Research Article

Effect of Dietary Lysine and Energy Levels on Apparent Nutrient, Nitrogen, and Amino Acids Digestibility of Local Muscovy Ducks

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Abstract | A 3x2 factorial arrangement was used in the study to evaluate the apparent nutrient and amino acid digestibility of local Muscovy ducks in two periods. Two factors of the trial were dietary lysine levels (0.8%, 1.0% and 1.2%) and metabolizable energy (ME) levels (12.55MJ/kg DM and 12.97MJ/kg DM) for 8-week-old period; and dietary lysine levels (0.7%; 0.9%; 1.1%), and ME levels (13.39MJ/kg DM; 13.81 MJ/kg DM) for 10-week-old period. There were three replications and four ducks per experimental unit. The findings indicated that the apparent nutrient digestibility coefficients of DM, OM, and EE were significantly higher for the Lys 1.2 and Lys 1.1 treatments in both periods (P<0.05). At 8-week-old period, the digestibility results of lysine, and valine in the Lys 1.2 treatment; and of isoleucine, leucine, phenylalanine in the ME 12.97 treatment were significantly (P<0.05) higher than those of the other treatments. At 10-week-old period, the Lys 1.1 and ME 13.81 treatments had some better essential amino acid digestibility values, particularly, arginine, isoleucine, lysine; and methionine isoleucine, lysine, methionine, and threonine (P<0.05). Additionally, nitrogen retention in the Lys 1.2 and Lys 1.1 treatments (for 8 and 10-week-old periods) were significantly (P<0.05) higher than the other treatments. It could be concluded that Local Muscovy ducks at 8 weeks and 10 weeks of age, the appropriate diets contained 1.2% lysine and 12.97 MJ ME/kg DM, and 1.1% lysine and 13.81 MJ ME/kg DM, respectively.

Keywords | Amino acid, Digestibility, Local Muscovy duck, Lysine, Metabolizable energy

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INTRODUCTION

Muscovy duck is a kind of native duck of the Center and South of America which is called *Cairina moschata* as a binomial name that has a high quality of meat and egg (Stahl, 2003; Yakubu, 2013; Downs et al., 2017). They are also popularly raised in villages of Mekong delta of Vietnam for meat production to improve income of the producers.

Energy and amino acids (AA) are important in the dietary formulation of animal, especially for poultry because it accounts for the main cost of animal diets (Kong and Adeola, 2014). Parsons (2020) also recommends that we should formulate the poultry diets on the digestible AA basis. Additionally, lysine is one of the essential amino acids, which is necessary for the growth performance of poultry. It is important to determine optimum lysine levels in diets with several reasons which are one of the most expensive poultry feed ingredients, and environmental concerns such as nitrogen excretion in poultry feces (Nasr and Kheiri, 2012). Metabolizable energy is also necessary to determine in the poultry diets in order to evaluate the nutritional and economic values for the poultry (Yang et al., 2020). Besides, the optimum energy concentration in di*et al*lows for the better performance of animal activities and metabolic. The findings from some previous studies indicated that the positive effects of lysine and ME on the nutrient digestibility and performance of poultry were clearly recorded (Cemin et al., 2017; Ishii et al., 2019; Khwatenge et al., 2020). The appropriate levels of lysine and ME in diet could improve the growth performances of poultry (Cemin et al., 2017; Ishii et al., 2019; Khwatenge et al., 2020). NRC (1994) also suggested that the lysine level in diets of Pekin ducks from one week-old-chicken to 2-week-old-chicken was 0.9%; from 2–7 week old chicken was 0.65%. Sharma et al. (2018) reported that broiler chicken increased lysine digestibility when enhancing lysine level from 0.95 to 1.15% and the digestible lysine was approximately 10% higher than the recommendation. Aftab (2019) debated that, broiler chickens were more responsive to dietary amino acid (AA) and less focused on ME. The poultry was fed high energy diets tended to require high amino acid density (Wen et al., 2017). The poultry could not absorb all of ME in the diet, which was fermented in the caecum, energy losses were consequently due to this reason (Yang et al., 2020). Also, the appropriate combination of lysine and ME in diets improved better growth rates and meat performances for chicken and Muscovy ducks (Tang et al., 2007; Linh et al., 2018). These results proved that lysine and ME in the diet may support better nutrient digestibility for poultry. Although there were many studies focusing on poultry nutrition in Vietnam, but the studies on digestibility of dietary energy and Lys for Muscovy ducks are limited. Moreover, the suitable levels of ME and lysine are important for Muscovy ducks in Vietnam to improve their performance. Therefore, this research was implemented to determine the optimum Lys and ME levels in Muscovy's diets for apparent nutrient and amino acid digestibility.

MATERIALS AND METHODS

Location and ethnic approvals

The experiment took place in Tra Vinh University's Experimental Farm in Tra Vinh City, with feeds, refusals, and feces calculated at Can Tho University's Laboratory of Animal Sciences. The experimental time was from February to August 2020. To avoid all unnecessary discomfort to the experimental animals, all of procedures were checked and approved with ethical approval from Tra Vinh University.

