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The Effect of Binders on the Quality of Fermented Poultry Manure Pellets as Unconventional Feed

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ABSTRACT

Poultry manure has the potential to be used as a feed ingredient because it has a high enough protein and amino acid with less growth of patoghenic microorganism. The improvement of poultry manure as pellet can help to increase the palatability and feed storaging. This study aimed to determine the influence of different binders on the chemical and physical attributes of pellets derived from fermented poultry manure. Three binders, namely tapioca flour (T1), wheat flour (T2), and cassava flour (T3), were utilized in the fermentation process, with the fermented poultry manure. A 10% binder was added into the mixture, which was subsequently processed using a pelletizer. Each treatment was replicated three times, with each replication requiring 1500 g of the pellet mixture. Laboratory analyses were conducted to evaluate chemical quality through proximate analysis and gross energy assessment, while physical quality analyses included physical characteristics, measurements of diameter, length, and density, stacking density, stack compaction density, pellet durability index (PDI), modulus of uniformity, modulus of fineness, buoyancy, and water resistance. The results indicated that variations in binders did not yield numerically differences in dry matter content, organic matter, crude fat, crude fiber, and gross energy. Notably, pellets containing a wheat flour binder exhibited the highest crude protein content numerically. Furthermore, influenced the buoyancy test, with wheat flour binder showing the best buoyancy. This study recommends the adoption of wheat flour as a binder in the production of pellets based on fermented poultry manure.

Keywords: binder, poultry manure, pellet quality, unconventional feedstuff

ABSTRAK

Kotoran unggas yang difermentasi berpotensi untuk dijadikan bahan pakan karena masih memiliki kandungan protein dan asam amino serta microoganism patogen yang rendah. Pemanfaatan kotoran unggas yang difermentasi sebagai pelet dapat meningkatkan palatabilitas dan penanganan dalam penyimpanan pakan. Penelitian ini bertujuan untuk mengetahui pengaruh bahan pengikat (*binder*) yang berbeda terhadap sifat kimia dan fisik pelet yang berasal dari kotoran unggas yang difermentasi. Tiga bahan pengikat yaitu tepung tapioka (T1), tepung terigu (T2), dan tepung singkong (T3), digunakan dalam proses fermentasi dengan kotoran unggas yang difermentasi. Bahan pengikat 10% ditambahkan ke dalam campuran, yang selanjutnya diproses menggunakan pelet. Setiap perlakuan diulang tiga kali, setiap ulangan membutuhkan 1500 g campuran pelet. Analisis laboratorium dilakukan untuk mengevaluasi kualitas kimia melalui analisis proksimat dan penilaian energi kotor, sedangkan analisis kualitas fisik meliputi karakteristik fisik, pengukuran diameter, panjang, dan kepadatan, kepadatan tumpukan, kepadatan pemadatan tumpukan, indeks ketahanan pelet (PDI), modulus keseragaman, modulus kehalusan, daya apung, dan ketahanan air. Hasil penelitian menunjukkan bahwa variasi bahan pengikat tidak menghasilkan perbedaan secara numerik pada kandungan bahan kering, bahan organik, lemak kasar, serat kasar, dan *gross energy*. Namun, penggunaan tepung terigu secara numerik menghasilkan kandungan protein kasar tertinggi. Selain itu, variasi bahan pengikat mempengaruhi uji daya apung, dengan bahan pengikat tepung terigu menunjukkan daya apung terbaik. Penelitian ini merekomendasikan penggunaan tepung terigu sebagai bahan pengikat dalam produksi pelet berbahan dasar kotoran unggas yang difermentasi.

Kata kunci: binder, ekskreta ayam, kualitas pelet, pakan inkonvensional

INTRODUCTION

The waste produced by a closed-house type poultry farm was poultry manure with fresh characteristics and not mixed with litter. According to Henuk and Digle (2003), the excreta of laying hens contained water content ranging from 4.50% to 11.4%, crude protein ranging from 23.8% to 31.0%, crude fiber ranging from 10.1% to 13.8%, and ash ranging from 23.7% to 35.7%. Poultry manure with such characteristics had a high potential for environmental pollution.

