



Performance and Digestibility of Grower-Stage Turkeys Fed Different Forage-Based Rations

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Abstract | Turkey meat is favored for its low-fat, high-protein nutritional profile. While turkeys can consume forage, their diets often lack the right balance of nutrients. Sorghum, cultivated as fodder, provides a potential solution. Rich in nutrients and low in anti-nutrients, sorghum can improve turkey performance by optimizing digestive health and nutrient absorption. The aim of the research was to examine the effect of using forage-based rations on grower stage turkeys. The material used was 252 unsex turkeys in the grower phase. The study used a completely randomized design (CRD) with 3 treatments and 7 replications, consisting of: T0 (Ration without forage), T1 (Ration with water hyacinth), and T2 (Ration with fodder sorghum). The data obtained was then analyzed using analysis of variance (ANOVA) to test the diversity of the data and if there was a real influence, it would be continued with the Duncan's Multiple Range Test (DMRT) with a significance level of 5%. The parameters observed in the research included: body weight gain, livestock consumption, feed conversion ratio (FCR), carcass percentage and over feed and Turkeys costs (IOFTC). The results showed that a final weight of 634-702 g/head, body weight gain of 424-510 g/head, feed consumption of 77.87-81.13 g/head/day, FCR 4.81-5.90, carcass percentage 49.73-54.58 and IOFTC (IDR) 11937-16571. The use of complete feed base fodder sorghum and maggot jam shows an increase in feed performance and efficiency.

Keywords | Digestibility, Feed, Forage, Turkey, Performance

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INTRODUCTION

Turkey meat is one of the livestock products that people like, because of its lowfat content. Turkey meat has a protein content of around 30.5% and fat 11.6%. Meanwhile, the turkey rearing process lasts 24-30 weeks. The body weight of a male turkey ranges from 5-5.5kg. Feeding

by turkey breeders usually does not pay attention to the nutritional needs of the livestock, so it does not provide maximum performance (Rawski *et al.*, 2020). Turkeys are classified as poultry that can be given fiber feed (Lestari *et al.*, 2020), so they have ability to consume forage. Turkeys can digest 9% crude fiber without affecting feed efficiency due to higher levels of microorganisms in the cecum (Var-

astegani and Dahlan, 2014). Turkey feed consists of forage and concentrate with a crude protein content above 20% for the grower phase.

Forages with potential as turkey feed are water hyacinth and sorghum fodder, as they are easily available and have good nutritional content. In addition, water hyacinth and sorghum fodder are nutritious forages that are relatively cheaper than other forages. However, not many studies have discussed the utilization of water hyacinth and sorghum fodder for poultry feed. Water hyacinth is an abundantly available forage that is considered a weed with high nutrient content. Fodder is a plant that is harvested at a young age, used as feed, because of its high protein and carbohydrate content, and low crude fiber content (Wahyono *et al.*, 2020). These conditions make fodder suitable for use as poultry feed. Sorghum is a plant that is often used as an energy source of feed. The fodder system is suitable for planting sorghum (Wahyono *et al.*, 2019). Fodder on sorghum can increase the nutritional value, and can reduce the anti-nutrient content of sorghum, namely tannin. The tannin content in sorghum fodder is around 0.30-0.45%. The nutritional content of sorghum fodder is metabolizable energy 3200 kcal/kg, crude protein 16.93%, crude fat 7.26%, Neutral Detergent Fiber (NDF) 53.54% and Acid Detergent Fiber (ADF) 32.59% (Wahyono *et al.*, 2020). Sorghum fodder can be used as an alternative feed ingredient in making complete turkey feed by adding protein source feed ingredients (Utama *et al.*, 2023).

Livestock productivity is a parameter of success in livestock farming. Factors that influence livestock productivity include body weight, feed conversion, animal age, and mortality rate (Tyl *et al.*, 2020). Feed conversion can be more optimal if the digestive tract is healthy. The poultry digestive tract is the most important organ in the process of nutrient absorption. The function of the digestive tract is as a place where food is digested and where food is absorbed (Livovsky *et al.*, 2020). Good turkey performance can be achieved if the digestive organs function optimally. Good digestive organs can optimally supply the nutrient needs of the livestock's body. Increasing the productivity and feed efficiency of turkeys can be done by using complete feed. Providing complete feed for turkeys in Janocha *et al.* (2022) research resulted in high body weight gain and carcass percentage.

