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Physical properties evaluation of rice bran forgery with corn cob addition

Evaluasi sifat fisik pemalsuan dedak padi dengan penambahan tongkol jagung

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A B S T R A C T

The objective of this study was to evaluate physical properties of rice bran forgery with corn cob addition. Corn cob mixed with rice bran by different levels 0%, 5%, 10%, 15%, and 20%. The experimental design was completely random design (CRD) with 5 treatments and 3 replications. The data were analyzed by ANOVA and followed by orthogonal contrast test if there were significant differences between the treatments. The results showed the addition of corn cob (0%, 5%, 10%, 15% and 20%) significantly (P<0.01) decreased the specific gravity (kg L-1) by 1.36, 1.32, 1.26, 1.20 and 1.16 (r = 93%), bulk density (g L-1) by 286.53, 283.02, 275.74, 268.35 and 263.86 (r = 98%), compact bulk density (g L-1) by 475.44, 463.69, 453.18, 443.14 and 433.53 (r = 99%) and angle of repose (°) by 44.40, 43.91, 43.27, 43.15 and 42.70 (r = 93%) while the particle size (mm) increased by 1.22, 1.23, 1.23, 1.24 and 1.25 (r = 95.8%). Detection of rice bran forgery can be evaluated through physical test correlation and the highest correlation is found in the compact bulk density parameter.

A B S T R A K

Penelitian ini bertujuan untuk mengevaluasi sifat fisik dedak padi yang telah dicampur dengan tepung tongkol jagung. Tepung tongkol jagung dicampurkan pada dedak padi dengan level berbeda 0%, 5%, 10%, 15%, dan 20%. Rancangan yang digunakan yakni rancangan acak lengkap (RAL) dengan 5 perlakuan dan 3 ulangan. Data yang diperoleh dianalisis dengan sidik ragam ANOVA dan jika terdapat perbedaan dilanjutkan dengan uji kontras orthogonal. Hasil penelitian ini menunjukkan penambahan tepung tongkol jagung (0%, 5%, 10%, 15% dan 20%) ke dalam dedak padi mempengaruhi penurunan nilai berat jenis (kg L-1) sebesar 1,36; 1,32; 1,26; 1,20 dan 1,16 (r = 93%), kerapatan tumpukan (g L-1) sebesar 286,53; 283,02; 275,74; 268,35 dan 263,86 (r = 98%), kerapatan pemadatan tumpukan (g L-1) sebesar 475,44; 463,69; 453,18; 443,14 dan 433,53 (r = 99%), dan sudut tumpukan (°) sebesar 44,40; 43,91; 43,27; 43,15 dan 42,70 (r = 93%) serta mempengaruhi peningkatan ukuran partikel (mm) sebesar 1,22; 1,23; 1,23; 1,24 dan 1,25 (r = 95.8%) bahan dengan sangat signifikan (P<0,01). Deteksi pemalsuan dedak padi dapat dievaluasi melalui korelasi pengujian fisik dan korelasi tertinggi terdapat pada pengujian kerapatan padatan tumpukan.

Kata kunci:
Tongkol jagung
Pemalsuan
Sifat fisik
Dedak padi

INTRODUCTION

Quality of ration depends on the nutrient content of feedstuff. It can be changing due to effects i.e., treatments, addition of other ingredients or storage. Generally, good quality of rice bran can be determined by its physical properties such as moisture content less than 14%, free of insects, no broken or damaged grain, appropriate smell or taste, unchanging external appearance and no or few adulterations (Marbun et al., 2019). Several feedstuffs which are widely used in ration formulation are rice bran, pollard, and soybean meal.

Rice bran was agriculture by-product and the percentage of rice bran from rice kernel is 5% – 8% (Bodie et al., 2019). Rice bran in feed can be used as a source of protein and carbohydrates (Nurcahyani, Wulandari, & Nusantoro, 2017). National production of rice kernel was 55.3 million tons, and the estimation of rice bran production was 2500 – 4500 tons (BPS, 2022). This makes rice bran as a local feed ingredient that is widely used in the feed mill. However, the availability of this feedstuff is fluctuated based on the harvest season and it implicates the price of rice bran. When the price is high, some producers try to mix pure rice bran with other things so the price of the rice bran will decrease. This adulteration makes the quality decrease and somehow it can be harmful to animals. Forgery of rice bran uses feedstuffs with low-quality nutrients such as rice husk, corn cob and sawdust (Hidayat et al., 2015).