Poultry manure had the potential to be used as a feed ingredient rich in nitrogen (N) and amino acids. Saptoningsih and Agus (2001) stated that the utilization of poultry manure as a substitute feed ingredient is a good solution to address environmental pollution issues and alternative feed availability. According to Sinaga and Silalahi (2002), the protein and amino acid content of laying hen excreta are sufficiently high to be used as an alternative feed ingredient. The utilization of poultry manure as feed could help reduce feed costs in livestock industries, such as in catfish farming. This study aimed to utilize poultry manure as one of the feed ingredients for compound feed for catfish. Catfish feed was relatively expensive in the market, so the use of pellet-based on chicken excreta could help reduce high feed costs. Before being used as unconventional feed, chicken excreta needed to be fermented first to decrease contamination by pathogenic bacteria and improve protein digestibility. The fermentation of poultry manure could be referred to as a compound feed processed into pellets. According to Shrinivasa and Mathur (2020), compound feed is an additional feed or supplement given to livestock to complement the nutrition from the basal feed provided.

This study used a fermented chicken excreta mixed with rice bran, molasses, and Bacillus strain LS2B inoculum. The inoculum has proteolytic activity that could help to increase the digestibility of protein, especially in the manure containing a lot of feathers, which are hard to degrade in the track digestive by animals. The fermented product was then processed into pellet feed to extend shelf life, facilitate application in feed presentation, increase feed density, and reduce transportation costs. The aim of this research was to find the best binder type to enhance pellet quality, as the success of pellet production depended heavily on binder usage. Binders were adhesive materials in pellets derived from starch-containing substances. The binders used in this study included tapioca flour, wheat flour, and cassava flour. Tapioca flour contains 17% amylose and 83% amylopectin so it can be used as an alternative natural adhesive in fish feed (Sari *et al*. 2016). Wheat flour was chosen as a binding agent because among the various types of flour that can be used, wheat flour has a high protein content (Larasati *et al*. 2017). Cassava flour is one of the ingredients that has the potential to be used as a binder. Apart from being cheap and easy to obtain, it is also a natural ingredient which tends to be safer to add to fish feed (Mulia *et al*. 2017). These three materials were easily and continuously accessible. The present study was purposed to investigate the effects of different binder types on the quality of pellet based fermented manure. The physical characteristics fermented manure mainly is coarse, which could not be directly pellet without binder since containing low stach as binder agent.

MATERIAL AND METHODS

Material

The ingredients used in this study were fresh poultry manure from ISA Brown strain at 50 weeks of age, collected from PT Peternakan Sawo Jaya. LS2B bacillus strain was used as a microbial source, while ground cassava and molasses were used to provide energy. Tapioca flour, cassava flour, and wheat flour were used as binding agents. The materials used in this study included a silo with a capacity of 30 kg and a pelletizer (Maruzen SZLP-12, China) with a capacity of 75 – 120 kg and a die diameter of 5 mm.

Methods

The research activities were conducted at the Faculty of Animal Science, Universitas Gadjah Mada. The stages of the method included the fermentation process, the pellet-making process, and the analyses process.

Fermentation process. The fermentation process was conducted for 14 d under anaerobic conditions. The ingredients, as presented in Table 1, were mixed and sprayed with LS2B bacillus strain at 1×10^5 cfu/ g. The mixture of ingredients was placed into a silo with a capacity of 30 kg.

Table 1. Formulation and chemical composition of fermented poultry manure

Items	Value
Ingredients (%)	
Poultry manure	70
Ground cassava	30
Molasses	2
Chemical composition	
Dry matter (%)	59.52
Crude protein (%, DM)	12.05
Crude ash (%, DM)	21.81
Ether extract (%, DM)	2.79
Crude fiber (%, DM)	25.13

DM= Dry matter

Pelleting process. The pellet processing was begun by mixing the fermentation result with binder agents, as presented in Table 2. Each treatment was in 3 replications with a total of 1500 g of each. The ingredients mixture were inserted into pelletizer and the pellet results would be dried by using oven for 3 d at 55 ºC.