The aim of the research is to examine the effect of using forage-based rations on grower stage turkeys. The benefit of the research is that it provides information about forage-based turkey rations to improve performance.

MATERIALS AND METHODS

MATERIAL

The materials used were 252 grower phase turkeys, white

sorghum, maggot, soybean meal, Corn Gluten Meal (CGM), mineral mix, corn, rice bran, fish meal, 0.3 N H_2SO_4 , 1.5 N NaOH, n-hexane, Acetone, H_3BO_4 4%, concentrated H_2SO_4 , HCl 0.1 N, NaOH 45%, Methyl Red indicator, Methyl Blue and distilled water. Tools for turkey cages, feed containers, drinkers, analytical scales with an accuracy of 0.0001 grams, trays, weighing bottles, ovens, electric furnaces, desiccators, porcelain crucibles, glass beakers, Erlenmeyer, measuring cups, filter paper, Buncher funnels, paper Whatman filter, filter paper, filter machine, Kjeldahl flask, filter flask, upright cooler, autoclave, aluminum foil and soxhlet.

METHOD

The experimental design in this study used a completely randomized design (CRD) with 3 treatments and 7 replications. The experimental unit in this study used 252 grower phase turkeys consisting of 11 turkeys/replication and 21 turkeys as endogenous controls. Turkeys were used as the object of research and their performance and digestibility were observed after being treated. The ratio of 44% water hyacinth in T1 was chosen because it is the amount commonly used by local farmers, while the ratio of 35% sorghum fodder and 15% maggot meal in T2 was based on the results of the lowest cost calculation but the highest nutrient yield. The research treatment consists of:

T0: Ration without forage

T1: Ration with 44% water hyacinth

T2: Ration with 35% fodder sorghum + 15% maggot flour

The composition of the treatment feed consists of the ingredients presented in Figure 1 and Table 1.

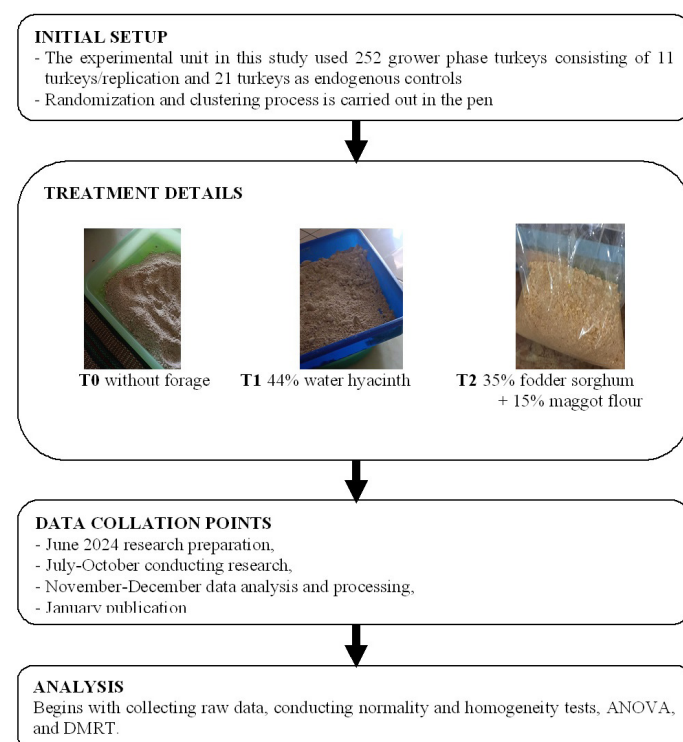


Figure 1: Research chart.

Table 1: Composition of treatment feed.

Feed Ingredients	T0	T1	T2
	Percentage %		
Sorghum Fodder	-	-	35
Maggot flour	-	-	15
water hyacinth	-	44	-
Fish flour	13	10	-
Soybean Meal	20	14	20
Corn	35	10	-
Rice Bran	10	10	10
Corn Gluten Meal (CGM)	20	10	18
Mineral Mix	2	2	2
Nutrient			
Metabolic Energy (kcal/kg)	3015	3033	3041
Crude protein (%)	22,5	22,1	22,9
Ether Extract (%)	4,8	4,1	5,9
Crude Fiber (%)	5,1	8,1	7,1
Ca (%)	1,88	1,56	1,90
P (%)	0,87	0,81	0,82

Description: Results of nutritional and feed laboratory analysis, Faculty of Animal and Agriculture Science, Diponegoro University, Semarang.