Birds and experimental design

Local Muscovy ducks raised in Tra Vinh province were used in the experiment. From 1 to 28 days of age, one-day-old ducklings were selected, brooded, and fed a diet containing 20% CP and 12.5 MJ/kg supplied *ad libitum*. The trial was conducted in two sections when the birds were 5-8 and 9-11 weeks old. The birds were chosen and weighed individually, with average initial live weights of 750 g at 5 weeks age and 2050 g at 9 weeks age to see the effects of Lys and ME on growing period as the most development phase of local Muscovy ducks in Vietnam. At two and three weeks, all the birds were given vaccines to against the diseases of Avian Influenza and Duck Plague. On one occasion during the trial, all ingredients such as maize, rice bran, broken rice, fish meal, dicalcium phosphate (DCP) and soybean meal were purchased from a local animal feed store in Tra Vinh province. All feed ingredients, chemical composition was determined, and the experimental diets were created and supplied in mash form. Table 1 shows the chemical compositions of the feed ingredients.

Table 1: Chemical composition of ingredients used in the experiment.

Item (%)	Maize	Rice bran	Broken rice	Fish meal	Soybean meal	DCP	Premix vitamin	Lysine	Methionine
DM	88.6	87.1	87.1	92.1	94.3	100	100	97.4	99.3
OM	99.0	90.9	98.5	79.5	94.5	14.8	-	-	-
CP	8.71	12.3	8.72	60.2	43.1	-	-	-	-
EE	3.96	9.10	2.28	8.55	18.2	-	-	-	-
NFE	83.0	64.2	89.2	9.55	23.9	-	-	-	-
CF	3.34	5.27	3.34	1.18	9.33	-	-	-	-
NDF	19.6	25.7	19.6	7.15	17.2	-	-	-	-
ADF	3.96	10.2	1.79	1.84	11.6	-	-	-	-
Ash	0.99	9.06	0.65	20.5	4.57	85.2	-	-	-
Lysine	0.27	0.49	0.23	3.38	1.92	-	-	74.5	-
Methionine	0.17	0.23	0.19	1.42	0.57	-	-	-	87.1
Ca	0.16	0.32	0.22	5.83	0.56	23.5	-	-	-
P	0.03	1.30	0.24	2.52	0.65	18.6	-	-	-
AME (MJ/kg)	15.67	11.50	14.30	12.40	14.53	-	-	-	-

OM: Organic matter; DM: Dry matter; CP: crude protein; NDF: Neutral detergent fiber; CF: crude fiber; EE: ether extract; Lys: lysine; Met: methionine; DCP: Dicalcium phosphate; AME: metabolizable energy.

Table 2: Feed and chemical composition of experimental diets for 5-8-week-old local Muscovy ducks (%DM).

Item (%)	ME 12.55			ME 12.97		
	Lys 0.8	Lys 1.0	Lys 1.2	Lys 0.8	Lys 1.0	Lys 1.2
Corn	7.00	9.00	10.0	16.4	14.9	15.3
Rice bran	58.65	53.83	52.39	48.56	44.28	42.84
Broken rice	13.1	18.0	18.0	13.1	20.0	20.0
Fish meal	5.00	11.5	11.7	5.70	9.40	9.20
Soybean meal	15.0	6.30	6.30	15.0	10.0	11.0
Vitamin Mineral premix*	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	-	0.17	0.41	-	0.20	0.44
Methionine	0.05	-	-	0.04	0.02	0.02
Dicalcium Phosphate	0.50	0.50	0.50	0.50	0.50	0.50
Cr_2O_3	0.40	0.40	0.40	0.40	0.40	0.40
Chemical composition						
DM	88.7	88.4	88.5	88.8	88.7	88.8
OM	91.6	90.9	90.7	92.3	91.8	91.7
CP	18.9	19.0	19.0	18.9	18.9	19.0
EE	9.19	7.86	7.79	8.70	7.80	7.85
NFE	58.5	59.8	59.7	60.0	61.0	60.6
CF	5.01	4.12	4.08	4.80	4.18	4.21
NDF	20.0	18.3	18.1	19.3	17.6	17.5
ADF	8.37	7.12	7.01	7.72	6.83	6.81
Ash	7.68	8.28	8.20	7.00	7.21	7.07
Lysine	0.81	1.00	1.20	0.81	1.00	1.20
Methionine	0.38	0.38	0.38	0.38	0.38	0.38
Calcium	0.75	1.09	1.10	0.77	0.97	0.96
Phosphorus	1.13	1.19	1.18	1.02	1.04	1.02
ME (MJ/kg)	12.56	12.55	12.56	12.96	12.94	12.96
Essential amino acids (EAA)						
Arginine	1.12	1.13	1.13	1.07	1.06	1.07
Isoleucine	0.76	0.74	0.74	0.75	0.74	0.74
Leucine	1.26	1.28	1.28	1.26	1.27	1.28
Lysine	0.81	1.00	1.20	0.81	1.00	1.20
Methionine	0.38	0.38	0.38	0.38	0.38	0.38
Histidine	0.20	0.20	0.20	0.19	0.19	0.18
Phenylalanine	0.76	0.73	0.73	0.75	0.73	0.74
Threonine	0.63	0.64	0.64	0.62	0.62	0.63
Valine	0.80	0.83	0.83	0.79	0.80	0.80

*: Premix-mineral-Vitamin: vitamin A: 2,500,000 UI; vitamin D_3: 600,000 UI; vitamin E: 4000 mg; vitamin K_3: 400 mg; folic acid: 80 mg; choline: 100,000 mg; manganese: 14 g; Zn: 40 g; Fe: 32 g; Cu: 48 g; I: 0.5 g; Cobalt: 0.28 g; Selenium: 0.04 g.

