Research Article

The Effect of Natural Pellet Binders and Dosage to Produce Pellet made of Miana Plant (*Plectranthus scutellarioides*, (L.) R. Br.) as Poultry Feedstuffs

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Abstract | An experiment was conducted to determine the interaction between natural pellet binders and dosage in producing pellet made of Miana plant as poultry feedstuffs. This experiment was administered in a completely randomized design with two factors. The first factor was natural pellet binders composed of brown seaweed *Sargassum binderi*, taro tubers (*Colocasia esculenta* (L.) Schott), and tapioca flour (*Manihot utilissima*), and the second factor was dosage (1.5; 3; and 4.5%) of natural pellet binders. Each treatment was repeated three times. The measurements were moisture content, stack density, stack compaction density, stack angle, and pellet durability. The results showed no interaction (P>0.05) between the natural pellet binders and dosage on moisture content, stack density, stack compaction density, stack angle, and pellet durability of the Miana plant. Both the first factor (natural pellet binders) and the second factor (dosage) affected moisture content, stack density, stack compaction density, stack angle, and pellet durability highly significantly (P<0.01). In conclusion, the best natural pellet binder to produce pellet made of Miana plant as poultry feedstuffs was tapioca flour with a dosage of 4.5%.

Keywords | Poultry, Miana plant, Natural pellet binder, Physical quality, Pellet

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INTRODUCTION

The quality and the form of feed greatly affect the productivity of poultry. Pellet diets were reported positively affect growth performance, feed intake, and feed conversion of broiler (Abdollahi et al., 2013; Abdollahi et al., 2018) and improve the performance and albumen quality of laying hens (Wan et al., 2021). On the other hand, making pelleted feed also has detrimental effects on production through chemical and physical changes that occur during the pelleting (Svihus, 2011; Shivus and Zimonja, 2011). The physical form of the pellet is strongly influenced by the type of diet material used, the size of the pellet, the amount of water, pressure, and pellet binder material to produce a pellet with a strong, compact, and sturdy structure so that the pellets are not easily broken (Rahmana et al., 2016). Miana plant is an ornamental plant widely spread in Indonesia. This plant contains some phytochemicals substance like alkaloids, flavonoids, saponins, tannins, and anthocyanin (Auliawan and Cahyono, 2014; Puspita et al., 2018), which are very beneficial for health and improve the performance of poultry. Beside that Miana plants contain water 84.5%, dry matter 15.5%, crude protein 14.96%, crude fiber 21.09%, crude fat 10.18%, ash 13.6%, metabolic energy 1,357.39 kcal/kg, and 206.40 ppm anthocyanins

(Mahata et al., 2021). This plant is known by local names in Indonesia, such as Miana, Jawer Kotok, and Iler. Salim and Munadi. (2017) stated Miana plant is included in 66 biopharmaceutical plant commodities according to the Decree of the Indonesian Minister of Agriculture, Number 511/Kpts/PD.310/9/2006. Previous research reported that Miana plant flour in broiler diets could be used as much as 12.5% in the diet without affecting broiler performance (Mahata et al., 2021). Based on our previous experience in a feeding trial of Miana plant flour in broiler diet, diet out from the feeder so that the phytochemicals substances contained in Miana flour in the diet were not consumed and utilized optimally by broilers. Therefore, the feeding of the Miana plant for the broiler should be modified into pellet form as an effort to the phytochemical substances from the Miana plant can be consumed optimally by the broiler.

To produce feed in pellet form requires a pellet binder to combine the feedstuff to form a pellet. The pellet binder commonly used by animal feed factories is synthetic binder such as bentonite lignosulphonate (Retnani et al., 2010). Furthermore, Carboxyl Methyl Cellulose (CMC) is expensive, increasing production costs and pellet prices. For this reason, it is necessary to look for alternative binders that are inexpensive, have a high binder, are easy to obtain, non-toxic, and do not interfere with the nutritional content of the diet.

