International Research Journal of Advanced Engineering and Science
ISSN (Online): 2455-9024

# The Effect of Corn Substitution with Palm Kernel Meal and Fermented Tapioca Waste (PKMFTW) on Density and Digestibility of Broilers Feed

Alfita Yan Kusuma[1], Osfar Sjofjan[2], Irfan H. Djunaidi[2]
[1]Master Student,Faculty of Animal Science, Brawijaya University, Malang, East Java, Indonesia -65145
[2]Lecturer, Faculty of Animal Science, Brawijaya University, Malang, East Java, Indonesia -65145
Veteran Street, Lowokwaru, Malang, East Java, Indonesia
* Correspondence Email: osfar @ ub.ac.id

***Abstract***— *Purpose from this research was to determine the best treatment of corn substitution with palm kernel meal dan fermented tapioca waste (PKMFTW) as broiler feed on the density, crude protein digestibility, apparent metabolizable energy (AME), and apparent metabolizable energy nitrogen corrected (AMEn). The materials of the research were unsexed broilers, corn, palm kernel meal and fermented tapioca waste (PKMFTW), rice bran, broiler concentrate, Aspergillus oryzae, Saccharomyces cerevisiae, and Cellulomonas sp. The method used in this study was a field experiment using a completely randomized design (CRD) using 7 treatments and 4 replications. The treatment were used T0: without substitution palm kernel meal and fermented tapioca waste (control feed), T1: substitution 10% palm kernel meal and fermented tapioca waste, T2: substitution 20% palm kernel meal and fermented tapioca waste, T3: substitution 30% palm kernel meal and fermented tapioca waste, T4: substitution 40% palm kernel meal and fermented tapioca waste, T5: substitution 50% palm kernel meal and fermented tapioca waste, T6: substitution 60% palm kernel meal and fermented tapioca waste. Data were analyzed using analysis of variance (ANOVA) and continued using Duncan's Multiple Range Test (DMRT). The result of this study shows that palm kernel meal dan fermented tapioca waste as corn substitution caused lowering the value of feed density, crude protein digestibility, apparent metabolizable energy (AME), and apparent metabolizable energy nitrogen corrected (AMEn). Palm kernel meal dan fermented tapioca waste as much as 20% is the best corn substitution for broiler feed.*

***Keywords***— *Broilers, density, digestibility, palm kernel meal (PKM), tapioca waste.*

## I. INTRODUCTION

Feed is one of the most influential factors on successful of livestock business. Good quality feed is needed to support optimal growth and development of livestock. The poultry feed ingredients are compete with food, for example is corn. Corn is the main source of energy in the poultry feed manufacture because its have high energy content and complete nutrients. The nutritional content of corn in the form of energy reaches ±3,350 Kcal/kg, crude protein 9.5%, crude fat 3.7%, crude fiber 0.6%, carotenoid compounds 6.4-11.3 μg/g (22% carotene and 51% xanthophyll), methionine, lysine, and tryptophan. Corns are widely used as food and bioenergy (fuel), so its causes limited availability and expensive. This incident has led to finding other feed ingredients alternatives that have high nutritional content, cheaper, easy to obtain, abundant availability, and do not compete with foodstuffs, that is waste. The waste that can be used as corn substitution is palm kernel meal (PKM) and tapioca waste.

Palm kernel meal (PKM) is waste from the processing of palm kernel oil (PKO). The nutritional content of PKM consists of gross energy ±4,758 Kcal/kg, crude protein 13.98%, crude fat 8.61%, crude fiber 17.63%, methionine, lysisn [18;24]. Tapioca waste is waste from the processing of cassava into tapioca flour, which is dry and hard. The nutritional content of tapioca waste is gross energy ±2,700-3,500 Kcal/kg, crude protein 2.2%, crude fat 2.40%, crude fiber 12.45%, carbohydrates 51.8%, BETN 62.10% [14;27]. The production of these wastes in Indonesia is overflow and the nutritional content are high, so its potential to be used as alternative ingredients for poultry feed. It is feared that the direct use of waste for poultry feed will reduce feed digestibility and performance due to very high crude fiber content of feed and high fat content in PKM. This obstacle must be overcome by fermentation so it can decrease crude fiber, increase feed digestibility, and does not cause problems when it is used for large amounts of poultry feed.