Section 1 from 5–8 weeks of age

At the beginning of 5weeks of age, a total of 72 local Muscovy ducks were allotted in this experiment (a factorial design) with two factors: Lysine at concentrations of 0.8%, 1.0%, and 1.2%, and metabolizable energy (ME) at concentrations of 12.55MJ/kg DM and 12.97 MJ/kg DM. Crude protein for this experiment was 19% CP. There were 6 treatments and three replicate per treatment with 4 birds, balanced for sex per experimental unit. Dietary feed ingredient and chemical composition for 5-8-week-old local Muscovy ducks presented in Table 2.

Section 2 from 9-11 weeks of age

A total of 72 local Muscovy ducks at 9 weeks of age was selected based on average live weight from the birds used for the 5-8 weeks old. They were then randomly assigned to six treatments using a factorial design with 02 factors, 03 levels of lysine (0.7%, 0.9%, and 1.1%), 02 levels of metabolizable energy (ME) (13.39MJ/kg DM and 13.81 MJ/kg DM), CP was 17.0%. There were three replicates per treatment and four birds per replicate balanced for sex. Dietary feed ingredient and chemical composition for the 9-11 weeks old local Muscovy ducks were shown in Table 3.

Diet and feeding

Broken rice (BR), corn, rice bran (RB) fish meal (FM) and soybean meal (SBM) used in the different diets. A vitamin and trace element mixture (0.3%) was added to all diets. Chromic oxide (0.4 %) was carefully mixed with other feed ingredients for each diet before feeding occasion (Kim et al., 2014). Each experimental period lasted 19 days divided in three stages. Before the research began, birds were gradually introduced to the experimental meals over a seven-day period. This was followed by a seven-day adaption phase and a five-day collection of excreta. To avoid spillage, the birds were fed in groups of four and three times daily (7:30, 13:00, and 17:00 a.m.). The ducks were fed ad libitum over the 7-day adaption period to determine their actual feed intake. However, in order to reduce feed refusals, the feeding level was set slightly below the feed intake (90 percent) throughout the collecting time. The feeds and refusals were weighed and collected daily each morning for calculating feed intakes. Water was provided for birds around the clock in nipple drinkers.

Housing and management

In the trial, 72 ducks were randomly assigned to 18 wire metabolic cages (0.6x 0.8x 0.6m) with a similar averagelive weight per cage. A nipple drinkers and feeders were placed beneath each cage, and a plastic tray was placed underneath the cage to collect all excreta. To collect feed spilled every morning before feeding, a plastic cover was placed under each cage's feeder. The cages were placed in a ventilated house with natural light during the day and electric lighting at night to allow *ad libitum* eating for 24 hours each day. Every morning, the cages, food, and plastic trays were cleaned.

Table 3: Feed and chemical composition of experimental diets for 9-11 weeks old locall Muscovy ducks (%DM).

Item (%)	ME 13.39			ME 13.81		
	Lys 0.7	Lys 0.9	Lys 1.1	Lys 0.7	Lys 0.9	Lys 1.1
Corn	24.9	25.0	25.76	36.2	38.07	39.0
Rice bran	37.35	37.01	36.0	27.06	26.0	27.83
Broken rice	20.0	20.0	20.0	18.0	18.0	18.0
Fish meal	5.50	5.56	5.57	6.00	8.50	5.50
Soybean meal	11.0	11.0	11.0	11.5	8.00	8.00
Vitamin-mineral premix*	0.30	0.30	0.30	0.30	0.30	0.30
Lysine	-	0.23	0.47	-	0.21	0.45
Methionine	0.05	-	-	0.04	0.02	0.02
DCP	0.50	0.50	0.50	0.50	0.50	0.50
Cr_2O_3	0.40	0.40	0.40	0.40	0.40	0.40
Chemical composition						
DM	88.6	88.7	88.7	88.8	88.8	88.79
OM	93.5	93.2	93.0	94.2	93.7	93.5
CP	16.9	16.9	16.9	16.9	17.0	16.9
EE	7.43	7.40	7.33	7.02	6.54	6.48
NFE	64.8	64.6	64.6	66.0	66.3	66.3
CF	4.21	4.19	4.15	4.07	3.76	3.73
NDF	17.7	17.7	17.5	17.3	17.0	16.9
ADF	6.58	6.55	6.45	6.01	5.59	5.51
Ash	5.92	5.91	5.82	5.20	5.48	5.40
Lysine	0.71	0.90	1.10	0.71	0.90	1.10
Methionine	0.33	0.33	0.33	0.33	0.33	0.33
Ca	0.73	0.74	0.74	0.75	0.88	0.87
P	0.86	0.86	0.84	0.74	0.77	0.76
ME (MJ/kg)	13.39	13.37	13.38	13.83	13.80	13.80
Essential amino acids (EAA)						
Arginine	0.94	0.94	0.93	0.89	0.88	0.88
Isoleucine	0.66	0.66	0.65	0.64	0.63	0.63
Leucine	1.15	1.15	1.15	1.16	1.16	1.16
Lysine	0.71	0.90	1.10	0.71	0.90	1.10
Methionine	0.33	0.33	0.33	0.33	0.33	0.33
Histidine	0.16	0.16	0.16	0.15	0.15	0.15
Phenylalanine	0.66	0.66	0.66	0.66	0.64	0.64
Threonine	0.54	0.54	0.54	0.54	0.54	0.54
Valine	0.70	0.70	0.70	0.69	0.69	0.69

*: Premix-mineral-Vitamin: vitamin A: 2,500,000 UI; vitamin D_3: 600,000 UI; vitamin E: 4000 mg; vitamin K_3: 400 mg; folic acid: 80 mg; choline: 100,000 mg; manganese: 14 g; Zn: 40 g; Fe: 32 g; Cu: 48 g; I: 0.5 g; Cobalt: 0.28 g; Selenium: 0.04 g; Lys unit: %; ME unit: MJ ME/ kg DM.