RESEARCH PARAMETER TESTING

Turkeys rearing lasts for 4 weeks. Body weight gain data was collected by subtracting the final weight from the initial weight. The weighing process was carried out every week during the maintenance process. Feed consumption data was collected every day by calculating the feed given minus the remaining feed. Feed conversion ratio (FCR) was a comparison between the amount of feed consumed and the amount of body weight produced. The FCR value was obtained using the formula (Tadjudin *et al.*, 2020).

$$FCR = \frac{\text{Total Feed Consumption}}{\text{Final Body Weight}}$$

Turkey slaughter was carried out using the kosher method, namely by cutting the jugular vein, carotid artery, trachea and esophagus. The hair removal process was done manually. Carcass weight was obtained by weighing chicken samples without blood, feathers, head, feet and internal organs. Carcass cuts were obtained by cutting the body parts into commercial cuts into 4 parts, namely thighs, wings, chest and back. Carcass characteristic parameters were as follows:

$$\text{Percentage of carcass cuts} = (\text{Weight of carcass parts} : \text{Carcass Weight}) \times 100\%$$

$$\text{Carcass Percentage} = (\text{Carcass weight} : \text{Live weight}) \times 100\%$$

Collecting data on nitrogen retention and metabolic energy in turkeys by collecting excreta using the total collection method. The turkeys were moved to the total collection pen and allowed to adapt to the cage environment. Turkeys were fasted for 24 hours, then given treatment food for 24 hours, then fasted again for 24 hours and then their excreta is collected. Total collection was carried out by collecting feces, the feces were sprayed with 0.1N HCl solution to prevent loss of nitrogen. The excreta that has been collected was then cleaned of hair and other dirt. The fresh weight of the excreta was weighed, then it will be dried and the dry weight will be weighed. The dry extract that has been weighed was then homogenized and a sample of 50 grams was taken to test its content using an analytical test. The N Retention value data was obtained using the formula (Shen *et al.*, 2020).

$$\text{Nitrogen retention} = \frac{(Fi \times Nf) - (E - Ne)}{(Fi \times Nf)} \times 100$$

Description;

Nf: Feed nitrogen (%).

Ne: excreta nitrogen (%).

Fi: Feed intake (g).

E: excreta (g).

Metabolic energy data was obtained using the formula (Yuniarti and Wahyono, 2015) and (Nurrohman *et al.*, 2015):

$$AME \text{ (kkl/kg)} = \frac{(EB \times X) - (Ebe \times Y)}{X}$$

$$TME \text{ (kkl/kg)} = \frac{(EB \times X) - [(Ebe \times Y) - (Ebk \times Z)]}{X}$$

Description;

EB: Feed gross energy (kkl/kg).

Ebe: Excreta gross energy (kkl/kg).

Ebk: Endogenous gross energy (kkl/kg).

X: Feed intake (g).

Y: Excreta (g).

Z: Endogenous excreta (g).

DATA ANALYSIS

The field data obtained will be calculated according to the guidelines referred to. The data is then tested for normality and homogeneity. If the data analyzed is normally distributed, the data can be analyzed for the effect of the treatment. Data variability and treatment effects are analyzed using analysis of variance (ANOVA). If there is a significant effect ($P < 0.05$), then it is further tested with Duncan's Multiple Range Test (DMRT) with a significance level of 5%. DMRT was chosen because it can show the hierarchy of treatment differences.

PERFORMANCE OF GROWER STAGE TURKEYS WITH VARIOUS TYPES OF TREATED FEED

Based on the results of the analysis in Tables 2 and 3, giving different rations showed significant differences in the parameters of final weight, body weight gain, ration consumption, FCR and carcass percentage ($p < 0.05$), while IOFTC did not differ significantly among treatments. Final weight, body weight, FCR and carcass percentage showed that T2 had a significant differences from T1 and T2. Feed consumption showed that T2 was not significantly different from T0, but significantly different from T1. The research results showed that giving rations made from sorghum feed produced the highest value seen from the final weight, body weight gain, IOFTC, and carcass percentage value. The T2 treatment that shows the highest carcass percentage indicates that T2 produces the largest carcass production. The T2 treatment showed a good interaction between the fodder method in sorghum combined with maggot flour. Fodder can reduce crude fiber in sorghum, while maggot flour plays a role in increasing protein levels in feed.

Table 2: Performance of turkeys in the grower phase with various types of feed.