Fermentation of palm kernel meal and tapioca waste were used 3 types of microbes namely *Aspergillus oryzae*, *Saccharomyces cerevisiae*, and *Cellulomonas sp*. [28;31] explained that *Aspergillus oryzae* and *Saccharomyces cerevisiae* are able to work synergistically, because *Saccharomyces cerevisiae* is a growth factor for cellulolytic bacteria (*Aspergillus oryzae* and *Cellulomonas sp.*) by providing nutrients in the form of vitamins, minerals and amino acids. The increasing population of cellulolytic microbes has an effect on the increasing cellulolytic activity to digest crude fiber. According to [28] *Saccharomyces cerevisiae* produce amylase enzyme which is useful for starch digesting in tapioca waste. *Aspergillus oryzae* produces cellulase and hemicellulase enzymes that can stimulate cellulolytic bacteria growth to digest crude fiber. According to [32] fermentation using *Cellumonas sp.* causes break down the fibers contained in the material so the bonds become more tenuous. Bond in the fibers that has been loosened results in a simpler protein bonding so the protein content of the material also increases and improves digestibility.

Based on that statement, it is necessary to do further research on the effect of the utilization of industrial waste in the form of palm kernel meal and tapioca waste by fermentation using 3 types of microbes, *Aspergillus oryzae*, *Saccharomyces cerevisiae*, and *Cellulomonas sp*. as alternative corn substitution on the density and digestibility of broiler feed.

## II. MATERIALS AND METHODS

### A. Materials

The materials used in this research were unsexed 35 days broilers, there are 28 chickens. The feed were used is self mixed complete feed consist of yellow corn, broiler commercial concentrate, rice bran, palm kernel meal and fermented tapioca waste (PKMFTW). The microbes were used *Aspergillus oryzae* (2,7x$10^8$ CFU/ml), *Saccharomyces cerevisiae* (3,21x$10^7$ CFU/ml), and *Cellulomonas sp* (1,86x$10^7$ CFU/ml). The nutritional content of feed ingredients that will be used in the preparation of broiler feed can be seen in table 1. The composition and content of the treatment feed ingredients for digestibility testing can be seen in table 2.

The equipment were used includes metabolic cage 20x35x35 cm equipped with feeding and drinking tools, provided with tray and plastic to accommodate the excreta, and lighting. Metabolic cages were used from the age of 35-41 days totaling 28 plots, each plot was filled 1 chicken.

TABLE 1. Nutrient content of feed ingredients

| Food Nutrient | Feed ingredients | | | |
|---|---|---|---|---|
| | Yellow corn * | PKMFTW * | Rice Bran * | Concentrate** |
| Metabolic Energy (Kcal/kg) | 3397.87 | 3057.32 | 2505.94 | 2300 |
| Crude Protein (%) | 9,56 | 8.57 | 8.77 | 41 |
| Crude Fat (%) | 3.27 | 11.41 | 8.86 | 5 |
| Crude Fiber (%) | 2.75 | 21.11 | 19.17 | 6 |
| Calcium (Ca,%) | 0.01 | 0.27 | 0.06 | 2.50 |
| Phospor (P,%) | 0.26 | 0.43 | 0.18 | 1.40 |

PKMFTW: Palm kernel meal and fermented tapioca waste
Source: * Proximate Test Results in the Laboratory of Animal Nutrition and Feed, Faculty of Animal Science, Brawijaya University
** Broiler commercial concentrate based on label produce by feed industry

TABLE 2. Composition and content of treated feed ingredients for digestibility testing

| Feed Materials | Treatment (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | T0 | T1 | T2 | T3 | T4 | T5 | T6 |
| Yellow corn | 60 | 50 | 40 | 30 | 20 | 10 | 0 |
| PKMFTW | 0 | 10 | 20 | 30 | 40 | 50 | 60 |
| Rice Bran | 10 | 10 | 10 | 10 | 10 | 10 | 10 |
| Broiler Concentrate | 30 | 30 | 30 | 30 | 30 | 30 | 30 |
| Metabolic Energy (Kcal/kg) | 3049.32 | 3015.26 | 2981.21 | 2947.15 | 2913.10 | 2879.04 | 2844.99 |
| Crude Protein (%) | 20.19 | 19.88 | 19.57 | 19.26 | 18.94 | 18.63 | 18.32 |
| Crude Fat (%) | 4.54 | 5.16 | 6.77 | 7.39 | 8.00 | 8.62 | 9.23 |
| Crude Fiber (%) | 5.37 | 7,20 | 9.04 | 10.88 | 12.71 | 14.55 | 16.38 |
| Calcium (Ca,%) | 0.76 | 0.79 | 0.81 | 0.84 | 0.87 | 0.89 | 0.92 |
| Phospor (P,%) | 0.52 | 0.55 | 0.58 | 0.61 | 0.64 | 0.67 | 0.70 |