Sampling procedure for excrete

Dietary samples were gathered during the last 5-day collection period for each experimental period, and total excreta was collected for the estimation of real feed and nutrient consumption, as well as chemical analyses. Excreta were collected quantitatively three times a day, at 7:00, 13:00, and 19:00 o'clock, and then frozen at -20°C (Kim et al., 2014). Feathers, scales, and detritus were avoided as much as possible. Excreta were thawed, then collected in pens and dried for 24 hours at 55-60°C in an oven before being analyzed. Representative samples were taken and maintained in airtight plastic containers at 4°C for later tests after the dried excreta were weighed, homogenized, and powdered to pass through a 0.5 mm sieve (Ravindran and Bryden, 1999).

Chemical analysis

For analyzing the composition of broken rice (BR), rice bran (RB), feed meal (FM), and soybean meal (SBM) excreta, this study used the standardof AOAC procedures to process it (AOAC, 1990). The analysis of acid detergent fiber and neutral detergent fiber were also performed, following Goering and Van Soest's procedure (1991). ME/AME contents of the feeds were calculated following Janssen (1989). Amino acids were measured in representative samples of BR, RB, FM, and SBM, as well as excreta (Procedure of 994.12, AOAC, 2000). Cr2O3 levels in diets and excreta were also measured following the method of AOAC (1990).

Measurement calculations

Each bird was weighed individually. The total feed consumption of 4 ducks per pen was used to compute daily feed intakes. Excreta were gathered quantitatively.

Apparent nutrient digestibility (%) = (Nutrient intake – Nutrient in excreta) / Nutrient intake) x 100 (Mc Donald et al., 2011).

Nitrogen retention = Nitrogen intake in feed - Nitrogen in excreta and urine (Carvalho et al., 2012) Nitrogen retention/ $BW^{0.75}$= (The amount of consumed nitrogen from feed excreted Nitrogen in feces)/ $BW^{0.75}$ (g of N per kg of $BW^{0.75}$)

Apparent excreta amino acid digestibility was calculated using Cr_2O_3 as indigestible marker (Ravindran and bryden, 1999; Bryden et al., 2009) as shown below:

$$\text{Apparent amino acid digestibility} = \frac{(AA/Cr_2O_3)d - (AA/Cr_2O_3)e}{(AA/Cr_2O_3)d}$$

Where; $(AA/Cr_2O_3)_d$ = amino acid ratio to indigestible marker in diet; $(AA/Cr_2O_3)_e$ = amino acid ratio to indigestible marker in excreta.

Statistical analysis

The data were analyzed using the ANOVA of General

Linear Model procedure following a 3x2 factorial design of Minitab Reference Manual Release 16.1.0 (Minitab, 2010). When the F-test was significant at P<0.05, paired comparisons were performed using Tukey´s procedure (Minitab, 2010).

RESULTS AND DISCUSSION

Apparent nutrient and amino acid digestibility of local Muscovy ducks at 8 weeks of age

Daily intakes of feed and nutrients of local Muscovy ducks at 8 weeks of age

The results of Table 4 show that daily intakes of DM and CP significantly (P<0.05) increased with increasing lysine levels, with the highest DM and CP values (94.8 and 18.0 g/bird, respectively) for the Lys 1.2 treatment. The ME 12.97treatment had significantly higher intakes of DM, OM, CP, CF than those of the ME 12.55 treatment (P<0.05).

In the first period, the apparent nutrient digestibility significantly increased (P <0.05) when dietary Lys levels enhanced from 0.8% to 1.2% (Table 5), particularly DM, OM, EE and ADF. For ME level factor, the ME 12.97 treatment tended to have higher DM and nutrient digestibility coefficients (P>0.05), except for ADF digestibility. There was no significant interaction between Lysine and ME factors in these results.

The apparent amino acid (AA) digestibility of local Muscovy ducks at 8 weeks of age (Table 6) showed that most of essential and nonessential amino acid digestibility coefficients tended to increase with increasing dietary lysine from 0.8% to 1.2% and ME from 12.55 MJ/kg DM to 12.97 MJ ME (P>0.05). For Lys factor, particularly, 2 essential amino acids such as lysine and valine and 4 essential amino acids such as alanine, aspartic, glutamic and serine in the Lys 1.2 treatment had significantly (P<0.05) higher digestibility coefficients than the remaining treatments. For the ME factor, the digestibility of isoleucine, phenylalanine, valine, and aspartic, glutamic, tyrosine in the ME12.97 treatment were significantly higher (P<0.05). The significant interaction was not found between two factors in these results.

The nitrogen balance of local Muscovy ducks at 8 weeks of age

N intake and N retention were the highest (P<0.05) for the Lys 1.2 and ME 12.97 treatments as compared to the remaining treatments (Table 7). The ratio of N retention and N intake was significantly (P<0.05) higher for the Lys 1.2 treatment, while increasing dietary ME levels did not influence (P>0.05). The results of N intake and N retention/$W^{0.75}$ in the Lys 1.2 and ME 12.97 treatments were significantly (P<0.05) higher than the rest of the treatments.