Laboratory analysis. The analysis of chemical composition of fermented poultry manure pellets (FPMP) was based on the Association of Official Agricultural Chemists (2005), including the determination of dry matter (DM) (method number 934.01; AOAC, 2005), crude ash (CA) (method number 942.05; AOAC, 2005), crude protein (CP) (method number 984.13; AOAC, 2005), ether extract (EE) (method number 920.39; AOAC 2005), and crude fiber (CF) (method 978.10; AOAC 2005). While the gross energy

Table 2. Formulation of fermented poultry manure pellets in different binder agents (%)

Ingredients	Treatments[1]		
	T1	T2	T3
Fermented poultry manure	90	90	90
Tapioca flour	10	0	0
Wheat flour	0	10	0
Cassava flour	0	0	10
Total	100	100	100

[1]T1= the use of tapioca flour as a binder; T2= the use of wheat flour as a binder; T3= the use of cassava flour as a binder.

method was conducted based on Stypinski *et al*. (2023) by using Parr Instrument 6400 adiabatic oxygen bomb calorimeter.

The physical characteristics were assessed based on a survey involving a total of 20 respondents, utilizing the method outlined by Albert *et al*. (2012). Pellet measurements were analyzed using a ruler to measure both the diameter and length of the pellet samples. The density test, stacking density test, and stuck compaction density test were conducted following the procedure outlined by Khalil (1999). The Pellet Durability Index (PDI) was determined using the method described by Ismi *et al*. (2017). The Modulus of Uniformity (MU) and Modulus of Fineness (MF) tests were performed according to the procedure outlined by Syarief and Halid (1933). Additionally, the feed buoyancy and water durability test were conducted based on the procedure outlined by Saade *et al*. (2010).

Statistical analysis. The data on chemical compositions were analyzed descriptively based on standard error, while data on physical quality were analyzed using the Statistical Product and Service Solutions (SPSS) program with one-way ANOVA. If a significant difference was detected, the analysis was continued with a Tuket test procedure. The physical characteristics of the FPMP were described using a descriptive method.

RESULTS AND DISCUSSION

Chemical Compositions

The findings revealed that regardless of the binder used, the material inside the pellets remained similar (Table 3). This indicates that the choice of binder didn't really alter the DM, CA, EE, CF and gross energy of the pellets. Based on standard error, chemical compositions of pellets were not affected by binder in the numerical results, except CP content. According to Imaningsih (2012), tapioca flour has 86.2% of DM and wheat flour has 88.0% of DM, while according to Lolit (2014) the DM amount of cassava flour is approximately 87.0%. The same characteristic of the binders also influenced the similarity of CA content in each treatment numerically. Wijana *et al*. (2009) stated that CA in tapioca flour reach at 99.1% - 99.4% and CA in cassava flour reach at 99.2%. Imaningsih (2012) added that CA in wheat flour is 99.2%. Numerically, the CP amount in the T2 treatment is slightly higher compared to the other treatments, influenced by the CP content of each binder ingredient. According to Imanningsih (2012), the CP content in wheat flour is 10.3%, while according to Susilawati *et al*. (2012), cassava flour has 3.3% CP, and tapioca flour has 1.8%. The EE and CF contents also presented no significant difference in each treatment numerically. Notably, Imaninngsih (2012) highlighted that the EE content in tapioca flour is approximately 1%, while in wheat flour, it stands at approximately 1.6%. Furthermore, Prasetyo *et al*. (2019) reported the range of EE content in cassava flour, varies from 0.35% to 1.01%. Their study also revealed that the CF content in cassava flour ranged between 2.93% and 3.91%. Hidayat *et al*. (2019) found the CF content in wheat flour to be 2.1%. In addition, Herawati and Mega (2020) asserted that tapioca flour boasts a robust 2% crude fiber content. The similar EE and CF content in each ingredient leads to a lack of significant differences.

The differences in binder types did not indicate any significant difference in the gross energy value of the pellets numerically. Susilawati *et al*. (2012) stated that the energy content of tapioca flour was 3720 kcal/kg, while cassava flour was 3320 kcal/kg. According to the Food Composition List (2012), the energy content of wheat flour is 3650 kcal/kg. In general, the gross energy is one of considered requirement of nutrient for cat fish. Lovell (1989) mentioned that the energy requirement for catfish during the growth phase is at least 3000 kcal/kg. The average GE value for all three treatments in this study was 3242.65 kcal/kg, which was sufficient to meet the energy needs of catfish and could be used as a supportive compound feed for energy in catfish farming.