* Calculation based; PKMFTW= Palm kernel meal and fermented tapioca waste

### B. Research Method

#### 1. Feeding digestibility

The research method was used field experiment using a completely randomized design (CRD) using 7 treatments and 4 replications. The treatments were used:

T0 : without substitution PKMFTW (control feed)
T1 : Corn substitution using 10% PKMFTW in feed
T2 : Corn substitution using 20% PKMFTW in feed
T3 : Corn substitution using 30% PKMFTW in feed
T4 : Corn substitution using 40% PKMFTW in feed
T5 : Corn substitution using 50% PKMFTW in feed
T6 : Corn substitution using 60% PKMFTW in feed

Feeding treatment in the form was mash using restricted feeding methods 140 grams/chicken/day. Feeding treatment starts from day old chick (DOC) until 41 days, so it does not require feed adaptation. The drinking treatment was used ad-libitum method. Chickens are placed in metabolic cages start from 35-41 days, 3 days for cage adaptation treatment and 3 days for excreta sample collection. The excreta is collected on trays that have been coated with plastic and sprayed every 6 hours using boric acid ($H_3BO_3$) and the ratio 1:10 which serves to fix nitrogen. Excreta were cleaned of feathers loss and feed residue before weighing it as wet weight. The excreta was sun dried for 3 days, then weighed as sun dry weight, oven at 60$^o$C for 24 hours, and weighed again to determine the oven dry weight. The dry excreta was grinded using grinder and tested following the test standards in the laboratory.

#### 2. Density

The feed ingredients in the form of palm kernel meal and fermented tapioca waste (PKMFTW), corn, broiler commercial concentrate, and rice bran are weighed according to the proportion/percentage of treatment, mixing the treatment using mixer until homogeneous and labeled according to the treatment. Weighed the empty measuring cup, the sample is put in the measuring cup. Weighed the measuring cup and sample to determine the density of broiler feed sample.

### C. Research Variable

#### 1. Feeding density

Feeding density testing was carried out by [20]:

$$\rho = \frac{(w2 - w1)}{Vp}$$

ρ = density (g/L)

$w_1$ = measuring cup weight (g)
$w_2$ = measuring cup + sample weight (g)
Vp = measuring cup volume (L)

*2. Feeding digestibility*

Feeding digestibility were measured using the total collection method. Feeding digestibility test consists of:

a. Crude protein digestibility was analyzed based on dry matter and crude protein from feeding samples and excreta [5].

$$\textit{Crude protein digestibility}\ (\%) = \frac{\text{protein consumption} - \text{protein excreta}}{\text{protein consumption}} \text{ x } 100\%$$

Note :
- Protein consumption = total feed consumption (% dry matter) x % crude protein of feed
- Protein excreta = total excreta (% dry matter) x % crude protein of excreta

b. Apparent metabolizable energy (AME) and apparent metabolizable energy nitrogen corrected (AMEn) was analyzed based on dry matter and metabolizable energy. Metabolic energy is obtained differences between gross energy content of feed and gross energy lost through excreta [11].

$$\text{AME (Kcal/kg)} = \frac{\text{feed gross energy} - \text{excreta gross energy}}{\text{feed consumption}}$$

$$\text{AMEn (Kcal/kg)} = \frac{\text{feed gross energy} - \text{excreta gross energy}}{\text{feed consumption}} - (8{,}73 \text{ x nitrogen retention})$$

Notes:
- Feed gross energy/consumption gross energy = feed consumption (dry matter) x feed gross energy
- Excreta gross energy = total excreta (dry matter) x excreta gross energy
- Nitrogen retention = nitrogen consumption - nitrogen excretion

*D. Data Analysis*

The analysis data was used analysis of variance (ANNOVA) if the results were significant effect (P<0.05) or very significant effect (P<0.01) continued with Duncan's Multiple Range Test (UJBD). The purpose of this analysis was to determine the best treatment of the percentage of palm kernel meal and fermented tapioca waste (PKMFTW) on feeding digestibility so it can be used as corn substitution alternative for broiler feeding.

## III. Results and Discussion

*A. Effect Treatment on Feeding Density*

The density measurements results of corn, palm kernel meal and fermented tapioca waste (PKMFTW), and feeding teratments can be presented in table 3.