Table 4: Daily intakes of DM and nutrients of local Muscovy ducks at 8 weeks of age (g/bird).

Item	Lys levels			ME levels		SEM/P-value		
	Lys 0.8	Lys 1.0	Lys 1.2	ME 12.55	ME 12.97	Lys levels	ME levels	Lys*ME
DM	87.5^{b}	91.0^{ab}	94.8^{a}	88.8	93.4	1.75/0.039	1.43/0.040	2.47/0.992
OM	80.5	83.1	86.4	80.8	85.9	1.60/0.064	1.31/0.018	2.26/0.998
CP	16.5^{b}	17.2^{ab}	18.0^{a}	16.8	17.7	0.33/0.028	0.27/0.046	0.47/0.984
EE	7.27	7.54	8.06	7.39	7.85	0.37/0.341	0.30/0.305	0.52/0.123
CF	3.75	3.82	3.93	3.56	4.10	0.18/0.790	0.15/0.027	0.26/0.172
NDF	16.2	16.3	16.9	16.0	16.9	0.49/0.604	0.41/0.141	0.700.248
ADF	6.34	6.43	6.55	6.18	6.69	0.25/0.845	0.20/0.099	0.35/0.270

Means with different letters within the same rows are significantly different at the 5% level; Lys unit: %; ME unit: MJ ME/ kg DM.

Table 5: Apparent nutrient digestibility of local Muscovy ducks at 8weeks of age (%).

Item	Lys levels			ME levels		SEM/P-value		
	Lys 0.8	Lys 1.0	Lys 1.2	ME 12.55	ME 12.97	Lys levels	ME levels	Lys*ME
DM	76.6^{b}	79.2^{ab}	82.1^{a}	78.1	80.6	1.28/0.034	1.05/0.113	1.82/0.200
OM	79.9^{b}	82.4^{ab}	84.9^{a}	81.2	83.6	1.08/0.019	0.88/0.087	1.52/0.136
EE	73.8^{b}	81.6^{ab}	85.9^{a}	77.5	83.3	1.89/0.024	1.55/0.088	2.68/0.369
CF	29.9	37.1	41.2	34.7	37.4	3.41/0.101	2.78/0.513	4.83/0.458
NDF	34.6	44.1	50.3	39.8	46.2	4.21/0.063	3.44/0.216	5.96/0.052
ADF	30.7^{b}	40.1^{b}	42.9^{a}	34.2	41.6	2.81/0.026	2.30/0.042	3.99/0.226

Means with different letters within the same rows are significantly different at the 5% level; Lys unit: %; ME unit: MJ ME/ kg DM.

Table 6: Apparent amino acid digestibility of local Muscovy ducks in 8 weeks of age.

Item	Lys levels			ME levels		SEM/P-value		
	Lys 0.8	Lys 1.0	Lys 1.2	ME 12.55	ME 12.97	Lys levels	ME levels	Lys*ME
Essential amino acid								
Arginine	85.7	87.5	87.8	86.4	87.6	0.94/0.267	0.76/0.263	1.32/0.486
Isoleucine	77.1	81.0	81.0	77.9	81.5	1.23/0.067	1.01/0.025	1.74/0.131
Leucine	84.3	86.5	86.3	84.6	86.8	1.01/0.292	0.82/0.079	1.42/0.056
Lysine	80.9^{b}	86.6^{ab}	92.5^{a}	84.7	88.5	2.05/0.006	1.68/0.134	2.90/0.127
Methionine	83.2	84.0	85.1	83.1	85.2	3.28/0.915	2.68/0.570	4.64/0.105
Histidine	79.5	83.6	84.1	80.8	83.9	2.03/0.251	1.66/0.210	2.87/0.127
Phenylalanine	83.6	86.9	87.9	83.5	88.7	1.56/0.176	1.27/0.013	2.21/0.235
Threonine	77.6	79.5	80.5	78.3	80.1	2.20/0.658	1.79/0.482	3.11/0.183
Valine	77.9^{b}	83.4^{ab}	87.2^{a}	78.9	86.8	1.76/0.010	1.44/0.002	2.49/0.080
Non-Essential amino acid								
Alanine	81.7^{b}	84.9^{a}	87.1^{a}	84.3	84.9	0.80/0.002	0.65/0.520	1.13/0.552
Aspartic	82.6^{b}	85.4^{ab}	86.8^{a}	83.7	86.1	0.89/0.017	0.73/0.042	1.26/0.278
Glutamic	85.6^{b}	88.6^{a}	88.7^{a}	86.7	88.7	0.73/0.019	0.61/0.037	1.04/0.083
Glycine	76.3	79.9	82.9	77.8	81.5	1.92/0.160	1.57/0.181	2.72/0.075
Proline	85.2	88.9	90.8	86.8	89.8	1.56/0.067	1.28/0.129	2.21/0.062
Serine	79.8^{b}	83.4^{ab}	85.8^{a}	81.5	84.6	1.34/0.025	1.09/0.065	1.89/0.934
Tyrosine	81.0	83.6	84.9	81.2	85.2	1.26/0.123	1.03/0.019	1.785/0.674

Means with different letters within the same rows are significantly different at the 5% level; Lys unit: %; ME unit: MJ ME/ kg DM.

Table 7: Nitrogen intake and retention of local Muscovy ducks at 8 weeks of age.