In this study, there were evaluation of rice bran with corn cob addition. Corn cob as a counterfeit material is used because the color is almost similar. Corn cob had in vitro digestibility < 50% and low palatability (Yulistiani et al., 2012). Paynor et al. (2016) stated that corn cob had 1.48% moisture content, 2.26% ash, 0.61% crude fat, 2.86% crude protein and 30.93% crude fiber. Detection of this forgery can be done by using proximate analysis, but it takes time to evaluate. Rapid evaluation is needed in the field and it can be performed by using physical evaluation such as organoleptic and feedstuffs physical properties test.

Physical properties are also a distinctive character of a feed ingredient so that it can be used as an indicator of adulteration. Study on physical properties of corn cob and rice bran forgery with corn cob addition was rarely. Therefore, the objective of this experiment was to evaluate physical properties of rice bran forgery with corn cob addition.

MATERIALS AND METHODS

Materials

The material used in this study was 15 kg of rice bran (RB) obtained from local milling and 2 kg of corn cob from local farmers. Both locations were in Bogor District. The rice bran was the result of the first grinding of rice milling so it is still classified as coarse rice bran. The whole corn cob (CC) was grounded into mash form.

Figure 1. Visualization of rice bran (a) and corn cob (b)

Experimental Design

Design of the experiment was completely randomized design (CRD) with five treatments and three replications. The treatments were:

(P0)= 100% RB
(P1)= 95% RB + 5% CC
(P2)= 90% RB + 10% CC
(P3)= 85% RB + 15%CC, and
(P4)= 80% RB+ 20% CC

Collected data were analyzed using analysis of variance (ANOVA) and followed by orthogonal contrast test if there were significant differences between the treatments (Steel & Torrie, 1993).

Proximate Analysis

Proximate analysis of moisture content, ash, crude protein (CP), crude fat (EE) and crude fiber (CF) were performed to examine rice bran and corn cob. The analysis was based on AOAC (2005).

Particle Size Measurement

Particle size was determined using vibrator ball mill (mesh 4, 8, 16, 30, 50, 100 and 400). Sample was put on the first sieve (mesh 4) and the tools were shaken to filter the sample in all sieves. The remaining sample in every sieve was measured. Modulus of fineness (MF) were determined by following equation:

$$MF = \frac{\Sigma(\% \; sample \times specified \; sieve \; number)}{100}$$

Particle size values were obtained by the following equation:

Particle size = (0.0041) x 2^{MF} x 2.54 cm x 10 mm

Specific Gravity

Specific gravity was measured using Archimedes' Law principles. Sample (50 g) were put into measuring cylinder (500 mL) which already contained 200 mL aquadest. Changes in water volume will be recorded. The specific gravity was determined based on Khalil (1999a) with modification, as follows :

Specific gravity = Sample mass (kg) : Δ Volume (L)

Bulk Density

Sample (50 g) was poured into measuring cylinder (500 mL) by using funnel. The volume occupied by the sample was measured. The bulk density was determined based on Khalil (1999a) with modified:

Bulk density = Sample mass (g) : Occupied volume (L)

Compact Bulk Density

Sample (50 g) was poured into measuring cylinder (500 mL) by using funnel then it is shaken for certain time. The volume occupied by the sample was measured. The compact bulk density was determined based on Khalil (1999a) with modified:

$$\text{Compact bulk density} = \frac{\text{Sample mass (g)}}{\text{Occupied volume (L)}}$$

Angle of Repose

Angle of repose was measured by dropping 500 g of sample from a height 32.5 cm using a funnel on a flat surface. The diameter (d) and height (h) of sample were measured. The angle of repose was determined based on Khalil (1999b):

$$Angle \; of \; repose = Arc \; Tg \frac{2h}{d}$$

RESULTS AND DISCUSSIONS

Feedstuffs Evaluation

Rice Bran

In this study, the rice bran had brown color and smooth texture. Prasad et al. (2019) mentioned that good quality of rice bran has brown color, smooth particles, not clumping, no rancid smell, not showing any other mixture (husk), can clump when it held. Based on Indonesia National Standardization (SNI 1996 and SNI 2013), the rice bran of this research was categorized as quality II. The result of rice bran proximate analysis was shown on Table 1.

Quality of rice bran can also be measured by using physical properties tests. The results of the measurement of the physical properties of the rice bran used and several research results related to it are shown in Table 2. Data on Tabel 2 showed that particle size, specific gravity, and angle of repose in this study were higher than that the report of Ridla and Rosalina (2014) . Meanwhile, bulk density and compact bulk density were lower than Ridla & Rosalina (2014) and Nafisah & Nahrowi (2021). The differences were caused by rice varieties and milling techniques (machine characteristics and settings, filter settings) (Rafe et al., 2017).