TABLE 3. Corn, PKMFTW, and feeding treatment density

| Treatment | Density (g/L) |
|---|---|
| Corn | 558 |
| PKMFTW | 237 |
| P0 | 598 |
| P1 | 509 |
| P2 | 450 |
| P3 | 420 |
| P4 | 355 |
| P5 | 350 |
| P6 | 314 |

Note: PKMFTW (palm kernel meal and fermented tapioca waste)

Density is ratio between the mass of material to their volume, the unit is g/mL. Density give affects to the homogenity and stability of mixing quality. According to table 3, the greatest density value of feeding treatment was found at P0, the treatment is without using palm kernel meal and fermented tapioca waste in feed. This result was due to the fact that P0 feed had the lowest crude fiber content. [9] explains that the higher fiber content of feed cause the lower density value, which indicates that feed is getting more bulky, while the lower fiber content causes the higher density of feed.

The higher using palm kernel meal and fermented tapioca waste as corn substitution give effect to the lower feed density. The lower density indicates that feed is getting voluminous/bulky. The increasing use of palm kernel meal and fermented tapioca waste causes crude fiber content of feed increase. This result is described [16] that corn substitution using higher wheat into the feed caused the lower feed density. The lower density affects to feed nutrient density, at the same volume of nutritional value of feed will be less if it has lower density.

Different density values on feeding treatment was due to the voluminous/bulky of palm kernel meal and fermented tapioca waste. The result of [2] research explained that voluminous characteristic of noni leaves give impact to the differences of density values. The addition of noni leaves causes larger cavity in the pellet feed. [10] added that particles shape give affect to the material density, large porosity particles cause the cavities particle to be filled air so the density is smaller.

Feeding density are indicates voluminous/bulky level of feed that affect to quality and consumption of livestock. Feeding density affects to the total of consumption and level of feeding digestibility [29]. High density give effect on increasing consumption and reducing spillage of feed [12]. [26] added that the higher level of voluminous feed causes the sensation of being full is faster, so feed consumption is limited. According to [28] the lower density of feed ingredients indicates that feed is getting more voluminous. The characteric of feed quality is smooth surface, not rotten, not rancid and moldy, healthy nutritional content, and high digestibility.

Feeding density related to the feeding process such as homogenity during the mixing process and making pellets. Density is influenced by particle size, material properties, material composition and degradation of the molecules in the material due to processing. The good quality of mixing feed produces a good density value. The homogeneous feeding texture is more resistant to pressing process during pellet making so the bonds between material particles are not filled with air cavities [15].

*B. Effect Tretament on Crude Protein Digestibility, Apparent Metabolizable Energy (AME), and Apparent Metabolizable Energy Nitrogen Corrected (AMEn)*

The palm kernel meal and fermented tapioca waste (PKMFTW) as corn substitution alternative on crude protein digestibility, apparent metabolizable energy (AME), and apparent metabolizable energy nitrogen corrected (AMEn) in broiler feed can be presented in table 4.

*1. Crude Protein Digestibility of Broiler Feed*

According to table 4, the treatment of palm kernel meal and fermented tapioca waste (PKMFTW) as corn substitution in broiler feed has very significant effect (P<0.01) on crude protein digestibility. The results of Duncan's multiple range test showed that between treatments gave significant effect. The best result is P0 (77.73±4.63%), the treatment without palm kernel meal and fermented tapioca waste (PKMFTW). This result caused feed at P0 had the highest protein content and low crude fiber content. This result same as [13;30] explanation that crude protein digestibility is influenced by feed constituents, feeding protein percentage, protein consumed total, and feeding fiber content. The crude fiber content is low causes feed can stay longer in the digestive tract so the available time is longer for digestive enzymes to digest feed and affects to the higher protein digestibility.

TABLE 4. The results of crude protein digestibility, AME, and AMEn of broilers feed

| Treatment | Crude protein digestibility (%) | AME (Kcal/kg) | AMEn (Kcal/kg) |
|---|---|---|---|
| P0 | 77.73± 4.63$^{C}$ | 2598.08± 210.88$^{b}$ | 2489.09± 215.31$^{b}$ |
| P1 | 68.81± 1.57$^{B}$ | 2595.07± 58.25$^{b}$ | 2523.63± 65.91$^{b}$ |
| P2 | 70.29± 4.95$^{BC}$ | 2688.95± 177.91$^{b}$ | 2596.51± 171.59$^{b}$ |
| P3 | 64.92± 4.46$^{B}$ | 2589.28± 149.21$^{b}$ | 2509.55± 142.20$^{b}$ |
| P4 | 65.94± 4,51$^{B}$ | 2587.37± 173.90$^{b}$ | 2502.36± 167.49$^{b}$ |
| P5 | 66.25± 3.10$^{B}$ | 2548.62± 119.49$^{b}$ | 2459.12± 114.45$^{b}$ |
| P6 | 55.86± 4.62$^{A}$ | 2257.63± 166.23$^{a}$ | 2198.00± 155.13$^{a}$ |

Note: The different superscripts value in the same column showed significant effect (P<0.05) and very significant effect (P<0.01).