Brown seaweed *Sargassum binderi* is a type of seaweed that is widely distributed in almost all Indonesian waters. Brown seaweed can be used as a pellet binder because it contains an alginate compound of as much as 40.51%, and it has properties as a gelling, stabilizer, emulsifier, suspending agent, and binder (Kadi, 2005; Tayag et al., 2010). The use of brown seaweed as a pellet binder for fish feed can be used up to 3.7% with pellet diet quality equivalent to commercial pellet diets (factory pellet diet) (Sutrisno, 2016). The other report showed that the range of brown seaweeds as pellet binder was 5-10% (Wulansari et al., 2016). Taro tubers contain relatively high starch, as much as 75.19%, with amylose of 7.51% and amylopectin of 67.68%, so it has the potential as a binder in making pellets (Kaushal et al., 2011). The taro tuber could be used as pellet binder as much as 2-8% (Sandro et al., 2020). Tapioca is a starch derived from the extraction of cassava tubers. Hartanti et al. (2017) reported that Tapioca flour contains 89.11% starch. This flour has a high viscosity and fast gelatinization time compared to the rice flour and wheat flour (Imanningsih, 2012), so it can be used as a binder for producing diets in pellet form. The use of 4% tapioca flour as a feed pellet binder for the broiler diet was reported to have an excellent physical property (Syamsu, 2007).

The type and dosage of pellet binder will affect the moisture content, stack density, stack compaction density, stack angle, and pellet durability due to the starch content of each different binder type. The information about the type and dosage of pellet binder is also needed to produce pelleted diets that have good physical quality for packing, transporting, and storing feed. Based on the variation of pellet binders dosage in previous research, we decided to use the dosage of pellet binder in this experiment were 1.5%, 3%, and 4.5%.

So far, rarely a report of Miana plant in the form of pellets as broiler feedstuff, and it is also unknown what type of pellet binders and the proper dosage to produce this feedstuff in the form of pellets that can meet the quality standards of pellet. Therefore, research was conducted to determine the type and dosage of the pellet binders for the Miana plant in pellet form and their quality as broiler feedstuff.

MATERIALS AND METHODS

Research material

The raw materials used in this research were Miana plant flour and pellet binders. The materials of pellet binders used in this experiment were brown seaweed, taro tubers, and tapioca flour.

The Miana plant flour sample preparation

The Miana plant flour was prepared by chopping the Miana leaves into a size of 2-3 cm. Then, the sliced leaves were dried in the sun for 3-5 days, and were milled by a Hummer mill HMR-50 grinder machine.

Pellet binder preparation

The pellet binders used in this experiment were brown seaweed flour, taro tuber flour, and tapioca flour. The brown seaweed *Sargassum binderi* flour was first cleaned from the sea salt by soaking in water flow for 15 hours. Secondly, the brown seaweed was dried and ground into flour. The taro tubers (*Colocasia esculenta* (L.) Schott) were peeled, cleaned with water, and cut into small pieces. Then the sliced tubers were dried in the sun and ground into flour with moisture content of 14%. Furthermore, tapioca (*Manihot utilissima*) flour was purchased from local minimarkets.

Each type of pellet binder was weighed with dosage according to the treatment (1.5, 3, and 4.5%) of 500 g of Miana plant flour as pellet diets, namely 7.5, 15, and 22.5 g. Furthermore, each type of pellet binder was mixed with 500 ml water and heated at 100°C while stirring until it formed a gel and allowed to stand until the temperature reached 70°C. Furthermore, each type of pellet binder formed a gel is mixed with 500 g of Miana plant flour until well mixed. Then the pellet manufacturing process is carried out.

Pellet preparation from Miana plant flour

Miana plant flour mixed with each type of pellet binder was printed using a Thcheng PZ30 brand pellet machine. The pellet eyes used were 0.5 cm with a diameter and length of 1 cm. The resulting pellets were dried in the sun for 3 hours and continued in the oven at 60°C for 24 hours. Then the resulting pellet will be tested for physical quality.

The measurements

Water content: The moisture content of the pellets was measured using an oven at 105°C for 6-8 hours (AOAC, 1999).

Stack density: The stack density can be calculated by weighing the measuring cup by normalizing the scales first. The measuring cup on top of the scales was added slowly by the bulk method using white paper up to a measuring limit of 250 ml, and the result was the weight of the material (Jaelani et al., 2016). The stack density was expressed in g/ml and was calculated by the formula:

$$\text{The stack density} = \frac{\text{Material weight (g)}}{\text{The volume of space occupied (ml)}}$$

Stack compaction density: The measurement of the compaction density of the pellet stack could be calculated in the same way as the determination of the stack density, but the volume of the material was read after the compaction process was carried out by shaking the measuring cup until the volume did not change anymore (Jaelani et al., 2016). Compaction was carried out in no more than 10 minutes. The formula that calculates the stack compaction density is:

$$\text{The stack compaction density} = \frac{\text{Material weight (g)}}{\text{The volume of material after compaction (ml)}}$$

