Effect of Particle Size on Local Feed Ingredient Flowability

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Abstract. This study aims to determine the flowability of local feed ingredients with different particle sizes. This study on factorial design (3x5) is based on completely randomized design with three replications. The first factor (A) is particle size. The particle size is fine (mesh 26), medium (mesh 12), and coarse (mesh <12). The second factor (B) is local feed ingredients (rice bran, coffee hull, fish meal, coconut meal, and corn cobs). Each feed ingredient was ground using a milling machine with the type RD-85 DI-2S with a 200 kg/hour capacity and a sieve size of 5 mm. Based on variance, it was shown that the treatment of particle size and the interaction between particle size and various local feed ingredients significantly ($P<0.01$) affect the flowability of feed ingredients. The flowability of coarse ingredients was significantly different compared to medium and fine particle sizes. Fine and medium particle sizes were not significantly different. Thus, the particle size of feed ingredients greatly determines the flowability of various feed ingredients.

1 Introduction

Local feed ingredients are feed ingredients that can be obtained without importing from other countries. In Indonesia, local feed ingredients are abundant from its potential perspective, most of the farmers and feed industries prioritize the use of local feed ingredients in poultry and ruminant rations to make it more cost-efficient.

Physical quality is part of the quality properties category (aspects that can be directly observed or measured from materials). The properties of materials are important quality factors, it is due to the usefulness or diversity of the commodity. The material properties that characterize several derived product quality characteristics can be seen after measuring the physical properties.

The physical characteristics of the particle size play an important role for nutritionists in choosing the ingredients used, thus they can speed up feed production. Knott and Shurson (2002) [1] reported that knowledge of physical properties is also used to determine the efficiency of a handling, processing, and storage process [2].

The physical characteristics of the flowability of feed ingredients are also factors that can influence the quality of the mixing results. Thus, based on the description above, research

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was carried out that aimed to determine the physical characteristics of the flowability of local feed ingredients at different particle sizes.

2 Materials and Method

This research used a Hummer Mill machine (type RD-85 DI-2S) with a capacity of 200 kg/hour and a sieve size of 5 mm with a mesh of 26, 12, and <12, as well as a tray and stopwatch. The feed ingredients used in this research were rice bran, coffee husks, fish meal, coconut meal, and corn cobs.

This research was arranged on factorial design (3x5) based on a completely randomized design [3]. Each combination was repeated three times. The first factor (A) is particle size, namely fine particle size (mesh 26), medium particle size (mesh 12), and coarse particle size (mesh <12). The second factor (B) is local feed ingredients, namely rice bran, coffee husks, fish meal, coconut cake, and corn cobs. The parameters observed in this research were the flowability of feed ingredients at each particle size.

This research began by grinding each feed ingredient and was sieved using a mesh size of 26 for the fine category, 12 for the medium category, and <12 for the coarse category to determine the percentage and particle size of the feed ingredients in each mesh.

Flowability measurements were carried out based on the results of particle size categories (in the coarse <12, medium 12, and fine 26). The first technique for flowability measuring is weighing 10 grams of feed material as a sample, and then preparing a tray and stopwatch. Furthermore, the sample was dropped at 2 m of height and the time of the sample until it fell on the tray was recorded. Flowability was calculated using the following formula [4].

$$DA = \frac{m}{t}$$

Note: DA = Flowability
m = Range
t = Time

Data was statistically analyzed using the SPSS program. Differences between means were tested using the least significant difference (LSD) test [3].

3 Result and Discussion

3.1 Percentage and Particle Size of Local Feed Ingredients

The results of research regarding the physical characteristics of local feed ingredients (particle size) in each mesh can be seen in Table 1.

Table 1. Percentage and average particle size of local feed ingredients in each mesh

Ingredients	Mesh 26		Mesh 12		Mesh <12	
	%	(gr)	%	(gr)	%	(gr)
Rice Bran	49.40	247.00	49.47	247.33	1.13	5.67
Coffee Husk	7.60	38.00	37.07	185.33	55.33	276.67
Fish Meal	47.93	239.67	45.60	228.00	6.47	32.33
Copra Meal	30.80	154.00	49.07	245.33	20.13	100.67
Corn Cobs	38.33	7.67	24.67	123.33	67.67	338.33

The average flowability presented in Table 1 shows that the rice bran has the highest percentage of the fine category (mesh 26), it was 49.40% (247 gr) of material that passed

through the sieve. This also showed that rice bran feed ingredients in the medium category (mesh 12) have the highest percentage, 247.33 gr (49.47%) of material that passes through the sieve. It indicates that rice bran is included in the fine and medium categories. The percentage of calculation obtained was higher than other local feed ingredients such as coffee husks, fish meal, coconut meal, and corn cobs. The quality of rice bran varies and is greatly influenced by rice varieties [5] machine systems, and milling processes [6], these factors not only affect the physical quality of rice bran but also affect its nutritional components [5].

Other feed ingredients, such as fish meal have fine and medium categories. It is 47.93% fine and 45.60% medium particle, then it is only 6.47% coarse particles. Thus, the particle size of fish meal is categorized into fine and medium particles. In contrast, copra meal showed the highest percentages on medium particles (mesh 12) (49.07%), which is higher than fine and medium particles.