The lowest crude protein digestibility was found at P6 (55.86± 4.62), the treatment by palm kernel meal and fermented tapioca waste (PKMFTW) as much as 60%. The lowest value at P6 is comparable to the lowest density of the feed, which indicates that crude fiber content of feed is very high. According to [9] fiber content of feed is higher causes the feed more bulky/voluminous, so the density value is lower. Very high crude fiber content causes feed is faster to leave digestive tract so impact to the digestion and absorption process of feed unoptimal. The fiber character is voluminous so broiler feel full easily when consuming feed containing high crude fiber because chicken's crop is full faster [4]. According to [26] the higher voluminous/bulky rate of feed causes the sensation of being full faster so the consumption is limited. Broiler will stop eating when they feel full (crop is full), the impact is feed consumption decreased and lack of protein intake, so protein digestibility is low.

The value of crude protein digestibility based on the results of this study ranged from 55.86 to 77.73%. According to [1;17] crude protein digestibility is divided into 3, low digestibility levels ranging from 50-60%, moderate digestibility levels ranging from 60-70%, and high digestibility levels >70%. Based on this explanation, the digestibility level in this study is classified as moderate. This result is supported by an explanation from [19] that broilers protein digestibility in the tropics is around 60-85%. Protein digestibility describes that total protein used by the body in digestive process, both for basic living and production [8]. The total protein that break out with excreta is less cause crude protein digestibility is higher [17].

*2. Apparent Metabolizable Energy (AME) of Broiler Feed*

According to table 4, the treatment of palm kernel meal and fermented tapioca waste (PKMFTW) as corn substitution in broiler feed had significant effect (P<0.05) on apparent metabolizable energy (AME). The results of Duncan's multiple range test showed that the treatments gave significant effect. The apparent metabolizable energy if viewed based on the notation does not make any difference to P0-P5, if based on the greatest value found at P2. The best results were due to the highest consumption of feed than the others. Feed consumption is higher causes higher apparent metabolizable energy. The affect factors of apparent metabolizable energy value are feed energy content, feed consumption, age, types of livestock, and the ability of livestock to metabolize in the body. The value of apparent metabolizable energy (AME) is directly proportional to feed consumption and dry matter digestibility [19].

The gross energy and crude fat content of P6 was higher than P2, however was not proportional to apparent metabolizable energy value. According to [7] feed containing high fat causes higher gross energy content of feed and proportional to the higher digestibility value of metabolizable energy, but in this study the opposite occurs because the crude fiber content is too high. Crude fiber content is very high will inhibit the digestion process of feed because feed leaves the digestive tract more quickly, so the digestive enzymes do not have much time to digest the feed. The low apparent metabolizable energy value is proportional to feed density which is very low than the other treatments. Feed density values is lower indicate that the feed is getting bulky/voluminous because crude fiber content of feed is higher [9].

The value of apparent metabolizable energy is influenced by the level of feed consumption. The influenced of broiler feed consumption is crude fiber content, shape and color of feed. Broiler prefer bright/light colored feeds to dark colored



Alfita Yan Kusuma, Osfar Sjofjan, and Irfan H. Djunaidi, "The Effect of Corn Substitution with Palm Kernel Meal and Fermented Tapioca Waste (PKMFTW) on Density and Digestibility of Broilers Feed," *International Research Journal of Advanced Engineering and Science*, Volume 6, Issue 1, pp. 183-188, 2021.

feed [22]. [25] explained that broilers prefer feed has yellow colour and bright.

Feed consumption is low but the excreta production is solid and lots that indicates feed has low metabolizable efficiency. [7] explained that broiler feed consumption is high but excreta production is high indicates that feed nutrients can not be digested by the digestive tract, that affected so many energy is released through excreta. Metabolic efficiency is influenced by fat content, fiber content, low moisture content, excreta color, total excreta, and excreta viscosity [22]. High metabolic efficiency value can be indicated by green excreta, liquid and low production.

*3. Apparent Metabolizable Energy Nitrogen Corrected (AMEn) in Broiler Feed*

According to table 4 the treatment of palm kernel meal and fermented tapioca waste (PKMFTW) as corn substitution in broiler feed had a significant effect ($P<0.05$) on apparent metabolizable energy nitrogen corrected (AMEn). The results of Duncan's multiple range test showed that the treatments gave significant effect. The best apparent metabolizable energy nitrogen corrected value was found at P2 due to the highest feed consumption. Feed consumption is influenced by the balance of gross energy content and feed [3]. The feed consumption is higher impact to the higher apparent metabolizable energy nitrogen corrected because its value affected by gross energy consumption, crude protein content, nitrogen consumption, and feed nutritional balancing [21].