Parameters	Treatment		
	T0	T1	T2
Final Weight (g/head)	634 ± 43,29 ^b	647 ± 53,30 ^b	702±48,27 ^a
Body Weight Gain (BWG) (g/head)	423± 91,40 ^b	424 ± 55,65 ^b	510± 54,32 ^a
Feed Consumption (g/head/day)	80,67± 1,25 ^{ab}	77,87± 0,93 ^b	81,13 ± 1,16 ^a
FCR	5,90 ± 1,74 ^b	5,84 ± 0,84 ^b	4,8 ± 0,52 ^a
IOFTC (IDR)	11937,16 ± 3896	13532,24 ± 4831	16571,02 ± 4505

Note: Parameters that are not superscripted indicate no significant effect. Different superscripts (letters) in the same row indicate significant differences ($P < 0.05$).

Table 3: Percentage of grower stage turkey carcasses with different feed treatments.

Parameters	Treatment		
	T0	T1	T2
	Percentage %		
Carcass	50,39 ^b	49,73 ^b	54,58 ^a
Chest	25,01 ^b	22,52 ^b	30,02 ^a
Back	22,04	22,18	23,14
Thigh	29,94 ^{ab}	29,58 ^b	32,90 ^a
Wing	13,80 ^b	14,47 ^a	15,22 ^a

Note: Parameters that are not superscripted indicate no significant effect. Different superscripts (letters) in the same row indicate significant differences ($P < 0.05$).

Based on Table 2, different feeding treatments affect the final weight of grower phase turkeys. Final body weight ranged from 634 – 702 g/head, with the best results found in T2, namely 702 g/head. *Lestari et al. (2020)* stated that the weight of local turkeys aged 8 weeks is 550-650g. The study was conducted over a short period, which may not reflect long-term effects of the diets. However, the results of the study allow for equally good results over a longer period of time. High final body weight in treatment T2 is related to high body weight gain. This is thought to be because in the T2 treatment there was sorghum fodder and maggot meal which had high protein content and decreased tannin content in sorghum. *Schiavone et al. (2019)* stated that maggot flour contains high levels of carbohydrates, protein, fat and iron which can increase body weight.

Turkey body weight gain (BWG) was influenced by different types of feed ($p < 0.05$). Turkey body weight gain was highest at T2 (510g) and lowest at T0 (423g). *Lestari et al. (2020)* stated that the body weight gain of turkeys in the grower phase is around 450-500 g/head. Treatment T2 obtained the best BWG due to better feed quality compared to other treatments. *Tavangar et al. (2021)* stated that body weight gain is closely related to feed, in terms of quantity related to feed consumption, if feed consumption is disturbed it will disrupt growth.

The research results showed that feed consumption was influenced by feed treatment. The highest turkey feed consumption was shown in treatment T2 (81.13 g/head/day). *Shukla et al. (2018)* stated that the average consumption value of turkey is 75-90 g/head/day. The level of feed consumption is related to the energy needs of livestock so that the level of animal feed consumption is different. Ration consumption is influenced by environmental temperature, ration, health, body size, life phase and the balance of food substances contained in it. Feed consumption is also affected by the presence of tannins in water hyacinth and fodder. Tannins are natural compounds that can bind to proteins and block the absorption of nutrients. The more tannins contained in feed will reduce the level of feed consumption in poultry (*Irianing et al., 2015*). The fodder method can reduce tannin levels to 0.30-0.45%, resulting in increased feed consumption. Higher feed consumption will cause the intestines to be more active in digesting so that it can accelerate growth and determine livestock development. *Der Poel et al. (2020)* stated that feed consumption is one of the things that can be measured to express production success in livestock performance.

The type of feed treatment affects the FCR value of grower phase turkeys. The best FCR results were found in the T2 treatment. This shows that the T2 treatment has good quality compared to other treatments. Feed conversion is related to the level of digestibility of animal feed. Good

nutrient digestibility will have an impact on feed efficiency which results in better body weight (Trisnanto *et al.*, 2018). Dogan *et al.* (2018) stated that ration conversion is an indicator of the quality of the ration itself. The higher the ration conversion rate, the lower the quality of the ration because what can be converted into body weight gain is low. This condition is supported by data on body weight gain and better consumption compared to other treatments. Tadjudin *et al.* (2020) stated that ration conversion is influenced by two things, namely ration consumption and body weight gain. The feed conversion ratio (FCR) value is related to other variables, such as body weight gain and feed consumption to achieve one unit of body weight.

