	4.7
	Corn meal	42.27	4.3
2	Protein sources		
	Soybean meal	36.62	2.5
	Fish meal	44.10	3.7
	Meat and bone meal	40.82	2.9
	Coconut oil cake	40.99	4.5
3	Fiber source		
	Gliricidia leaf meal	37.35	5.4
	Leucaena leaf meal	39.39	3.2
4	Mineral sources		
	Limestone	46.54	3.2

III. RESULTS AND DISCUSSION

The observation of the physical characteristics of the local livestock feed ingredients in general showed that there were variations or differences in the results of the physical properties of the observed variables. This difference occurred between the source of feed ingredients, as well as between different types of feed materials, which was caused by the physical and chemical properties of the feed material. While variations that occur at each observed variable of physical properties was reflected by standard deviation. The average of angle of repose is shown in Table II.

Some of the factors that affect the variation or difference angle of repose were particle size, density, surface characteristics of the materials, as well as water content and fat content of feed animals. Angle of repose is the angle formed when material is poured on a horizontal plane through a funnel. Angle of repose is the criteria of freedom of movement of particles of a material pile. The ideal particle movement is indicated by the feed liquid form, with a pile angle equal to zero. Feed has a solid form stacks angle ranges between 20 and 50° [8].

TABEL III. AVERAGE OF BULK DENSITY OF FEEDSTUFFS

No	Feedstuffs	Bulk density (kg/m^3)	
		Average	Standard of deviation
1	Energy sources		
	Rice bran	285.13	3.1
	Corn grain	784.93	3.1
	Corn meal	443.55	3.5
2	Protein sources		
	Soybean meal	497.91	3.0
	Fish meal	520.23	3.5
	Meat and bone meal	620.20	1.9
	Coconut oil cake	422.33	2.6
3	Fiber source		
	Gliricidia leaf meal	350.64	2.7
	Leucaena leaf meal	342.54	2.6
4	Mineral sources		
	Limestone	595.91	1.5

The feedstuffs with large particle size, the angle of repose will be small and vice versa. As an illustration in Table II shows that the whole corn grain which is a material with a large particle size that has a smaller angle of repose than the pile of groceries with small particle size such as corn meal and rice bran. The angle of repose is influenced by size, shape and surface characteristics of the particles, moisture content, specific gravity and bulk density.

Feed particle size, moisture content also significantly affect the value of the average angle of repose, i.e the higher the water content, the higher the angle of repose. A commodity can flow freely on the basis of gravity, when the magnitude of the funnel angle equal to or smaller than the apex angle stacks of material [4]. The physical properties of the angle of repose need to know for example to design the intake funnel (hopper) or funnel spending, for example in the silo or the processing machine. Funnel design errors due to lack of knowledge about the angle of repose, a commodity can lead to congestion as a funnel clogged by commodity passing smoothly [10].

Bulk density is the ratio between the weights of the volume of space they occupy. The unit is g / ml. These properties play an important role in calculating the volume of space it takes a certain weight material, such as for example by filling silos and warehouses (bulk or

container), elevators and automatic dosing accuracy, as well as the density [8]. The greater bulk density had the more efficient in handling material mechanically of the feedstuffs. The bulk density of feedstuffs is shown in Table III. It is seen that the magnitude of the density of pile is affected by particle size, where the larger the particle size, the bulk density will be greater, as shown in the corn meal and corn grain.

By knowing the bulk density, it would be useful to model a container or silos for storage of feed raw materials before processing, so we can build a model for the raw materials that have a small particle size with a raw material having a particle size larger. This would be more profitable and more economical materials to be used, if the raw material feed have a large pile density, the greater will need a place or space to be used.

TABEL IV. AVERAGE OF COMPACTED BULK DENSITY OF FEEDSTUFFS

No	Feedstuffs	Compacted bulk density(kg/m^3)	
		Average	Standard of deviation
1	Energy sources		
	Rice bran	393.55	3.8
	Corn grain	812.99	1.2
	Corn meal	589.34	3.4
2	Protein sources		
	Soybean meal	539.67	3.3
	Fish meal	598.38	3.8
	Meat and bone meal	753.91	2.1
	Coconut oil cake	471.82	2.2
3	Fiber source		
	Gliricidia leaf meal	433.45	3.0
	Leucaena leaf meal	430.72	1.9
4	Mineral sources		
	Limestone	719.85	2.1

The compacted bulk density is the ratio between the weights of the volume of space they occupy after compaction process (Table IV). This property is useful for estimating the capacity silo or packaging materials fodder. Capacity silo or packaging material located between bulk density and compacted bulk density. Capacity silos, containers and packaging such as sacks lies between the bulk density and compacted bulk density [9], so as to determine what the bulk density of compaction will be able to simplify the model extents of a silo, container or packaging to be more economical and more efficient, if the density of compaction low pile area where it used to be more narrow or more economical.

The conclusion of this study is the angle of repose of feedstuffs is influenced by particle size, surface characteristics of materials, density, moisture and fat. The bulk density and compacted bulk density is affected by particle size. Value of physical characteristics of feedstuffs such as angle of repose, bulk density and compacted bulk density is useful to improve the efficiency of feed processing mechanical.

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