The lowest apparent metabolizable energy nitrogen corrected was found at P6 because it has the lowest feed consumption and the highest crude fiber content. Crude fiber content of feed is higher give impact to the lower density value that can be shown in P6. High crude fiber component in the form of cellulose make stronger bond with energy component, so feed nutrients are increasingly difficult to digest and lost with excreta [17]. [4] explained that low feed consumption was due to the fiber characteristic is voluminous. According to [26] level of bulky feed is higher causes the animal feel full faster, so feed consumption is limited. Broiler will stop eating if the crop is full. Low feed consumption causes broiler get less energy supply and impact to the body size can not growth optimal.

According to [23] apparent metabolizable energy nitrogen corrected value is influenced by nitrogen retention content in broilers, nitrogen retention value is higher give impact to the lower excreta nitrogen retention. Nitrogen retention is directly proportional to nitrogen consumption but inversely proportional to nitrogen excreta [6]. Nitrogen retention is description of the efficiency level of using protein by livestock/protein that is left in the animal's body.

Apparent metabolizable energy nitrogen corrected (AMEn) value is lower than apparent metabolizable energy (AME) because AMEn calculates the energy conversion as nitrogen correction factor for uric acid, if it is completely oxidized it will produce as much as 8.22 Kcal/kg [16]. [21] explained that AMEn showed the metabolic energy value corrected by nitrogen retention by reducing the caloric value by 1 gram nitrogen (8.73) and multiplying by nitrogen retention.

## IV. Conclusion

The higher palm kernel meal and fermented tapioca waste (PKMFTW) as corn substitution impact to decreases of feed density value, crude protein digestibility, apparent metabolizable energy, and apparent metabolizable energy nitrogen corrected. The palm kernel meal and fermented tapioca waste (PKMFTW) as much as 20% is the best corn substitution alternative in broiler feed.

## References

[1] Abun., D. Rusmana, dan N.P. Indriani. 2003. Penentuan Kecernaan Ransum Mengandung Ampas Umbi Garut (*Maranta arundinacea Linn.*) Pada Ayam Broiler dengan Metode Pemotongan. *Jurnal Bionatura*. vol 5 issue 3. pp. 227–238. (*Indonesian Journal*).

[2] Akbar, M.R.L., D.M. Suci, dan I. Wijayanti. 2017. Evaluasi Kualitas *Pellet* Pakan Itik yang Disuplementasi Tepung Daun Mengkudu (*Morinda citrifolia*) dan Disimpan Selama 6 Minggu. *Buletin Makanan Ternak*. vol 104 issue 2. pp. 31–48. (*Indonesian Journal*).

[3] Allama, H., O. Sofjan, E. Widodo, dan H.S. Prayogi. 2012. Pengaruh Penggunaan Tepung Ulat Kandang (*Alphitobius diaperinus*) dalam Pakan Terhadap Penampilan Produksi Ayam Pedaging. *Jurnal Ilmu-Ilmu Peternakan*. vol 22 issue 3. pp. 1-8. (*Indonesian Journal*).

[4] Amrullah, I.K. 2003. *Nutrisi Ayam Petelur*. Cetakan I. Lembaga Satu Gunung Budi Kompleks IPB. Bogor. (*Indonesian Book*).

[5] AOAC. 2005. Official Methods of Analysis of the Association of Official Analytical Chemists. Published by the Association of Official Analytical Chemist. Marlyand. (*Indonesia Book*).

[6] Azizah, T.R.N., D.P. Singgih, H. Setiyatwan, T. Widjastuti, I.Y. Asmara. 2020. Peningkatan Pemanfaatan Ransum pada Ayam Sentul yang Diberi Ekstrak Buah Mengkudu (*Morinda citrifolia*) dengan Suplementasi Tembaga dan Seng. *Jurnal Nutrisi Ternak Tropis dan Ilmu Pakan*. vol 2 issue 1. pp. 25–34. (*Indonesian Journal*).

[7] Bahri, S. dan Rusdi. 2008. Evaluasi Energi Metabolis Pakan Lokal pada Ayam Petelur. *J. Agroland*. vol 15 issue 1. pp. 75–78. (*Indonesian Journal*).