Coffee husk has the highest coarse particle size, and the amount of passed material through the sieve was 276.67 (55.33%). Thus, coffee husk includes a coarse category (mesh <12). Meanwhile, fine and medium particles of coffee husk are 7.60% and 37.07%, respectively.

In the coarse category, corn cob feed ingredients have the highest percentage (67.67%) than other feed ingredients. It can be seen that corn cob has a coarser particle size than other local feed ingredients (Table 1).

3.2 Local Feed Ingredients Flowability

The results of the experiment regarding the effect of different particle sizes on the flowability of feed ingredients can be seen in Table 2.

Table 2. Results of the experiment regarding the effect of different particle sizes on the flowability of feed ingredients

Local Feed Ingredients	**Flowability (m/second)**			**Rata-rata**
	Fine (Mesh 26)	**Medium (Mesh 12)**	**Coarse (Mesh <12)**	
Rice Bran	1.64^{a}	2.07^{a}	2.40^{ab}	6.11
Coffee Husk	2.31^{c}	2.01^{a}	2.09^{a}	6.41
Fish Meal	1.83^{ab}	2.02^{a}	2.39^{ab}	6.23
Copra Meal	2.12^{bc}	2.13^{a}	2.62^{b}	6.87
Corn Cobs	2.11^{bc}	2.16^{a}	2.39^{ab}	6.67
Average	6.00^{b}	6.23^{b}	7.13^{a}	

Note: ^{abc} Different superscripts on the same line indicate very significant differences ($P<0.01$)

Analysis of variance showed that particle size and its interaction with various local feed ingredients had a significant effect ($P<0.01$) on the flowability of feed ingredients. The averages presented in (Table 2), show that the particle size in the fine category (mesh 26) with various local feed ingredients has the lowest average flowability value (6.00 m/sec and 7.13 m/sec) for the coarse particle (mesh <12). It indicates that the different flowability of each ingredient particle influences the falling speed achieved per second. Syamsu (2007) [7] stated that the smallest value shows the largest flowability. This is due to the shorter fall distance achieved per second.

Based on the least significant difference (LSD) test of the average interaction between flowabilities of various local feed ingredients with different particle sizes showed that the flowability of fine and medium particles was significantly different ($P<0.01$) with coarse particles. However, the flowability of fine was not different of medium particles. It indicates that different particle sizes of feed ingredients tend to have the highest flowability values in the coarse category. It means that larger particle sizes are far different from fine and medium particles.

The results of the LSD test on the interaction between various local feed ingredients with different particle sizes were significant. In the fine category (mesh 26), rice bran flowability (1.64 m/sec) was lower compared to coconut meal, corn cobs, and coffee husks. Meanwhile, it did not differ from fish meal. It also showed that fish meal, coconut meal, and corn cobs were significantly different from coffee husk by 2.31 m/sec.

The interaction between the local feed ingredients and particle size showed a significant difference. The particle size in the coarse category (mesh <12) showed that the average flowability value for rice bran feed ingredients is not different from coffee husk, fish meal, and corn cobs. Meanwhile, different flowability is found in coffee husk and coconut meal. Then, the interaction between local feed ingredients and particle size did not show significant differences in particle size in the medium category (mesh 12). Local feed ingredients such as rice bran, coffee husks, fish meal, coconut cake, and corn cobs at a particle size of mesh 12 have the same or no different flowability values.

4 Conclusion

Based on the results of research regarding the effect of different particle sizes on the flowability of local feed ingredients, it can be concluded that:

1. Particle sizes in the fine (mesh 26) and medium (mesh 12) categories are found in rice bran (49.40% fine and 49.47% medium) and fish meal (47.93% fine and 45.60% medium).
2. Higher percentages for the coarse category (mesh<12) were shown in coffee husk (55.33%) and corncob (67.67%). Coconut meal is in the medium category by 49.07% and it is higher than the fine and coarse particle sizes.
3. The flowability of various local feed ingredients at different particle sizes shows that mesh 26 (6.00 m/sec) and mesh 12 (6.23 m/sec) are significantly different from mesh <12 (7.13 m/sec.).
4. The interaction between local feed ingredients and particle size shows the different flowability values in the fine category particle size (mesh 26) which is shown in rice bran by 1.64 m/sec lower than in coconut meal and corn cob and coffee husk, but it is not different from fish meal. Meanwhile, the flowability of the coffee husk is higher than that of rice bran and fish meal.
5. The interaction between local feed ingredients with a coarse particle size category (mesh<12) shows a different flowability which is shown in coffee husk (2.09 m/sec) and coconut meal (2.62 m/sec), but the other local feed ingredients have no different of flowability at the same particle size.

Conflict of Interest

The authors declare no conflict of interest.

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Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions Statement

Ichlasul Amal: Conceptualization, Methodology, Investigation, Writing- Original draft preparation. Anis Salam: Data curation, Writing- Reviewing and Editing. Abdul Alim Yamin: Validation, Investigation, Writing- Reviewing and Editing. Jasmal Ahmari Syamsu: Conceptualization, Methodology, Validation, Writing- Reviewing and Editing.

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