Stack angle: The measure of the pellet stack angle by dropping 0.5 kg of the sample onto a flat plane through a plastic funnel. The height of the stack of material must be below the funnel. The sample was poured slowly and as close as possible to the wall of the plastic funnel to avoid clogging the feed at the end of the plastic funnel and reduce the weight of the feed. Diameter measurements were made on the same side for all observations using a ruler. Height measurements were carried out on the feed height from the flat to the top in all observations using a ruler (Khalil, 1999b). The formula that calculates the stack angle is:

$$\tan \alpha = \frac{t}{0.5\ d} = \frac{2t}{d}$$

Description: α= The angle of the stack of feed ingredients is expressed in degrees (°) ; d = stack diameter; and t = Tall

Pellet durability: Pellet durability to impact was measured by dropping the pellet from a height of 2 meters on a 2 mm thick iron plate. The pellets were dropped simultaneously by measuring the weight of the pellets first, then filtering with a vibrator ball mill german using the sieve analysis and weighing (Balagopalan et al., 1988). The formula that calculates the pellet durability is:

$$\text{The pellet durability}(\%) = \frac{\text{Whole pellet weight after dropping}}{\text{Initial pellet weight}} \text{x}100\%$$

Statistical analysis

All data were analyzed by analysis of variance (ANOVA), differences among treatments would be further analyzed using an analysis of Duncan's multiple range test (Steel and Torrie, 1991).

RESULTS AND DISCUSSION

The highest water content found in the pellet binder brown seaweed was 11.87%, while the water content in the pellet binders made from taro tuber and tapioca was lower than the pellet brown seaweed (10.7% and 9.06%, respectively). The starch content in each of the different binders affects the water content of the Miana plant in pellet form. In this experiment, each type of pellet binders (brown seaweed, taro tubers, and tapioca flour) was mixed with hot water at 70 °C before being used. Mixing each pellet binders with hot water causes the granules in the binder starch to break, making it difficult for water to penetrate and causing the water content to be low. According to Retnani (2010), the volume of starch granules would increase due to heating and cause starch granules to expand, resulting in gelatinization. This experiment found the highest starch content in the tapioca binder was 89.11% (Hartanti et al., 2017), 75.19% in the taro tubers (Rahmawati et al., 2012), and 56.80% in the brown seaweed (Diharmi et al., 2011). The amylopectin content in the taro tuber and tapioca binders did not differ much, i.e., 67.65% and 72.61%, respectively. Therefore, the taro tuber and tapioca binders had a lower water content effect than did the brown seaweed binders. The high water content in brown seaweed pellet binder was caused by low amylopectin of 50.52%, and brown seaweed had hydrocolloid properties, which absorbed water easily. According to Herawati (2018), hydrocolloids have the characteristics of absorbing water easily. The hydrocolloid properties found in the brown seaweed were caused by the presence of alginate. Furthermore, Dewi (2018) reported that brown seaweed *Sargassum binderi* contains 20.89% alginate.

Table 1: The average moisture content of Miana plant pellet

Variables	Pellet binders type	Pellet binder dosage (%)			Mean
		B1	B2	B3	
Moisture content (%)	A1	12.94	11.40	11.26	11.87[a]
	A2	10.84	9.93	9.33	10.04[b]
	A3	10.49	9.57	8.61	9.56[b]
	Mean	11.42[a]	10.30[b]	9.74[b]	10.49

A1 = Pellet binder of brown seaweed *Sargassum binderi*; A2 = Pellet binder of taro tuber (*Colocasia esculenta* (L.) Schott); and A3 = Pellet binder of tapioca flour (*Manihot utilissima*). Pellet binder dosage (B1 = 1.5%; B2 = 3%; and B3 = 4.5%).
Different lowercase superscripts in columns and rows showed a highly significant effect ($P < 0.01$).

Table 2: The average stack density of Miana plant pellet

Variables	Pellet binders type	Pellet binder dosage (%)			Mean
		B1	B2	B3	
Stack density (kg/m^3)	A1	413.95	444.85	464.05	440.95[a]
	A2	431.37	455.43	473.41	453.40[b]
	A3	433.11	464.47	485.15	460.91[c]
	Mean	426.14[a]	454.92[b]	474.20[c]	451.75

A1 = Pellet binder of brown seaweed *Sargassum binderi*; A2 = Pellet binder of taro tuber (*Colocasia esculenta* (L.) Schott); and A3 = Pellet binder of tapioca flour (*Manihot utilissima*). Pellet binder dosage (B1 = 1.5%; B2 = 3%; and B3 = 4.5%).
Different lowercase superscripts in columns and rows showed a highly significant effect ($P < 0.01$).