Table 1. Chemical composition of local RB based on 100% dry matter

Chemical Composition (%)	Exisiting Analysis	Group of RB		
		I	II	III
MC	10.18	Max. 13**	Max. 13**	Max. 13**
CP	10.53	Min. 12**	Min. 10**	Min. 8**
CF	15.42	Max. 12**	Max. 15**	Max. 18**
Ash	11.23	Max. 11**	Max. 13**	Max. 15**
EE	22.04	Max. 15*	Max. 20*	Max. 20*

MC: Moisture contents, CP: Crude protein, CF: Crude fiber, EE: Ether extract, (*) SNI 1996, (**) SNI 2013.

Table 2. Physical properties of three local RB

Items	RB-1Rice Bran1	RB-2 Rice Bran2	RB-3 Rice Bran3
Particle size (mm)	1.22	1.19	Not measured
Specific gravity (kg L^{-1})	1.36	1.21	1.29
Bulk density (g L^{-1})	286.53	340.52	352.95
Compact bulk density (g L^{-1})	475.44	525.40	509.34
Angle of repose (˚)	44.40	41.60	40.53

RB-1: existing laboratory analysis RB-2: Ridla and Rosalina (2014) RB-3: Nafisah and Nahrowo (2021)

Corn Cob

Corn cob (CC) had light brown color and grounded to resemble the texture of rice bran. Chemical analysis of corn cob based on this study and several studies are showed in Table 3.

Table 3. Chemical composition of three local CC (100% DM Basis)

Chemical Composition (%)	CC-1	CC-2	CC-3
MC	10.53	6.00	11.11
CP	4.37	4.19	3.67
CF	40.07	33.33	44.44
Ash	2.54	2.49	2.44
EE	4.00	4.72	0.67

MC: Moisture contents, CP: Crude protein, CF: Crude fiber, EE: Ether extract. CC-1 : existing laboratory analysis. CC-2 : Abubakar et al. (2016). CC-3 : Parakkasi (1999)

Table 4. Physical properties of CC

Items	CC
Particle size (mm)	1.39
Specific gravity (kg L^{-1})	0.57
Bulk density (g L^{-1})	206.19
Compact bulk density (g L^{-1})	266.67
Angle of repose (˚)	36.54

Grounded CC had similar texture to RB, which was quite fine, although it was finer than RB. This physical similarity made corn cobs as the one of ingredients which commonly used in rice bran forgery. The most frequently used adulteration materials were rice husks and grounded CC (adulteration materials containing nutrients) and sawdust (adulteration materials containing no nutrients).

The results of physical properties measurement of grounded CC were shown in Table 4. These results were lower than rice bran's physical properties, yet the particle size of grounded CC were higher than of RB. The physical properties standard of grounded CC has not been published because there has been no research that specifically examines this.

Physical Properties of Rice Bran Forgery

RB were adulterated by mixing grounded CC will cause changes in the characteristics of physical properties. The analysis of variance results of moisture content, particle size, specific gravity, bulk density, compact bulk density, and angle of repose could be seen in Table 5.

Particle Size

The particle size of 100% rice bran was 1.22 mm and it was classified as Medium size. Feedstuffs were categorized as fine if the particle size is 0.10 to 0.78 mm. Meanwhile the medium

Table 5. Moisture content and physical properties of rice bran

Items	Treatment				
	P0	P1	P2	P3	P4
MC (%)	9.24±0.03	9.24±0.10	9.16±0.12	8.97±0.12	8.91±0.07
PS (mm)	$1.22±0.003^{a}$	$1.23±0.003^{b}$	$1.23±0.002^{c}$	$1.24±0.002^{d}$	$1.25±0.005^{e}$
SG (kg L^{-1})	$1.36±0.10^{a}$	$1.32±0.10^{b}$	$1.26±0.00^{b}$	$1.20±0.00^{c}$	$1.16±0.00^{c}$
BD (g L^{-1})	$286.53±1.43^{a}$	$283.02±1.22^{b}$	$275.74±1.92^{c}$	$268.35±1.81^{d}$	$263.86±1.21^{e}$
CBD (g L^{-1})	$475.44±1.30^{a}$	$463.69±2.47^{b}$	$453.18±2.36^{c}$	$443.14±2.26^{d}$	$433.53±2.16^{e}$
AR (˚)	$44.40±0.21^{a}$	$43.91±0.25^{b}$	$43.27±0.27^{c}$	$43.15±0.25^{c}$	$42.70±0.19^{d}$

Different superscript in the same row showed significant differences (P<0.01). MC: Moisture content, PS: Particle size, SG: Specific gravity, BD: Bulk density, CBD: Compact bulk density, AR: Angle of repose. P0: 100% rice bran, P1: 95% rice bran + 5% corn cob, P2: 90% rice bran + 10% corn cob, P3: 85% rice bran + 15% corn cob, P4: 80% rice bran + 20% corn cob.

size was range from 0.79 to 1.79 mm and the coarse size was 1.80 to 13.33 mm. The grinding of rice bran was only done once so that the texture of the rice bran was a bit coarse. Particle size of rice bran was determined by the grinding process (Soltani et al., 2015). The rice bran from the first grinding was relatively the same size and sometimes still mixed with the husks, while the rice bran from the second grinding had a finer bran size (Zhou et al., 2021). Corn cob had particle size of 1.39 mm. It showed that the particle of grounded CC had similar size as RB because it was categorized as medium size.