Income over feed and turkeys cost (IOFTC) of grower phase turkeys is not influenced by giving different types of feed. IOFTC is an indicator of profitability in livestock production obtained by subtracting feed costs from income generated from the sale of livestock or its products (Hadi-ani *et al.*, 2022). Information regarding IOFTC specific to turkeys is limited. Most research on IOFTCs in poultry production has been conducted on broiler chickens, which are the poultry species most commonly raised for meat production. Feed costs are typically the largest expense in turkey production, so reducing feed costs while maintaining or increasing production can increase IOFTC. Hashim *et al.* (2023) stated that IOFTC can be achieved through careful management of feed quality and quantity, as well as genetic selection for feed efficiency. Although the results had no significant effect, the use of the T2 treatment feed had the highest IOFTC results. This indicates that T2 has the potential to produce quality feed at a more affordable price.

PERCENTAGE OF GROWER STAGE TURKEY CARCASSES WITH TREATED FEED

Table 3 shows that different types of feed treatment affect the percentage of carcass, breast, thighs and wings and do not affect the percentage of growing stage turkey backs.

The highest carcass percentage results were shown in the T2 treatment, namely 54.58%. T2 results show the highest carcass percentage related to consumption results and final weight of livestock. Baéza *et al.* (2022) stated that feed consumption is one of the factors that determines slaughter weight because the amount of feed consumed affects the amount of nutrients that enter the livestock's body. High T2 feed consumption causes high protein consumption, thereby increasing the carcass percentage. Attia *et al.* (2021) added that the carcass percentage is influenced by the nutritional content of the ration, especially the protein content of the feed.

The proportion of commercial cuts consisting of wings is 13.80 – 15.22%, thighs are 29.58 – 32.90%, breasts are 22.52 – 30.02%, and back with a range of 22.04 – 23.14%.

According to Jankowski *et al.* (2020) the percentage of turkey breast is around 22.2 – 23.2%, thigh 18.4 – 20%, wing 9.33% and back 10.58%. The highest percentage of cuts is in the breast and thigh, this is related to the amount of meat in the breast and thigh. Yuan *et al.* (2022) stated that the largest part of the meat is found in the chest, so the size of the chest is used as a measure of meat quality in livestock. The percentage of commercial wing fragments is the smallest, this is due to the large percentage of bones in the wings and the large number of feathers. According to Meisji *et al.* (2019) the smallest percentage of commercial cuts is found in the wings, because the large percentage of bone affects the reduction in meat deposits in the wings.

Table 4: Digestibility values of grower stage turkeys on different diets.

Parameters	Treatment		
	T0	T1	T2
Digestibility of crude fiber (%)	12,78±1,14 ^a	15,95±1,24 ^b	15,06±0,72 ^b
Digestibility of crude protein (%)	63,85±2,75 ^b	59,75±2,99 ^c	74,26±1,17 ^a
N retention (%)	47,18±2,27 ^b	48,43±1,68 ^b	61,89±1,11 ^a
Digestibility of Extract ether (%)	67,15±5,24 ^b	65,62±1,51 ^b	74,63±1,37 ^a
Apparent Metabolish Energy (kcal/kg)	2145,58 ±58,23 ^b	2044,75 ±63,75 ^c	2382,22 ±37,33 ^a
True Metabolish Energy (TME) (kcal/kg)	1880,24 ±51,88 ^b	1779,42 ±66,91 ^c	2116,89 ±38,43 ^a

Note: Parameters that are not superscripted indicate no significant effect. Different superscripts (letters) in the same row indicate significant differences (P<0.05).

DIGESTIBILITY VALUE OF FORAGE-BASED RATIIONS IN GROWER PHASE TURKEYS

The results of data analysis in Table 4 show that the different types of rations for turkeys show significant differences in the parameters of crude fiber digestibility, crude protein digestibility, N retention, crude fat digestibility, apparent metabolish energy and true metabolish energy. Digestibility of crude fiber showed that T0 had a significant differences from T1 and T2. Digestibility of crude protein, apparent metabolish energy and true metabolish energy showed that T2 had a significant differences from T0 and T1, T0 also had a significant differences from T1. N retention and digestibility of extract ether showed that T2 had a significant differences from T0 and T1. The T2 treatment showed higher digestibility of crude protein, n retention, digestibility of extract ether, apparent metabolish energy and true metabolish energy results than other treatments.