Physical Characteristics

Based on the results of the physical appearance characteristics color assessment, the color of the pellets in

Table 3. Chemical composition of fermented poultry manure pellets in different binder agents

Items	Treatments[1]		
	T1	T2	T3
Dry matter	79.4±0.39	79.2±0.28	78.7±0.47
Crude ash	20.0±2.82	18.2±0.30	19.3±1.26
Crude protein	11.8±0.42	14.1±0.21	12.1±0.03
Ether extract	2.24±0.32	2.28±0.28	2.35±0.67
Crude fiber	21.9±0.47	22.7±0.57	23.5±0.48
Gross energy	3248.02±41.41	3273.15±3.78	3206.78±29.74

[1]T1= the use of tapioca flour as a binder; T2= the use of wheat flour as a binder; T3= the use of cassava flour as a binder.

each treatment was dominantly light brown. In treatments with wheat flour and cassava flour binders, the resulting color became darker compared to the treatment with tapioca flour binder. This can be seen from Figure 1, where in treatment T1, the percentage of light brown color was 99%, in treatment T2 it decreased to 96%, and in treatment T3 it became 94%. The color characteristics in T1 appeared to be brighter than in other treatments, which is related with the findings of Hartanti *et al*. (2017) that tapioca flour has white intensity ranging from 90.3% – 92.7%. This intensity is higher than cassava flour, which only reaches 81.5% – 82.3%.

The aroma of FPMP was dominated by a slightly acidic aroma approaching neutral. This can be seen from Figure 1, which shows that in treatment T1, the percentage of slightly acidic aroma was 40% and neutral aroma was 26%. In treatment T2, the percentage of slightly acidic aroma increased to 49% while the neutral aroma remained at 26%. In treatment T3, the percentage of slightly acidic aroma decreased to 29% while the neutral aroma increased to 51%. Cassava flour possesses a strong aromatic cassava characteristic. Therefore, it has the potential to influence the aroma of FPMP. As a result, the T3 treatment tended to have a neutral aroma, while the other treatments tended to have an acidic aroma.

The texture of FPMP in each treatment was dominated by fine-textured pellets. Pellets with tapioca flour binder had the finest texture, while pellets with cassava flour binder had the coarsest texture compared to the other two treatments. This could be seen from Figure 1, which showed that in treatment T1, the percentage of fine-textured pellets was 74% and coarse-textured pellets was 20%. In treatment T2, the percentage of fine-textured pellets decreased to 59% while coarse-textured pellets increase to 38%. In treatment T3, the percentage of fine-textured pellets further decreased to 41% while coarse-textured pellets increased to 59%. The T1 and T2 treatments tended a fine texture, while T3 tended to be coarse. This is related to the percentage of CF in the T3 treatment (Table 3), where the numerical amount of CF was higher compared to the other treatments. The amount of CF in feed can influence the quality of pellet texture that feeds with high CF amount tend to result in a coarse texture.

The density of FPMP was dominantly compact. Pellets with tapioca flour binder had the most compact density compared to pellets with wheat flour and cassava flour binders. This could be seen from Figure 4, which showed that in treatment T1, the percentage of compact density was 67%. In treatment T2, the percentage of compact density decreased to 57%. In treatment T3, the percentage of compact density further decreased to 54%. The density has a positif relation with the texture, which is affected by the content of CF. As stated by Imiawan *et al*. (2015), an increased amount of CF in the feed will weaken particle bonds, leading to fragmentation and resulting in reducing the hardness of the pellets. That is related to the density of T2 and T3, which tended to have a lower compactness percentage compared to T1. Pellets with cassava flour binders had a smaller density, possibly because cassava flour particles are larger than tapioca flour and wheat flour particles. According to Mudjiman (2004), the particle binding influenced by the compression process during production, resulting in pellets with high hardness.