Inclusion CC into RB as much as 5%, 10%, 15%, and 20% caused high significantly changes in the particle size of RB (P<0.01). The particle

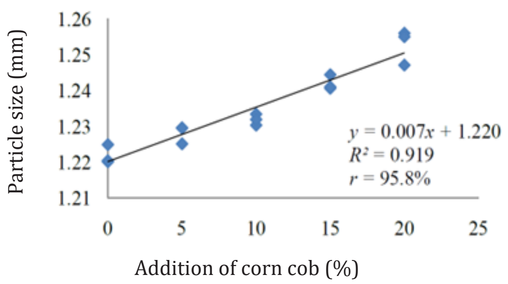

Figure 2. Correlation between the addition of CC (%) and particle size of treated RB (mm)

size became coarser than pure RB (1.25 mm). Comparing to Schmidt & Furlong (2012) which had particle size of 0.18 to 0.39 mm, adulteration of RB could be detected since the addition of 5% corn cob. The correlation between adding CC and the particle size of RB was shown in Figure 2.

Figure 2 showed that mixing 1% CC increased the particle size of RB by 0.007 mm and had high correlation (r = 95.8%) to the increase in particle size. The increase in particle size occurred because CC mixed in rice bran will increase the ratio of coarse-sized ingredients compared to rice bran without the addition of corn cob. The corn cobs should be ground with a smaller screen so that the particle size is more like rice bran. This difference caused particle size cannot be used to evaluate physical properties directly.

Specific Gravity

The RB had specific gravity of 1.365 kg L^{-1}, while CC 0.571 kg L^{-1}. Specific gravity can determine the bulky properties (Khalil, 1999a) and the homogenity of materials (Satjaritanun et al., 2021). The lower value of specific gravity,

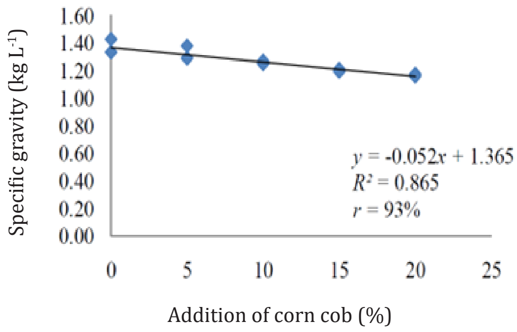

Figure 3. Correlation between the addition of CC (%) and specific gravity of treated RB (kg L^{-1})

the bulkier the feedstuffs had. Nafisah & Nahrowi (2021) added that specific gravity feedstuffs tend to be uniform could produce high homogeneity of feedstuffs while high specific gravity feedstuffs during mixing would tend to the bottom, so the mixing process was not homogeneous.

The addition of CC into rice bran were very significantly (P<0.01) reduced the specific gravity with specific gravity value range of 1,365 kg L^{-1} to 1,165 kg L^{-1}. The results of the orthogonal contrast test showed that rice bran without the addition of CC (P0) had a higher specific gravity value than the specific gravity of rice bran added with CC flour.

Based on Figure 3, the addition of 1% CC reduced the specific gravity of the material by 0.052 kg L^{-1} so that it has a high effect (r = 93%) on the specific gravity of the treated rice bran. The differences in specific gravity in the five treatments were influenced by differences in the type of material and the surface characteristics of the particles. CC added to P1, P2, P3, and P4 will float on the surface of aquadest when measuring. It caused the specific gravity value to be lower than 100% rice bran (P0). Mixing CC into rice bran would also change the surface characteristics to be less compact, resulting in lower specific gravity values. However, the results of specific gravity measurement were still in the range of local rice bran specific gravity values based on Nafisah & Nahrowi (2021) which was 1.3 kg L^{-1}, so the adulteration of rice bran was only seen in the addition of 10% CC.

Bulk Density

The bulk density of rice bran and CC were 286.53 g L^{-1} and 206.19 g L^{-1}. Ridla & Rosalina (2014) stated that the bulk density was directly proportional to the specific gravity of feedstuffs.

The higher the value of the specific gravity, the higher the value of feedstuffs bulk density.