The results of the analysis showed that feed treatment affected the digestibility of crude fiber. The lowest crude fiber digestibility results were in the T0 treatment. Lower crude fiber digestibility is caused by the ration having a low crude

fiber content. Treatment T1 uses water hyacinth forage so it has a higher crude fiber content than treatments T0 and T2 which has a higher digestibility effect than other treatments. [Tejeda and Kim \(2021\)](#) stated that factors that can influence the digestibility of crude fiber in poultry are the crude fiber content in the feed, the composition of crude fiber, and the activity of microorganisms.

The percentage of protein digestibility in grower phase turkeys was the best, namely at T2 with a value of 74.26%, while the lowest percentage of protein digestibility was shown by T1 with a value of 59.75%. High protein digestibility at T2 can be caused by consumption of protein and anti-nutrients from feed ingredients. [Bryan and Classen \(2020\)](#) stated that protein consumption, ration composition and anti-nutrient content can affect protein digestibility. The highest N retention value was shown in treatment T2 with an average of 83.64%. This is believed to be due to the use of sorghum in the form of fodder which has a lower anti-nutritional tannin content and a lower crude fiber content in the feed, thus affecting ration consumption. [Barzegar et al. \(2020\)](#) stated that if feed consumption is high, the nitrogen retention value will be higher, because it will give the body the opportunity to retain more food so that nutrient needs for growth are met.

The average metabolic energy obtained by AME ranged from 2044.75-2382.22 Kcal/kg and TME ranged from 1779.42-2116.89 Kcal/kg. According to [Rhamadhanti \(2022\)](#) the apparent and pure metabolic energy in poultry is 2189.60 Kcal/kg and 2210.47 Kcal/kg. Metabolic energy utilization in treatment T2 was higher than in treatments T0 and T1. This is because high ration consumption and feed digestibility can increase metabolized energy. [Barekatin et al. \(2021\)](#) stated that energy can be obtained from nutrient metabolism so that low digestibility values can influence low metabolic energy values.

Using complete feed based on sorghum fodder can increase the metabolic energy value compared to using water hyacinth greens, so that turkey energy needs can be met. This is because the crude fiber content in treatment T2 is lower than T1, so it does not interfere with feed consumption. [Barzegar et al. \(2020\)](#) stated that the decrease in feed consumption could be caused by low levels of animal nutrient absorption so that energy needs are not met which can affect metabolic energy. [Noblet et al. \(2022\)](#) added that metabolic energy in poultry can be influenced by digestibility, because low digestibility causes a lot of energy to be lost through excreta.

CONCLUSIONS AND RECOMMENDATIONS

The addition of 35% fodder sorghum and 15% maggots flour in rations showed the best results with high final

weight, FCR and carcass percentage in grower phase turkeys and showed a better level of digestibility compared to other treatments. This shows that sorghum fodder and maggot meal are feasible to be used as alternative ingredients for grower phase turkey feed. The combination of sorghum fodder and maggot meal can be given as a substitution to the main feed. Further research is needed to determine the ideal composition for using sorghum fodder as a feed ingredient in turkeys, as well as investigate the long-term effects of the feed.

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NOVELTY STATEMENTS

This study provides the latest scientific information about the combination of forage feed ingredients from cereals (sorghum) grown by the fodder method as forage and maggot as a source of animal protein combined in a ration of 35% fodder and 15% maggot for turkey feed. It is hoped that the combination of sorghum fodder and maggot can replace the turkey feed used so far in Kudus Regency turkey farms.

AUTHOR'S CONTRIBUTIONS

Cahya Setya Utama and Bambang Sulistiyanto, provide recommendations and suggestions on research topics, article preparation and finalization of scientific articles. Muhammad Fikri Haidar, conducts research, data processing and article preparation.

CONFLICT OF INTEREST

The authors declare that they have no competing interest.

REFERENCES

- Attia AI, Reda FM, Patra AK, Elnesr SS, Attia YA, Alagawany M (2021). Date (*Phoenix dactylifera* L.) by-products: Chemical composition, nutritive value and applications in poultry nutrition, an updating review. *Animals*, 11(4): 1133. <https://doi.org/10.3390/ani11041133>
- Baéza E, Guillier L, Petracci M (2022). Production factors affecting poultry carcass and meat quality attributes. *Animals*, 16: 100331. <https://doi.org/10.1016/j.animal.2021.100331>
- Barekatin R, Romero LF, Sorbara JOB, Cowieson AJ (2021). Balanced nutrient density for broiler chickens using a range of digestible lysine-to-metabolizable energy ratios and