Table 3: The average stack compaction density of Miana plant pellet

Variables	Pellet binders type	Pellet binder dosage (%)			Mean
		B1	B2	B3	
Stack compaction density (kg/m^3)	A1	446.19	484.32	513.03	481.85[a]
	A2	481.39	514.58	547.34	514.44[b]
	A3	510.64	546.50	583.41	546.85[c]
	Mean	479.41[a]	515.13[b]	548.59[c]	514.38

A1 = Pellet binder of brown seaweed *Sargassum binderi*; A2 = Pellet binder of taro tuber (*Colocasia esculenta* (L.) Schott); and A3 = Pellet binder of tapioca flour (*Manihot utilissima*). Pellet binder dosage (B1 = 1.5%; B2 = 3%; and B3 = 4.5%).
Different lowercase superscripts in columns and rows showed a highly significant effect ($P < 0.01$).

Table 4: The average stack angle of Miana plant pellet

Variables	Pellet binders type	Pellet binder dosage (%)			Mean
		B1	B2	B3	
Stack angle (^{0})	A1	46.45	45.42	44.14	45.33[a]
	A2	45.60	44.35	41.63	43.86[b]
	A3	44.42	42.10	40.42	42.31[c]
	Mean	45.49[a]	43.95[b]	42.06[c]	43.84

A1 = Pellet binder of brown seaweed *Sargassum binderi*; A2 = Pellet binder of taro tuber (*Colocasia esculenta* (L.) Schott); and A3 = Pellet binder of tapioca flour (*Manihot utilissima*). Pellet binder dosage (B1 = 1.5%; B2 = 3%; and B3 = 4.5%).
Different lowercase superscripts in columns and rows showed a highly significant effect ($P < 0.01$).

Table 5: The average pellet durability of Miana plant pellet

Variables	Pellet binders type	Pellet binder dosage (%)			Mean
		B1	B2	B3	
Pellet durability (%)	A1	92.77	93.94	94.77	94.82[a]
	A2	95.47	96.40	97.28	96.39[b]

A3	97.75	98.55	99.29	98.53^{c}
Mean	95.33^{a}	96.30^{b}	97.11^{c}	96.25

A1 = Pellet binder of brown seaweed *Sargassum binderi*; A2 = Pellet binder of taro tuber (*Colocasia esculenta* (L.) Schott); and A3 = Pellet binder of tapioca flour (*Manihot utilissima*). Pellet binder dosage (B1 = 1.5%; B2 = 3%; and B3 = 4.5%).
Different lowercase superscripts in columns and rows showed a highly significant effect (P < 0.01).

The lower dosage of each pellet binder in this experiment reduced the water content in the Miana plant pellet (Table 1). This is due to the lower starch content in the binder, thus creating more pellet cavities. These cavities become a way for water to enter the pellets, which causes the pellet water content to increase. Besides that, the pellet binder's composition strengthens the intermolecular bonds, thereby reducing porosity, and more pores will provide more space for water to enter (Jahiding et al., 2014). Furthermore, Sadee (2009) argues that a higher pellet binder dosage increases the physical quality of pellets.

The tapioca pellet binder in this experiment affected the highest stack density at 460.91 kg/m3, while the taro tuber and brown seaweed pellet binders were lower at 453.40 kg/m^3 and 440.95 kg/m3, respectively (Table 2). High stack density is associated with high starch content, causing starch granules to fill unfilled pores, and when compacted, the stack density value was also high. According to Supriadi et al. (2020), starch content causes a gelatinization process, which binds each feed component so that the volume of pellets produced gets smaller, and the volume of space occupied gets bigger. This experiment found that the increasing pellet binders dosage caused more production of starch and low water content, so the value of the stacking density was higher. According to Sholihah (2011), the stack density value was influenced by water content, so the higher moisture content of pellets reduces the value of stack density, the high water content causes the material to expand. Therefore, the volume of space was required significantly.