Mixing CC in rice bran had a very significant effect (P<0.01) on the decrease in the bulk density value of the treated rice bran with a value range of

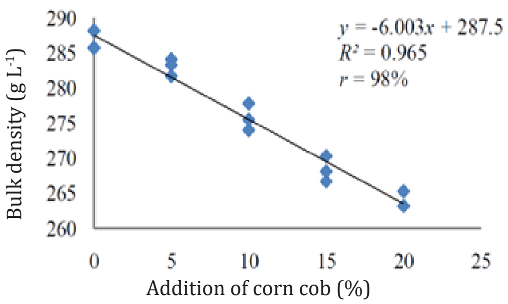

Figure 4. Correlation between the addition of CC (%) and bulk density of treated RB (g L^{-1})

286.53 g L^{-1} to 263.86 g L^{-1}. The bulk density of pure rice bran (P0) was 286.53 kg L^{-1}, higher than P1, P2, P3, and P4 which was 283.02 g L^{-1}, 275.74 g L^{-1}, 268.35 g L^{-1}, and 263.86 g L^{-1}. The relationship between rice bran with treatment and the bulk density could be seen in Figure 4.

Figure 4 showed that every 1% addition of CC to rice bran reduced the bulk density by 6 g L^{-1} and there was a very close relationship (r = 98%). The range of rice bran bulk density values based on Nafisah & Nahrowi (2021) which is 280 to 290 g L^{-1} so that adulteration of rice bran can already be seen in the addition of CC as much as 10%.

According to Khalil (1999a), the specific gravity was a determining factor of bulk density. The difference in the measurement of specific gravity and bulk density was that specific gravity was the ratio between the mass of feedstuffs with the addition of the volume of the space that already contains water while bulk density was the ratio

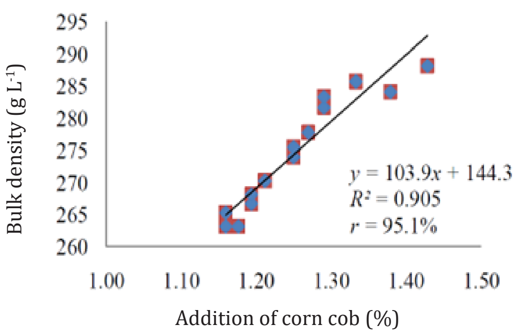

Figure 5. Correlation between specific gravity (kg L^{-1}) and bulk density of RB (g L^{-1})

between the mass of feedstuffs and the volume of space occupied through the pouring process, so the specific gravity becomes the determining factor of bulk density which had similar texture, particle size and water content (Ridla & Rosalina, 2014).

Correlation between specific gravity and bulk density is very high (r = 95.1%) as shown in Figure 5. Each decrease in specific gravity of 1 kg L^{-1} decreased bulk density by 0.104 g L^{-1}. Khalil (1999a) stated that rice bran had higher specific gravity and a smoother texture than CC, so the decrease in the specific gravity of rice bran with the addition of CC was followed by a decrease in the bulk density. The addition of CC into rice bran resulted in a decrease in the bulk density, this resulted in a longer material flow time (Akbar et al., 2017).

Bulk density had important role in calculating the volume of space required for feedstuffs with a certain weight, for example filling silos, elevators, and automatic dosing accuracy so the efficiency of the time required for rice bran with the addition of CC as a raw material in making rations will decrease.

Compact Bulk Density

Compact bulk density had similar method to bulk density, only differing in the compaction process done for the measurement of compact bulk density. The control rice bran had compact bulk density of 475.44 g L^{-1}, while CC was 266.67 g L^{-1}. The value of compact bulk density depended on type of feedstuffs, particle size, the intensity of the compaction process (Khalil, 1999a), and the working process of rice milling (Bodie et al., 2019).

Mixing CC into rice bran had significant effect (P<0.01) on the compact bulk density (Figure 6).

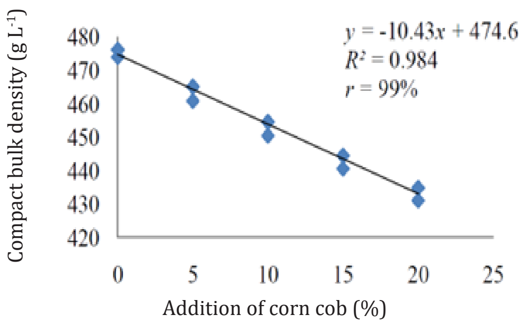

Figure 6. Correlation between the addition of CC (%) and compact bulk density of treated RB (g L^{-1})

As the addition of CC was increased to 20%, the compact bulk density became lower from 475.44 g L^{-1} to 433.53 g L^{-1}. The compact bulk density of local rice bran based on Ridla & Rosalina (2014) was 525.40 g L^{-1}, so the adulteration could be seen in 10% addition of CC.