[8] Fitasari, E., K. Reo, dan N. Niswi. 2016. Penggunaan Kadar Protein Berbeda Pada Ayam Kampung Terhadap Penampilan Produksi dan Kecernaan Protein. *Jurnal Ilmu-Ilmu Peternakan*. vol 26 issue 2. pp. 73–83. (*Indonesian Journal*).

[9] Hidayat, C., Sumiati, dan 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*. pp. 669-674. (*Indonesian Journal*).

[10] Jufri, M. dan R.D. Firli. 2006. Studi Kemampuan Pati Biji Durian Sebagai Bahan Pengikat dalam Ketoprofen Secara Granulasi Basah. *Jurnal ilmu kefarmasian*. vol 3 issue 2. pp. 78-86. (*Indonesian Journal*).

[11] Juliati, K., D. Sudrajat, dan D. Kardaya. 2016. Pengaruh Substitusi Tepung Ampas Kelapa dalam Pakan Komersil Terhadap Energi Metabolis Ayam Kampung. *Jurnal Peternakan Nusantara*. vol 1 issue 1. pp. 159–164. (*Indonesian Journal*).

[12] Krisnan, R. dan S.P. Ginting. 2009. Penggunaan Solid Ex-Decanter Sebagai Perekat Pembuatan Pakan Komplit Berbentuk *Pelet*: Evaluasi Fisik Pakan Komplit Berbentuk Pelet. *Seminar Nasional Teknologi Peternakan dan Veteriner*. pp. 480-486. (*Indonesian Journal*).

[13] Mangisah, I., Tristiarti, W. Murningsih, M.H. Nasoetion, E.S. Jayanti, dan Y. Astuti. 2006. Kecernaan Nutrien Eceng Gondok yang Difermentasi dengan *Aspergilus niger* Pada Ayam Broiler. *J.Indon.Trop.Anim.Agric*. vol 31 issue 2. pp. 124–128. (*Indonesian Journal*).

[14] Nuraini., Sabrina, dan S.A. Latif. 2008. Performa Ayam dan Kualitas Telur yang Menggunakan Pakan Mengandung Onggok Fermentasi dengan *Neurospora crassa*. *Media Peternakan*. vol 31 issue 3. pp. 195–202. (*Indonesian Journal*).

[15] Nurhayatin, T. dan M. Puspitasari. 2017. Pengaruh Cara Pengolahan Pati Garut (*Maranta arundinacea*) Sebagai Binder dan Lama Penyimpanan Terhadap Kualitas Fisik Pellet Ayam Broiler. *Journal of Animal Husbandry Science.* Vol 2 issue 1. pp. 32-40. (*Indonesian Journal*).

[16] Octavia, S.P., I.H. Djunaidi, dan E. Widodo. 2017. Kandungan Energi Metabolis Semu Pakan dan Energi Metabolis Semu Terkoreksi N pada Gandum dengan Suplementasi Enzim Sebagai Substitusi Jagung. *Jurnal*