The highest stack compaction density was found in the tapioca pellet binder, while the taro tuber and brown seaweed pellet binders were lower (Table 3). The high stack compaction density in tapioca pellet binder was related to the stack density and starch content in tapioca, causing the pellets to become solid and compact, in addition to increasing the value of the stack compaction density. Stack density and stack compaction density of pellet show a positive correlation; the higher the stack density, the higher the stack compaction density, and vice versa (Luciana, 2012). Besides that, the pellet binder dosage affects the compaction density of the Miana plant pellet. The pellet binders in the dosage of 4.5% caused the high compaction density, compared to those in the dosages of 3% and 1.5%. The high pellet binder dosage produces more starch and causes low water content so that the value of the compaction density will be higher. Sholihah (2011) argues that the higher the moisture content, the lower the compaction density, and vice versa (Sholihah, 2011).

Table 4 showed the highest stack angle was found in the brown seaweed pellet binder, while it was lower in the taro tuber and tapioca pellet binders. The high stack angle in brown seaweed pellet binders was associated with the high moisture content and low stack density. According to Khalil (1999b), the size of the stack angle was strongly influenced by the water content, density, size, shape, particle characteristics, and specific gravity. Furthermore, the stack angle of the taro tuber pellet binder was higher than the tapioca pellet binder. It was caused by the high water content in the taro tuber pellet binder. Wigati (2009) stated the high water content increases the stack angle of the pellet. This experiment also found the decreasing pellet binders dosage increased the stack angle; this was due to the less starch produced by low pellet binder dosage. The low stack angle at a dosage of 4.5% was caused by the higher starch content. According to Khalil (1999b), a high binder dosage will produce high starch that reduces the number of the pellet cavities. Therefore, it flows easily, and the stack angle value is low. In this experiment, the highest starch content found in tapioca pellet binder at 89.11% (Hartanti et al., 2017). Furthermore, taro tubers contain 75.19% starch (Rahmawati et al., 2012), and brown seaweed contains 56.86% starch (Diharmi et al., 2011). Therefore, this experiment obtained the highest stack angle for the brown seaweed pellet binder was 45.33000^{0}, and the lowest one was 42.3100^{0}, found in the tapioca pellet binder. In addition, the moisture content affects the stack angle. In this experiment, the increased pellet binder dosage decreased the water content of the pellet, resulting in lower stack angle values. Moisture content also significantly affects the value of the stack angle (Khalil, 1999b).

Pellet durability is crucial, reflecting resistance to pellet damage during handling, transport, and storage. Furthermore, the pellet durability can be influenced by the materials' characteristics used as a pellet binder and temperature during the pellet-making process (Siyal et al., 2021). The highest pellet durability found in tapioca pellet binder was 98.53%, while it was lower in taro tuber and brown seaweed pellet binders (96.39% and 94.82%, respectively) (Table 5). The high pellet durability in tapioca pellet binder was related to the stack density and high starch content. According to Jaelani et al. (2016), pellet durability was related to the stack density level of the feed; the denser the feed stack, the smaller the cavity between the particles, so that the feed will have more pellet durability. The starch in pellet binders could be gelatinized to make the pellets compact and have pellet durability (Retnani et al., 2011). According to Usmiati (2018), tapioca flour contains high carbohydrates at 86.55%, and is suitable for pellet binders. Furthermore, Setiyatwan et al. (2008) stated the carbohydrates in feed function as binders strengthen the bonds of the particles that make up the feed. The pellet durability of the taro tuber pellet binder was higher than the brown seaweed pellet binder used for higher stack density and starch content. Pellet binder dosage affects pellet durability. The pellet binder dosage at 4.5% was the highest pellet durability (97.11%), while the pellet durability of pellet binder dosage at 3% and 1.5% was lower than 4.5%, i.e., 96.30% and 95.33%, respectively. The increase of pellet binder dosage decreased the water content of pellets because the increase of starch content as a binder strengthens the bond of the material particles. As a result, the pellets dropped from a height of 2 meters are less damaged. According to Retnani et al. (2010), the high moisture content in pellets decreased the pellet durability.

CONCLUSION

In conclusion, there is no interaction between the type and dosage of pellet binder, the best type of pellet binder in this experiment was tapioca flour, with the best dosage of 4.5%.

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CONFLICTS OF INTEREST

All authors declare that they have no conflicts of interest concerning the work presented in this manuscript.

AUTHORS' CONTRIBUTIONS

Maria Endo Mahata participated in all stages of the research, namely the research design, the conduct of the experiment, sample analysis, data analysis, writing, and editing of articles. Hamdan Sukri Lubis participated in conducting the investigation and was responsible for data analysis. Takayuki Ohnuma and Yose Rizal participated in the research and editing of the article. All authors participated in writing the article and checking the statistical analysis, and finally approved the last version of the article for publishing.

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