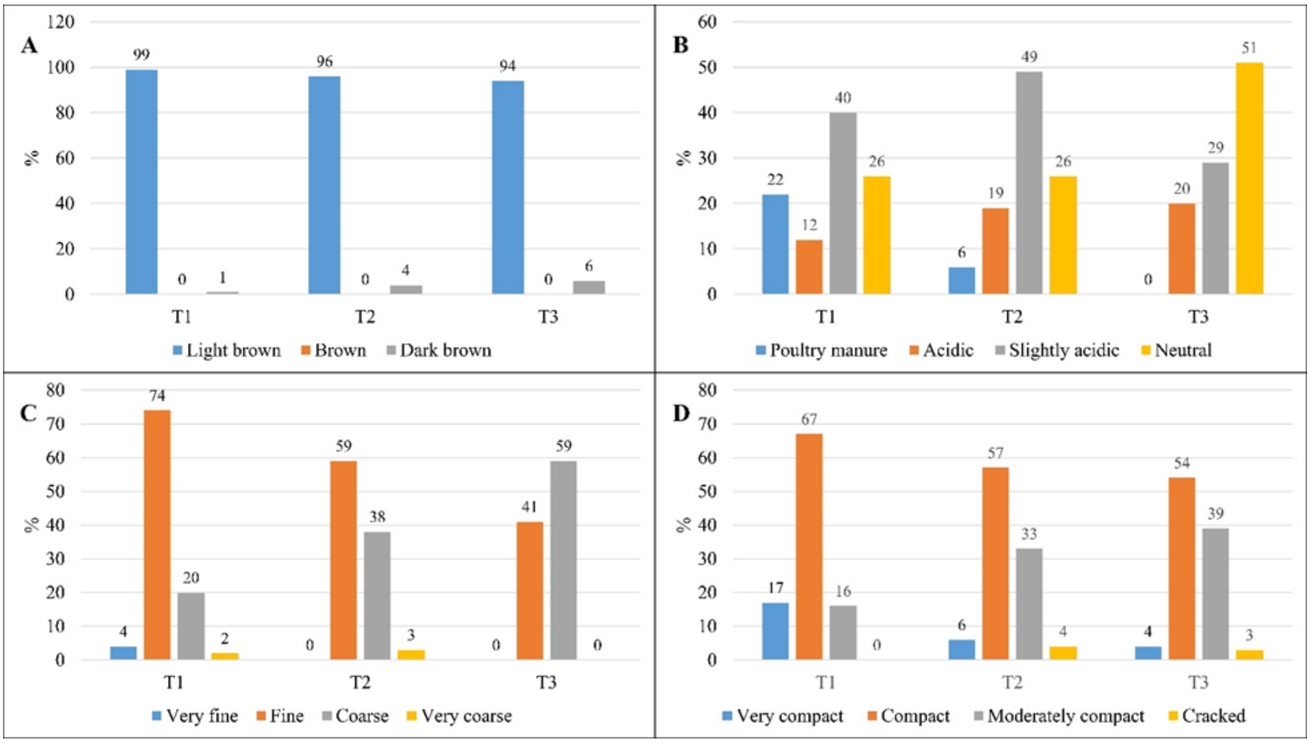

Figure 1. Color (A), aroma (B), texture (C), density (D) of fermented poultry manure with different binder. T1= the use of tapioca flour as a binder; T2= the use of wheat flour as a binder; T3= the use of cassava flour as a binder.

Physical Qualities

The physical quality of the FPMP, including measurements, density, stacking density, stacking compaction density, PDI, MU, MF, and water resistance, remained largely consistent across different treatments, showing no significant differences (Table 4). However, buoyancy time was an exception. Notably, buoyancy time varied among treatments (P<0.05), with the T2 treatment showing the longest buoyancy time. Subsequently, the T3 treatment followed by the T1 treatment showed progressively shorter buoyancy times.

Measurement. The length of the pellets produced aligns with Mudjiman's statement (2004) that fish pellets are generally sized at 1 – 2 cm. Supriadi *et al*. (2020) added that the addition of binder will effectively bind pellet ingredients, ensuring a more compact structure and contributing to the uniformity of pellet length. The Insignificant difference of measurement in FPMP also represented that there was no shrinkage or increase in pellet size during the making process.

Density. The density results of all treatments were relevant with Harahap *et al*. (2020) statement that pellet density generally ranges from 0.95 g/cm³ to 1.33 g/cm³. The uniformity of density might be caused by the similarity of the binder characteristics, thus resulting in a similar amount of density.