Figure 6 showed close relationship (r = 99%), with the addition of 1% CC to rice bran reduced the compact bulk density by 10.43 g L^{-1}. Damayanti et al. (2017) stated that apart from moisture content and particle size, the compact bulk density was also affected by the inaccuracy of measurements. Therefore, it was advisable to measure compact bulk density using a shaking machine whose strength was known and its consistency could be guaranteed. Shaking affected the compaction of the volume, but compaction could not eliminate the cavity caused by the effect of differences in the particle size (Akbar et al., 2017).

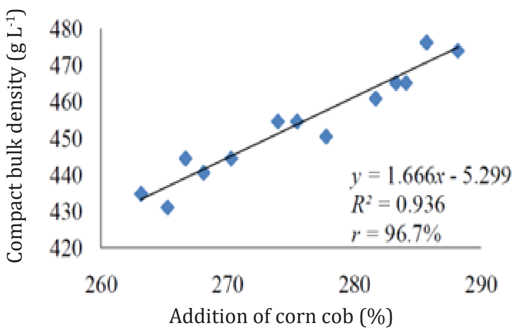

Figure 7. Correlation between bulk density (g L^{-1}) and compact bulk density (g L^{-1})

Correlation between bulk density and compact bulk density showed in Figure 7. The results indicated that there was huge closeness (r = 96.7%) between bulk density and compact bulk density. Compact bulk density value increased as the bulk density value increased.

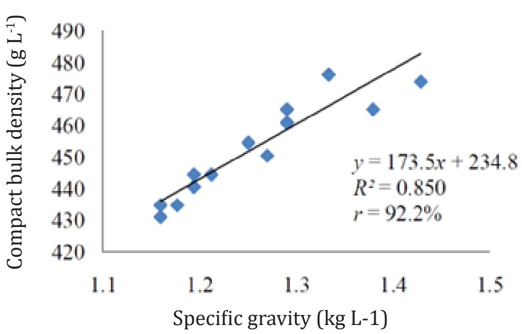

Figure 8. Correlation between specific gravity (kg L^{-1}) and compact bulk density (g L^{-1})

The specific gravity had correlation as of 92.2% with the compact bulk density as shown in Figure 8. Compaction of feedstuffs with high specific gravity increased their density, so the weight of the material per unit volume will increase (Harnentis et al., 2019).

Angle of Repose

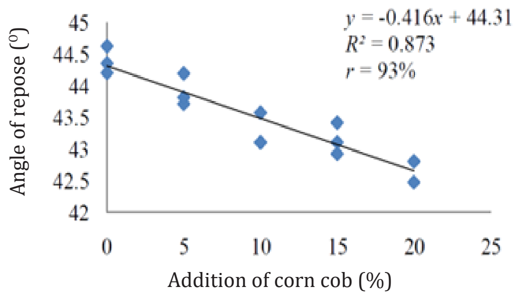

Figure 9. Correlation between the addition of CC (%) and angle of repose of treated RB (°)

The angle of repose was 44.4° for rice bran and 36.54° for CC. Beakawi Al-Hashemi & Baghabra Al-Amoudi (2018), indicated that rice bran and CC had moderate freedom of movement or flow. The angle of repose of CC was lower than rice bran, so the more addition of CC into the rice bran would reduce the angle of repose (Figure 9).

Addition of CCs into rice bran caused a very significant decrease ($P<0.01$) of 93% to the angle of repose formed up to 42.70°. Comparing to rice bran data belonging to Oryza.s et al. (2021) which had angle of repose 50.6°, the rice bran forgery could be seen since the addition of 5% CC.

Angle of repose affected the accuracy in the dosing process. Feedstuffs which had low angle of repose would be easier and more accurate

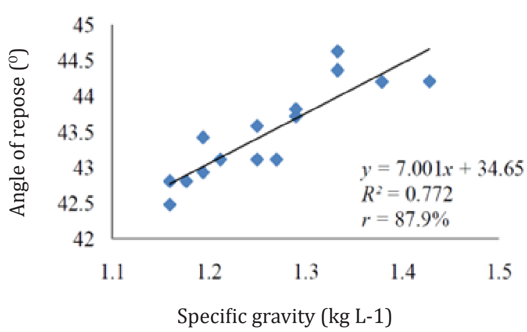

Figure 10. Correlation between specific gravity (kg L^{-1}) and angle of repose (°)

when measured and would be better if stored in packages or containers. The angle of repose could be used as an indicator of feedstuffs flow rate (Nafisah & Nahrowi, 2021). The factors that cause the flow rate to be easy or not were the moisture content, the shape and size of the particles, and properties of the mixture composition.

Beside particle size, specific gravity, bulk density, and moisture content affected the free flow rate of feedstuffs to observe the angle of repose (Khalil, 1999a). The results of this study showed that there was a significant effect of specific gravity, bulk density, and compact bulk density on the angle of repose as shown in Figures 10, 11, and 12.