Item	Lys levels			ME levels		SEM/P-value		
	Lys 0.8	Lys 1.0	Lys 1.2	ME 12.55	ME 12.97	Lys levels	ME levels	Lys*ME
N_{Intake}, g	2.65^{b}	2.76^{ab}	2.88^{a}	2.69	2.83	0.05/0.028	0.04/0.046	0.08/0.984
$N_{Excreta}$, g	0.84	0.74	0.65	0.78	0.71	0.05/0.56	0.04/0.246	0.06/0.101
N_{Ret}, g	1.81^{b}	2.02^{ab}	2.23^{a}	1.92	2.12	0.07/0.003	0.06/0.022	0.09/0.230
$N_{Ret.}/N_{Int.}$, %	68.1^{b}	73.1^{ab}	77.3^{a}	70.8	74.8	1.77/0.011	1.45/0.072	2.51/0.071
$N_{Int}/W^{0.75}$, g/kg$W^{0.75}$	1.67^{b}	1.72^{ab}	1.81^{a}	1.69	1.78	0.03/0.038	0.03/0.035	0.05/0.913
$N_{Re}/W^{0.75}$, g/kg$W^{0.75}$	1.14^{b}	1.26^{ab}	1.40^{a}	1.20	1.34	0.05/0.006	0.04/0.025	0.06/0.219

N: nitrogen; Int.: intake; Exc: Excreta; Ret. Retention; $W^{0,75}$: metabolizable body weight. Means with different letters within the same rows are significantly different at the 5% level; Lys unit: %; ME unit: MJ ME/ kg DM

Table 8: Daily intakes of DM and nutrients of local Muscovy ducks at 10 weeks of age (g/bird).

Item	Lys levels			ME levels		SEM/P-value		
	Lys 0.7	Lys 0.9	Lys 1.1	ME 13.39	ME 13.81	Lys levels	ME levels	Lys*ME
DM	89.4^{b}	92.5^{ab}	96.2^{a}	89.7	95.7	1.68/0.042	1.37/0.010	2.37/0.842
OM	83.9	86.5	89.8	83.7	89.8	1.57/0.062	1.28/0.006	2.22/0.846
CP	15.2^{b}	15.7^{ab}	16.3^{a}	15.2	16.2	0.28/0.047	0.23/0.008	0.40/0.820
EE	6.43	6.45	6.64	6.63	6.39	0.12/0.445	0.10/0.105	0.17/0.307
CF	3.67	3.70	3.79	3.68	3.75	0.07/0.477	0.06/0.392	0.10/0.260
NDF	15.7	16.0	16.5	15.8	16.3	0.29/0.149	0.23/0.170	0.41/0.808
ADF	5.60	5.62	5.74	5.45	5.86	0.10/0.579	0.08/0.006	0.15/0.300

Means with different letters within the same rows are significantly different at the 5% level; Lys unit: %; ME unit: MJ ME/ kg DM.

Apparent nutrient and amino acid digestibility of local Muscovy ducks at 10 weeks of age

Daily intakes of feed and nutrients of local Muscovy ducks at 10 weeks of age

The daily intakes of DM and CP were significantly (P<0.05) higher for the Lys 1.2 treatment (Table 8). The ME 12.97 treatment had significantly higher DM, OM, CP, ADF intakes than those of the ME 12.55 treatment (P<0.05).

The DM, OM and EE digestibility coefficients were significantly (P<0.05) higher for the Lys 1.1 treatment. Also, the DM, OM, EE and NDF digestibility values were higher for the ME 13.81 treatment (P<0.05) (Table 9). There was no influence of interaction between lysine and ME levels in these criteria.

Table 10 showed that amino acid (AA) digestibility of 10-week old local Muscovy ducks had 4 significantly higher essential AA (arginine, isoleucine, lysine, methionine) and 4 significantly higher non-essential amino acid (aspartic, glutamic, glycine, serine) digestibility coefficients for the Lys 1.1 treatment. Also, for ME level, the isoleucine, lysine, methionine, threonine and aspartic, glycine, proline, serine, tyrosine digestibilities were significantly (P>0.05) higher in the ME 13.81 treatment. There was no significant interaction found between two factors in these results.

The nitrogen balance of local Muscovy ducks at 10weeks of age

The results of N intake and N retention, the ratio of N retention and N intake, N Ret./ $W^{0.75}$ were significantly higher (P<0.05) for the Lys 1.1 and ME 13.81 treatments as compared to those of the remaining treatments (Table 11).

Comparing nutrient and amino acid digestibility values between 8 and 10 weeks of age of local Muscovy ducks

The digestibility values of DM, nutrients and most of AA were significantly (P<0.05) higher for 10-week-old ducks than the young ones showed in Table 12.

Table 9: The apparent nutrient digestibility (%) of local Muscovy ducks at 10 weeks of age.

Item	Lys levels			ME levels		SEM/P-value		
	Lys 0.7	Lys 0.9	Lys 1.1	ME 13.39	ME 13.81	Lys levels	ME levels	Lys*ME
DM	79.4^{b}	81.9^{ab}	84.2^{a}	79.4	84.3	1.06/0.027	0.87/0.002	1.50/0.396
OM	82.6^{b}	84.8^{ab}	86.6^{a}	82.3	86.8	0.96/0.030	0.79/0.002	1.36/0.306
EE	81.4^{b}	84.2^{ab}	87.7^{a}	82.5	86.4	1.19/0.009	0.97/0.014	1.68/0.414
CF	32.2	39.9	42.7	32.9	43.5	5.63/0.423	4.59/0.131	7.96/0.413
NDF	38.7	44.2	51.2	37.1	52.2	3.34/0.063	2.73/0.002	4.73/0.691
ADF	42.5	44.5	45.4	41.9	46.3	2.80/0.758	2.29/0.203	3.96/0.148

Means with different letters within the same rows are significantly different at the 5% level; Lys unit: %; ME unit: MJ ME/ kg DM.