- nutrient density: Growth performance, nutrient utilisation and apparent metabolizable energy. *Anim. Nutr.*, 7(2): 430-439. <https://doi.org/10.1016/j.aninu.2020.12.003>
- Barzegar S, Wu SB, Choct M, Swick RA (2020). Factors affecting energy metabolism and evaluating net energy of poultry feed. *Poult. Sci.*, 99(1): 487-498. <https://doi.org/10.3382/ps/pez554>
- Bryan DD, Classen HL (2020). In vitro methods of assessing protein quality for poultry. *Anim.*, 10(4), 551. <https://doi.org/10.3390/ani10040551>
- Der Poel AFB van, Abdollahi MR, Cheng H, Colovic R, den Hartog LA, Miladinovic D, Hendriks WH (2020). Future directions of animal feed technology research to meet the challenges of a changing world. *Anim. Feed Sci. Technol.*, 114692.
- Dogan N, Kaygisiz F, Altinel A (2018). Technical and economic efficiency of laying hen farms in Konya, Turkey. *Brazilian J. Poult. Sci.*, 20: 263-272. <https://doi.org/10.1590/1806-9061-2017-0649>
- Hadiani DPP, Kusumawati ED, Kustyorini TIW (2022). The value of quail day production, income over feed cost and break even point of Mrs. Anami's quail business during the covid-19 pandemic. *Int. Conf. Improving Trop. Anim. Prod. Food Secur.*, (ITAPS), 434-437. <https://doi.org/10.2991/absr.k.220309.084>
- Hashim M, Gonzalez-Sanchez D, Wealleans A, Abdelkader M, El-Safty SAR, Abdelhady ARY (2023). Effects of different doses of multienzyme supplementation on growth performance, duodenal pH and morphology, and carcass traits in broilers fed diets with an increasing reduction in energy. *Animals*, 13(14): 2378. <https://doi.org/10.3390/ani13142378>
- Irianing S, Suthama N, Mangisah I (2015). The effect of dietary corn substitution to avocado seed meal in ration on feed consumption, protein intake, and nitrogen retention in broiler chicken. *J. Pengembangan Penyuluhan Pertanian*, 11(22): 19-24. <https://doi.org/10.36626/jppp.v11i22.143>
- Jankowski J, Mikulski D, Mikulska M, Ognik K, Całyniuk Z, Mróz E, Zduńczyk Z (2020). The effect of different dietary ratios of arginine, methionine, and lysine on the performance, carcass traits, and immune status of turkeys. *Poult. Sci.*, 99(2): 1028-1037. <https://doi.org/10.1016/j.psj.2019.10.008>
- Janocha A, Milczarek A, Pietruiak D, Łaski K, Saleh M (2022). Efficiency of soybean products in broiler chicken nutrition. *Animals*, 12 (3): 294-301.
- Lestari GP, Hermana W, Suci DM (2020). The Use of *Eichhornia crassipes*, *Indigofera sp* and *Ipomea sp.* as forage in turkey rations on performance and meat cholesterol. *Nutr. Feed Technol. J.*, 18 (2): 32-37.
- Livovsky DM, Pribic T, Azpiroz F (2020). Food, eating, and the gastrointestinal tract. *Nutrition.*, 12(4): 986. <https://doi.org/10.3390/nu12040986>
- Meisji LS, Fitra Y, Sofia S, Nuni G, Nasir R (2019). The effect of probiotic originated from kumpai grass silage to final weight, carcass percentage and commercial carcass cut of pegagan duck. In *IOP Conf. Ser. Earth Environ. Sci.*, 347(1): 012050.
- Noblet J, Wu SB, Choct M (2022). Methodologies for energy evaluation of pig and poultry feeds: A review. *Anim. Nutr.*, 8: 185-203. <https://doi.org/10.1016/j.aninu.2021.06.015>
- Nurrohman A, Yunianto VD, Mangisah I (2015). Use of avocado seed meal and effect in the ration on crude fat digestibility and energy metabolism in broiler chickens. *J. Agric. Extr. Dev.*, 11 (22): 48-57.
- Rawski M, Mazurkiewicz J, Kierończyk B, Józefiak D (2020). Black soldier fly full-fat larvae meal as an alternative to fish meal and fish oil in Siberian sturgeon nutrition: The effects on physical properties of the feed, animal growth performance, and feed acceptance and utilization. *Animals*, 10(11): 2119. <https://doi.org/10.3390/ani10112119>