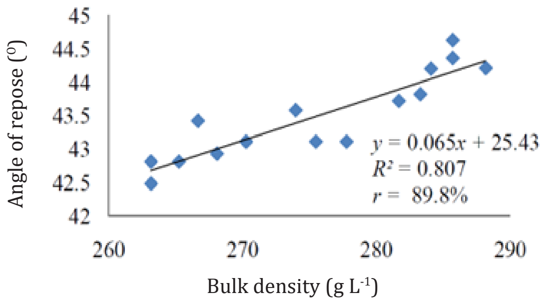

Figure 11. Correlation between bulk density (g L^{-1}) and angle of repose (°)

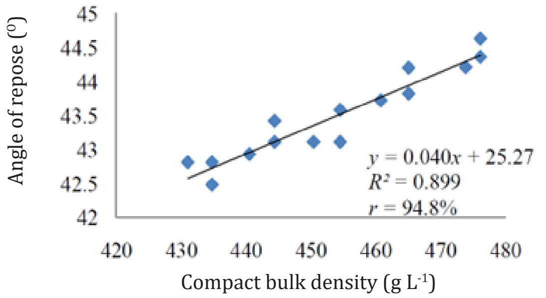

Figure 12. Correlation between compact bulk density (g L^{-1}) and angle of repose (°)

CONCLUSION

Particle size, specific gravity, bulk density, compact bulk density and angle of repose could determine rice bran forgery. Based on examining the close relationship, the compact bulk density was the most precise measurement. The rice bran adulteration could be found in mixing level 5% – 10% of corn cob. It is suggested the physical properties evaluation of different variety of rice bran are needed.

REFERENCES

Abubakar, U.S., Yusuf, K.M., Safiyanu, I., Abdullahi, S., Saidu, S.R., Abdu, G.T., & Indee, A.M. 2016. Proximate and mineral composition of corn cob, banana and plantain peels. International Journal of Food Science and Nutrition. 1(6).

Akbar, M. R. L., Suci, D. M., & Wijayanti, I. (2017). Evaluasi kualitas pellet pakan itik yang disuplementasi tepung daun mengkudu (Morinda citrifolia) dan disimpan selama 6 minggu. *Buletin Makanan Ternak*, *104*(2), 31–48.

AOAC. (2005). Official Methods of Analysis of AOAC International. In *Association of Official Analysis Chemists International*.

Beakawi Al-Hashemi, H. M., & Baghabra Al-Amoudi, O. S. (2018). A review on the angle of repose of granular materials. In *Powder Technology* (Vol. 330). https://doi.org/10.1016/j.powtec.2018.02.003

Bodie, A. R., Micciche, A. C., Atungulu, G. G., Rothrock, M. J., & Ricke, S. C. (2019). Current Trends of Rice Milling Byproducts for Agricultural Applications and Alternative Food Production Systems. In *Frontiers in Sustainable Food Systems* (Vol. 3). Frontiers Media S.A. https://doi.org/10.3389/fsufs.2019.00047

BPS. (2022). *Statistik Tanaman Pangan 2021*. Jakarta: Badan Pusat Statistik RI.

Damayanti, R., Lusiana, N., & Prasetyo, J. (2017). Studi Pengaruh Ukuran Partikel dan Penambahan Perekat Tapioka terhadap Karakteristik Biopelet dari Kulit Coklat (Theobroma Cacao L.) Sebagai Bahan Bakar Alternatif Terbarukan. *Jurnal Teknotan*, *11*(1). https://doi.org/10.24198/jt.vol11n1.6

Harnentis, Marlida, Y., & Amizar, R. (2019). The utilization of different binders for pelleted native chicken ration based on coconut meat waste supplemented with mannanolytic thermophilic bacteria and thermostable mannanase: A physical characteristic of pelleted native chicken ration. *IOP Conference Series: Earth and Environmental Science*, *287*(1). https://doi.org/10.1088/1755-1315/287/1/012017

Hidayat, C., Sumiati, & S Iskandar. (2015). Kualitas Fisik dan Kimiawi Dedak Padi yang Dijual di Toko Bahan Pakan di Sekitar Wilayah Bogor. *Prosiding Seminar Nasional Teknologi Peternakan Dan Veteriner*.

Khalil. (1999a). Pengaruh kandungan air dan ukuran partikel terhadap perubahan perilaku fisik bahan pakan lokal: kerapatan tumpukan, kerapatan pemadatan tumpukan, dan berat jenis. *Media Peternakan*, *22*(1), 1–11.