Table 10: Apparent amino acid digestibility of 10-week-old local Muscovy ducks.

Item	Lys levels		ME levels			SEM/P-value		
	Lys 0.7	Lys 0.9	Lys 1.1	ME 13.39	ME 13.81	Lys levels	ME levels	Lys*ME
Essential amino acid								
Arginine	87.1^{b}	89.5^{ab}	91.1^{a}	89.2	89.2	1.01/0.048	0.83/0.976	1.43/0.835
Isoleucine	81.4^{b}	81.8^{ab}	83.7^{a}	81.2	83.4	0.54/0.025	0.44/0.004	0.76/0.107
Leucine	84.9	86.4	87.7	85.5	87.3	2.87/0.798	2.35/0.591	4.06/0.750
Lysine	87.5^{c}	90.7^{b}	93.1^{a}	89.9	90.9	0.42/0.001	0.34/0.044	0.59/0.099
Methionine	83.9^{b}	85.9^{ab}	88.1^{a}	84.4	87.6	0.99/0.033	0.81/0.018	1.41/0.164
Histidine	82.7	83.9	85.6	83.1	85.1	1.98/0.585	1.62/0.392	2.81/0.329
Phenylalanine	88.4	89.7	90.9	88.8	90.6	1.67/0.569	1.36/0.352	2.36/0.109
Threonine	78.6	79.6	81.6	76.1	83.8	3.03/0.784	2.47/0.047	4.28/0.171
Valine	86.1	86.8	88.6	86.3	87.9	1.45/0.488	1.19/0.353	2.06/0.414
Non-Essential amino acid								
Alanine	82.6	84.9	86.8	83.2	86.4	1.46/0.166	1.19/0.085	2.07/0.084
Aspartic	85.0^{b}	86.4^{b}	87.9^{a}	85.9	87.0	0.41/0.001	0.33/0.034	0.58/0.521
Glutamic	87.6^{b}	88.6^{b}	90.2^{a}	88.4	89.2	0.32/0.001	0.26/0.066	0.45/0.063
Glycine	82.8^{b}	83.6^{ab}	85.6^{a}	83.2	84.8	0.63/0.023	0.51/0.048	0.88/0.139
Proline	87.4	89.2	89.9	87.1	90.7	1.14/0.303	0.93/0.018	1.62/0.151
Serine	83.4^{b}	83.8^{ab}	86.4^{a}	83.4	85.7	0.77/0.036	0.63/0.024	1.08/0.674
Tyrosine	86.5	88.1	89.0	86.8	88.9	0.76/0.108	0.63/0.033	1.08//0.814

Means with different letters within the same rows are significantly different at the 5% level; Lys unit: %; ME unit: MJ ME/ kg DM.

Table 11: Nitrogen balance of local Muscovy ducks at 10 weeks of age.

Criteria	Lys levels			ME levels		SEM/P-value		
	Lys 0.7	Lys 0.9	Lys 1.1	ME 13.39	ME 13.81	Lys levels	ME levels	Lys*ME
N_{Int}, g	2.42[b]	2.51[ab]	2.61[a]	2.43	2.59	0.05/0.047	0.04/0.008	0.06/0.820
N_{Exc}, g	0.68[a]	0.60[ab]	0.54[b]	0.66	0.55	0.03/0.028	0.03/0.008	0.04/0.228
$N_{Ret.}$, g	1.74[b]	1.91[ab]	2.06[a]	1.76	2.04	0.06/0.009	0.05/0.001	0.09/0.496
N_{Ret}/ N_{Int}, %	71.8[b]	75.8[ab]	79.0[a]	72.5	78.6	1.38/0.011	1.13/0.003	1.96/0.301
$N_{Int}/W^{0,75}$, g/kg$W^{0,75}$	1.33	1.37	1.40	1.32	1.42	0.02/0.084	0.02/0.03	0.03/0.733
$N_{Re}/W^{0,75}$, g/kg$W^{0,75}$	0.95[b]	1.04[ab]	1.11[a]	0.96	1.12	0.02/0.005	0.02/0.001	0.04/0.305

N: nitrogen; Int.: intake; Exc: Excreta; Ret: Retention; $W^{0,75}$: metabolizable body weight. Means with different letters within the same rows are significantly different at the 5% level; Lys unit: %; ME unit: MJ ME/ kg DM.

Table 12: Comparing nutrient and amino acid digestibility values between 8 and 10 weeks of age of local Muscovy ducks.