Stacking density. According to Rahmana *et al*. (2020), the similarity in pellet stacking density is expected due to the equal amount of starch in each ingredient, which possesses the ability to act as a binding property. This indicates that the uniformity in stacking density is maintained despite differences in binder ingredient.

Stack compaction density. Stack compaction density and stacking density have a positive correlation, the higher the value of staking density results the higher value of stack compaction density, so is the opposite. Azzahra *et al*. (2022) stated that stack compaction density is influenced by the intensity, stacking procedure, particle size, density, and stacking density value.

Pellet durability index. The high starch content in each binder that increase the gelatinisation percentage resulting in high pellet durability resulting in insignificant difference across each treatment. Overall, the PDI of the three treatments was in accordance with the statement of Dozier (2001) which the minimum index is 80%.

Modulus of uniformity and modulus of fineness. According to Jaelani *et al*. (2016), the modulus of fineness in pellets is categorized by the size of the particle such as coarse (4.1 – 7.0), medium (2.9 – 4.1), and fine (0 – 2.9). According to the statement, all the treatments tended to be categorized as coarse.

Feed buoyancy and water durability. A significant difference was observed in the buoyancy (P < 0.05) was related to the density of T2 since it had the lowest density among all treatments. Hutangalung *et al*. (2021) stated that the greater the density of feed compared to that of water (water's density =1), the faster the feed will sink. When the feed has a density close to 1, it will float. However, if the feed's density is less than 1, it will float on the water's surface. Based on Romadhon *et al*. (2013), average buoyancy time in commercial fish pellet is approximately 1 hour 48 minutes. The average time of buoyancy in three treatments was below the average time in the accordance of Romadhon *et al*. (2013) statement. According to Hutagalung *et al*. (2021), in catfish farming, the resistance of pellets is more crucial than their buoyancy. This is because the water conditions for catfish involve turbulent water surfaces due to the vigorous movements of the rather aggressive catfish. Therefore, when fish pellets are scattered on the water, they typically sink and stay underwater due to the turbulent water conditions. The submersion of pellets necessitates strong durability to maintain their shape and feeding efficiency, preventing them from dissolving or being wasted. The similarity in water durability in pellets might be caused by the fact that the three binders used in each treatment have starch content, which can enhance the hardness of the feed and, consequently, influence the durability of the pellets in water. Krisnan and Ginting (2009) stated that the content

Table. 4. Physical quality of fermented poultry manure pellets in different binder agents

Item	[1]Treatments			P-value
	T1	T2	T3	
Measurement				
Length (cm)	1.68±0.08	1.84±0.16	1.66±0.05	0.177
Diameter (mm)	5.00±0.00	5.00±0.00	5.00±0.00	1.000
Density (g/mL)	0.99±0.05	0.95±0.05	1.05±0.01	0.104
Stacking density (g/mL)	0.30±0.00	0.30±0.00	0.29±0.00	0.178
Stacking compaction density (g/mL)	0.33±0.00	0.33±0.00	0.32±0.00	0.125
Pellet Durability Index	93.6±1.65	96.7±0.05	95.1±1.30	0.051
Modulus of Uniformity	65.6±0.92	66.8±0.60	66.8±0.49	0.145
Modulus of Fineness	6.56±0.09	6.68±0.06	6.68± 0.04	0.145
Buoyancy (minute)	11.33±11.67b	65.00±7.81a	43.66±29.16ab	0.034
Water resistance (minute)	93.33±7.63	89.00±92.67	92.66±8.39	0.836

[1]T1= the use of tapioca flour as a binder; T2= the use of wheat flour as a binder; T3= the use of cassava flour as a binder.

a,b,c Different superscripts in the same column showed a significant difference (P < 0.05).

of binders, such as starch can affect the quality of the feed. Utomo (2015) mentioned that good catfish feed can endure for more than 15 minutes in water. The average water durability across the three treatments was 91.6 minutes, which was considered good for catfish feed.

CONCLUSION

The use of wheat flour as a binder in FPMP resulted in better buoyancy compared to tapioca flour and cassava flour. In general, the use of various binders did not affect the chemical composition and physical quality, including measurements, density, stacking density, stack compaction density, PDI, MU and MF, and water durability. The study recommended the use of wheat flour as a binder in pellets based on FPMP.

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