*Ilmiah Peternakan Terpadu.* vol 5 issue 3. pp. 68–71. (*Indonesian Journal*).
[17] Pangestu, G.A., R.I. Pujaningsih, dan I. Mangisah. 2018. Pengaruh Ransum yang Mengandung Limbah Tauge Fermentasi Terhadap Kecernaan Serat Kasar, Protein Kasar dan Energi Metabolis pada Itik Lokal Fase Starter. *Jurnal Ilmiah Peternakan Terpadu.* vol 6 issue 1. pp. 77-82. (*Indonesian Journal*).
[18] Puastuti, W., Yulistiani, D, dan Susana, I.W.R. 2014. Evaluasi Nilai Nutrisi Bungkil Inti Sawit yang Difermentasi dengan Kapang Sebagai Sumber Protein Ruminansia. *JITV.* vol 19 issue 2. pp. 143 - 151. (*Indonesian Journal*).
[19] Rambet, V., J. F. Umboh., Y.L.R. Tulung, dan Y.H.S. Kowel. 2016. Kecernaan Protein dan Energi Ransum Broiler yang Menggunakan Tepung *Maggot (Hermetia Illucens)* Sebagai Pengganti Tepung Ikan. *Jurnal Zootek*. vol 36 issue 1. pp. 13–22. (*Indonesian Journal*).
[20] Saputra, A.T, M.A. Wicaksono, dan Irsan. 2017. Pemanfaatan Minyak Goreng Bekas untuk Pembuatan Biodiesel Menggunakan Katalis Zeolit Alat Teraktivasi. *Jurnal Chemurgy*. vol 1 issue 2. pp. 1-6. (*Indonesian Journal*).
[21] Saputra, P.H., O. Sjofjan, dan I.H. Djunaidi. 2014. Pengaruh Penambahan Fitobiotik Meniran (*Phyllanthus niruri L.*) dalam Pakan Terhadap Kecernaan Protein Kasar dan Energi Metabolis Ayam Pedaging. Universitas Brawijaya. Malang. (*Indonesian Journal*).
[22] Sari, A.P. dan R. Rachmatika. 2014. Energi Metabolis Semu dan Efisiensi Metabolik pada Serindit Sumatera (*Loriculus galgulus* L., 1758). *Jurnal Biologi Indonesia.* vol 10 isue 1. pp. 11-16. (*Indonesian Journal*).
[23] Sjofjan, O., D.N. Adli, S. Lailiyah, dan M.J. Abdillah. 2019. Pengaruh Pengunaan Tepung Biji Asam Kandis (*Garcinia cowa*) Sebagai Imbuhan Pakan Alami (NGPS) Terhadap Kecernaan Protein, Energi Metabolis, Lebar Kripta, dan Panjang Vili Usus Ayam Pedaging, Dipaparkan dalam Seminar Nasional Tahun 2019 di Fakultas Peternakan, Universitas Jambi BW Luxury Hotel Jambi. Tema “Membangun Peternakan Berkelanjutan dalam Era Industry 4.0”. (*Indonesian Journal*).
[24] Sinurat, A.P., Purwadaria, T, dan Pasaribu, T. 2013. Peningkatan Nilai Gizi Bungkil Inti Sawit dengan Pengurangan Cangkang dan Penambahan Enzim. *JITV*. vol 18 issue 1. pp. 34-41. (*Indonesian Journal*).
[25] Situmorang, N.A., L.D. Mahfudz, dan U. Atmomarsono. 2013. Pengaruh Pemberian Tepung Rumput Laut (*Gracilaria verrucosa*) dalam Ransum Terhadap Efisiensi Penggunaan Protein Ayam Broiler. *Animal Agricultural Journal*. vol 2 issue 2. pp. 49-56. (*Indonesian Journal*).
[26] Sudarmin, B.F., N.N. Suryani, dan N.P. Mariani. 2019**.** Komposisi Kimia dan Sifat Fisik Ransum Sapi Bali di Penampungan Ternak Desa Nongan Kecamatan Rendang Kabupaten Karangasem. *Journal of Tropical Animal*. vol 7 issue 1. pp. 281–290. (*Indonesian Journal*).
[27] Supriyati. 2003. Onggok Terfermentasi dan Pemanfaatannya dalam Pakan Ayam Ras Pedaging. *JITV*. vol 8 issue 3. pp. 146-150. (*Indonesian Journal*).
[28] Suryani, N.N,. I.G. Mahardika, S. Putra, dan N. Sujaya. 2015. Sifat Fisik dan Kecernaan Ransum Sapi Bali yang Mengandung Hijauan Beragam. *Jurnal Peternakan Indonesia*. vol 17 issue 1. pp. 39-45. (*Indonesian Journal*).
[29] Toharmat, T., E. Nursasih, R. Nazilah, N. Hotimah, T.Q. Noerzihad, N.A. Sigit, dan Y. Retnani. 2006. Sifat Fisik Pakan Kaya Serat dan Pengaruhnya terhadap Konsumsi dan Kecernaan Nutrien Ransum pada Kambing. *Media Peternakan*. vol 29 issue 3. pp. 146-154. (*Indonesian Journal*).
[30] Widodo, A. R., H. Setiawan., Sudiyono., Sudibya, dan R, Indreswari. 2013. Kecernaan Nutrient dan Performan Puyuh (*Coturnix coturnix japonica*) Jantan yang Diberi Ampas Tahu Fermentasi dalam Ransum. *Tropical Animal Husbandry*. vol 2 issue 1. pp. 51-57. (*Indonesian Journal*).
[31] Wina, E. 2000. Pemanfaatan Ragi (Yeast) Sebagai Pakan Imbuhan untuk Meningkatkan Produktivitas Temak Ruminansia. *Wartazoa*. vol 9 issue 2. pp. 50-56. (*Indonesian Journal*).
[32] Wizna., H. Abbas., Y. Rizal., A. Dharma, and I. P. Kompiang. 2009. Improving the Quality of Tapioca By-Products (Onggok) as Poultry Feedthrough Fermentation by *Bacillus amyloliquefaciens. Pakistan J. Nutr*. vol 8 issue 10. pp. 1636-1640. (*Indonesian Journal*).