Item	8-week old period	10-week old period	SEM/ P-value
Nutrient digestibility			
DM	79.3	81.6	1.01/0.022
OM	82.4	84.7	0.91/0.023
EE	80.4	84.5	1.62/0.023
CF	36.1	38.3	3.81/0.574
NDF	43.0	44.7	2.99/0.586
ADF	37.9	44.1	2.61/0.029
Essential AA digestibility			
Arginine	86.9	89.2	0.85/0.018
Isoleucine	79.7	82.3	0.88/0.009
Lysine	86.6	90.4	1.25/0.008
Methionine	84.1	86.0	2.04/0.369
Histidine	82.4	84.1	1.68/0.325
Phenylalanine	86.1	89.7	1.50/0.029
Threonine	79.2	79.9	2.56/0.779
Valine	82.9	87.2	1.40/0.007

The DM intake was closed with the data of 85.8 g/bird in a previous study on local Muscovy ducks fed diet contained 12.55 MJ ME/ kg DM and 20% CP (Iskandar et al., 2001). The results of DM and nutrients intakes are supported by Bhogoju et al. (2017) and Khwatenge et al. (2020) that when increasing dietary Lys levels resulted in increase of the DM and nutrients consumed and digested by ducks. Also, it could be explained by the fact that Lys is one of essential amino acids which indispensable for poultry growth. The increasing digestibility coefficients of the essential and non essential amino acids amino acids when enhancing Lys levels in the present study, could be explained that there were the associations of Lys and others to improve meat performances (Linh et al., 2018). These results obtained are in agreement with the findings of Kamisoyama et al. (2009); Widyaratne and Drew (2011) who indicated that higher dietary Lys resulted in increasing nutrient digestibility in ducks. It was due to in dietary low Lys levels, the ducks have a higher ratio of facing deficiency in diets, thus the ducks have to stimulate consumption and digestion to overcome the deficiency (Bhogoju et al., 2017). Besides, ducks fed dietary sufficient ME could accumulate the protein and utilize feed efficiently (Aftab, 2019).

The results of amino acid digestibility at 8-week-old and 10-week-old in this study were in ranges found by Hai (2017) and Sharma et al. (2018). The results of Lys digestibility obtained in a current trial are consistent with the value of 88.6% in an AA digestibility study on Pekin duck (Kong and Adeola, 2014). The results of AA digestibilities of local Muscovy ducks in a present trial are consistent with the findings that increasing dietary lysine levels resulted in increasing most of amino acid digestibility of AA digestibility study on 8-week and 10 week old Guinea fowls (Hai, 2017). In addition, our results are consistent with the statements of Sharma et al. (2018); Hung et al. (2020) that the increasing dietary lysine level could increase the digestibility of other amino acids in the diet. The digestibilities of nonessential amino acids in the experiment were equivalent to the results of Kong and Adeola (2014) with the values of alanine, aspartic, glutamic, glycine, proline, serine and tyrosine which were 83,7; 83.0, 88.3, 78.2, 93.5, 89.9 and 91.6%, respectively. It was supported by the studies of Bhogoju et al. (2017) who indicated that the supplementation of Lys in the diets enhanced the amino acid digestibility in poultry. The increase Lys in diet could increase the digestibility of other amino acids in the diet (Sharma et al., 2018). The significant interaction was not found between Lys levels and ME levels in the diets (P>0.05). It was also debated in the study of Dozier et al. (2008) and Sharma et al. (2018) which showed there was no interaction between ME and AA in diets on broiler performance.

Lys and ME in the diets could improve the nutrient and amino acid digestibility of ducks. However, not all nutrients and amino acids were improved, probably due to the genotype, sex, kind of breed and age of poultry. The findings showed that there were significant differences ($P<0.05$) of some nutrient and amino acid digestibility values between two periods, possibly due to different age of ducks. The results obtained are corresponded with the statements of Olukosi et al. (2007) and Hai (2017) that the older poultry get higher nutrient and AA digestibility values, due to completely digestive organ development.

Nitrogen which cannot use all by the body should be converted and removed from the body. Moreover, nitrogen in feces was produced from metabolizable nitrogen which cannot absorb by poultry body. The results, a positive effect of Lys and ME on nitrogen balance was found out. The results of N retention obtained are consistent with the findings of Kim et al. (2014) and Chalova et al. (2016) that increasing dietary amino acid supplement could reduce nitrogen excreted resulted in increase of nitrogen retention. Nitrogen balance and nitrogen retention mostly shows the consumption of protein by body, if the energy in the diet is sufficient and protein is low, the N excretion will be decreased (Zhao et al., 2019). The ratio of N retention and N intake significantly increased with increasing Lys levels from 0.8 to 1.2% and from 0.7 to 1.1% for 8 week old duck and 10 week old duck, respectively. The values obtained in this study are similar to the findings of a previous research on Guinea fowls when increasing dietary Lys levels, stated by Hai (2017).

CONCLUSIONS AND RECOMMENDATIONS

It was concluded that:

- At 8 weeks of age the apparent digestibilities of DM, OM and EE increased with enhancing the dietary levels of lysine and they were improved with increasing levels of both lysine and ME at 10 weeks of age.
- For the 8-week old ducks, the valine digestibility rose with increasing lysine and ME levels, while lysine digestibility increased when enhancing dietary lysine levels, and the alanine, aspartic and glutamic digestibilities were improved with augmenting both lysine and ME levels.
- At 10 weeks of age, when increasing the lysine and ME levels, isoleucine, lysine and methionine digestibilities were improved, and the similar improvements were for aspartic, glycine and serin.
- Generally the digestibility coefficients of nutrients and most of amino acids of the Muscovy ducks at 10-week-old were higher than those at 8-week-old.

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NOVELTY STATEMENT

To the best our knowledge, this study is the first research on Muscovy ducks using Lysine and Energy Levels on Apparent Nutrient, Nitrogen, and almost all of Amino Acids Digestibility.

AUTHOR'S CONTRIBUTION

All authors contributed equally to the manuscript.

Conflict of interest

The authors have declared no conflict of interest.

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