Khalil. (1999b). Pengaruh kandungan air dan ukuran partikel terhadap sifat fisik pakan lokal: sudut tumpukan, daya ambang, dan faktor higroskopis. *Media Peternakan*, *22*(1), 33–42.

Marbun, F. G. I., Wiradimadja, R., & Hernaman, I. (2019). Pengaruh lama penyimpanan terhadap sifat fisik dedak padi. *JURNAL ILMIAH PETERNAKAN TERPADU*, *6*(3). https://doi.org/10.23960/jipt.v6i3.p163-166

Nafisah, A., & Nahrowi, N. (2021). The potential of pollard and rice bran with fractionation process as raw materials for high fiber processed food. *Food ScienTech Journal*, *3*(1), 62. https://doi.org/10.33512/fsj.v3i1.12225

Nurcahyani, D. T., Wulandari, S., & Nusantoro, S. (2017). Pengaruh pemberian dedak kasar fermentasi pada domba ekor tipis sebagai bahan baku konsentrat. Jurnal Ilmu Peternakan Terapan, 1(1), 17-24.

Oryza.s, M., Wongtangtintharn, S., Tengjaroenkul, B., Cherdthong, A., Tanpong, S., Bunchalee, P., Pootthachaya, P., Reungsang, A., & Polyorach, S. (2021). Physico-chemical characteristics and amino acid content evaluation of citric acid by-product produced by microbial fermentation as a potential use in animal feed. *Fermentation*, *7*(3). https://doi.org/10.3390/fermentation7030149

Parakkasi, A. 1999. Ilmu Nutrisi dan Makanan Ternak Ruminansia. Jakarta: Universitas Indonesia Press.

Paynor, K. A., David, E. S., & Valentino, M. J. G. (2016). Endophytic fungi associated with bamboo as possible sources of single cell protein using corn cob as a substrate. *Mycosphere*, *7*(2), 139–147. https://doi.org/10.5943/mycosphere/7/2/5

Prasad, B. J., Sharavanan, P. S., & Sivaraj, R. (2019). RETRACTED: Health benefits of black rice – A review. *Grain & Oil Science and Technology*, *2*(4). https://doi.org/10.1016/j.gaost.2019.09.005

Rafe, A., Sadeghian, A., & Hoseini-Yazdi, S. Z. (2017). Physicochemical, functional, and nutritional characteristics of stabilized rice bran form tarom cultivar. *Food Science and Nutrition*, *5*(3), 407–414. https://doi.org/10.1002/fsn3.407

Ridla, M., & Rosalina, A. (2014). Evaluasi pemalsuan dedak padi dengan penambahan tepung kulit kacang tanah menggunakan uji fisik. In W. Agustina, S. A. Putra, & R. F. Sitompul (Eds.), *Prosiding Konferensi dan Seminar Nasional Teknologi Tepat Guna* (pp. 266–276). LIPI.

Satjaritanun, P., Regalbuto, J. R., Regalbuto, J. A., Tippayawong, N., & Shimpalee, S. (2021). Mixing optimization with inward flow configuration contra-rotating impeller, baffle-free tank. *Alexandria Engineering Journal*, *60*(4). https://doi.org/10.1016/j.aej.2021.02.045

Schmidt, C. G., & Furlong, E. B. (2012). Effect of particle size and ammonium sulfate concentration on rice bran fermentation with the fungus Rhizopus oryzae. *Bioresource Technology*, *123*, 36–41. https://doi.org/10.1016/j.biortech.2012.07.081

SNI. (1996). Standar Nasional Indonesia Dedak Padi. Jakarta: Badan Standarisasi Nasional.

SNI. (2013). Standar Nasional Indonesia Dedak Padi. Jakarta: Badan Standarisasi Nasional.

Soltani, N., Bahrami, A., Pech-Canul, M. I., & González, L. A. (2015). Review on the physicochemical treatments of rice husk for production of advanced materials. In *Chemical Engineering Journal* (Vol. 264, pp. 899–935). Elsevier. https://doi.org/10.1016/j.cej.2014.11.056

Steel, R. G. D., & Torrie, J. H. (1993). Prinsip dan Prosedur Statistika: Suatu Pendekatan Biometrik. In *PT Gramedia Pustaka Utama* (Issue 5004).

Yulistiani, D., Puastuti, W., Wina, E., & Supriati. (2012). Pengaruh berbagai pengolahan terhadap nilai nutrisi tongkol jagung: komposisi kimia dan kecernaan in vitro. *Jurnal Ilmu Ternak Dan Veteriner*, *17*(1), 59–66.

Zhou, N., Wei, H., & Zhang, H. (2021). Response of milling and appearance quality of rice with good eating quality to temperature and solar radiation in lower reaches of huai river. *Agronomy*, *11*(1). https://doi.org/10.3390/agronomy11010077