- Rhamadhanti R (2022). The effect of *Bacillus cereus* V9 inoculum dosage in the fermentation of palm kernel cake on nitrogen retention and metabolism energy in broiler chicken. *J. Trop. Anim. Vet. Sci.*, 12 (2): 168-174. <https://doi.org/10.46549/jipvet.v12i2.222>
- Schiavone A, Dabbou S, Petracci M, Zampiga M, Sirri F, Biasato I, Gai F, Gasco L (2019). Black soldier fly defatted meal as a dietary protein source for broiler chickens: effects on carcass traits, breast meat quality and safety. *Animals*, 13 (10): 1-9.
- Shen J, Wang H, Pi Y, Gao K, Zhu W (2020). Casein hydrolysate supplementation in low-crude protein diets increases feed intake and nitrogen retention without affecting nitrogen utilization of growing pigs. *J. Sci. Food and Agric.*, 100(4): 1748-1756. <https://doi.org/10.1002/jsfa.10196>
- Shukla M, Bhattacharyya A, Shukla PK, Roy D, Yadav B, Sirohi R (2018). Effect of *Azolla* feeding on the growth, feed conversion ratio, blood biochemical attributes and immune competence traits of growing turkeys. *Vet. World*, 11 (4): 459.
- Tadjudin HDS, Shofiah MS, Aini SA, Hermana W, Darmawan A (2020). Utilization of dandelion (*Taraxacum officinale*) in the diet on turkey (*Meleagris gallopavo*) performance. *Nutr. Feed Technol. J.*, 18 (1): 19-23. <https://doi.org/10.29244/jintp.18.1.19-23>
- Tavangar P, Gharahveysi S, Rezaeipour V, Irani M (2021). Efficacy of phytobiotic and toxin binder feed additives individually or in combination on the growth performance, blood biochemical parameters, intestinal morphology, and microbial population in broiler chickens exposed to aflatoxin B1. *Trop. Anim. Health Prod.*, 53(3).
- Tejeda OJ, Kim WK (2021). Role of dietary fiber in poultry nutrition. *Animals*, 11(2): 461. <https://doi.org/10.3390/ani11020461>
- Trisnanto AW, Suprijatna E, Sukanto B (2018). Effect of feeding frequency and feeding periods on crossbred native chicken digestibility. *J. Sain Peternakan Indones.*, 13(2): 119-129. <https://doi.org/10.31186/jspi.id.13.2.119-129>
- Tyl RM, Rota CT, Lehman CP (2020). Factors influencing productivity of eastern wild turkeys in northeastern South Dakota. *Eco. Evo.*, 10(16): 8838-8854.
- Utama CS, Sulistiyanto B, Haidar MF (2023). The feasibility of Sorghum (*Sorghum vulgare*) fodder as poultry feed ingredients seen from growth performance, nutrient content and fiber profile of Sorghum fodder. *J. Adv. Vet. Anim. Res.*, 10(2) 222. <https://doi.org/10.5455%2Fjavar.2023.j672>
- Varastegani A, Dahlan I (2014). Influence of dietary fiber levels on feed utilization and growth performance in poultry. *J. Anim. Sci. Adv.*, 4(6): 422-429. <https://www.ejmanager.com/mnstemps/73/73-1389511539.pdf>
- Wahyono T, Sugoro I, Jayanegara A, Wiryawan KG, Astuti DA (2019). Nutrient profile and in vitro degradability of new promising mutant lines sorghum as forage in Indonesia. *Adv. Anim. Vet. Sci.*, 7 (9): 810-818.
- Wahyono T, Sukandar D, Dewi RK, Kurniawan W, Sihono S (2020). Effect of varietal differences on the crop profile of hydroponically grown green fodder sorghum. *J. Trop. Anim. Sci. Technol.*, 7(2): 101-109. <http://dx.doi.org/10.33772/jitro.v7i2.10862>

- Yuan C, Jiang Y, Wang Z, Chen G, Bai H, Chang G (2022). Indigenous, yellow-feathered chickens body measurements, carcass traits, and meat quality depending on marketable age. *Animals*, 12(18): 2422. <https://doi.org/10.3390/ani12182422>
- Yuniarti M, Wahyono F (2015). Protein digestibility and metabolic energy due to effect of red dragon fruit liquid additif (*Hylocereus polyrhizus*) by quail female age 16-50 days. *Ind J. Anim. Sci.*, 25 (3): 45-52.