Veterinary Integrative Sciences 2025; 23(2): e2025055-1-11. DOI: 10.12982/VIS.2025.055

Veterinary Integrative Sciences
ISSN; 2629-9968 (online)

Research article

Determination of nutrient digestibility, and apparent and nitrogen-adjusted metabolizable energy of paddy rice and brown rice for Luong Phuong chicken

La Van Kinh[1], Phan Van Sy[2] and Nguyen Vu Thuy Hong Loan[1*]

[1] Faculty of Veterinary Medicine and Animal Husbandry, HUTECH University, Binh Thanh district, Ho Chi Minh City 700000, Vietnam
[2] Institute of Animal Sciences for Southern Vietnam, Hiep Thang, Binh Thang, Di an, Binh Duong 824179, Vietnam

Abstract

A trial was conducted with 210 Luong Phuong cockerels to investigate the digestibility of dry matter, protein, fat, fiber, minerals, nitrogen-free extract, and metabolizable energy value of IR50404 paddy rice and brown rice in the diet. Cockerels, averaging 558 g/bird, had their ceca removed and were randomly assigned to metabolic cages, with 3 dietary treatments and 5 replicates. The diets included: a basal diet; and two experimental diets containing 20% paddy rice and 60% brown rice in the basal diet. The trial lasted 7 days, in which a 4-day adaptation and a 3-day collection. Digestibility of individual paddy rice and brown rice in the experimental diets was calculated by difference method. Results indicated that digestibility of dry matter (range 72.8-74.11%), neutral detergent fiber (64.94-69.83%) and total ash (60.23-62.54%) were not different between paddy and brown rice ($P>0.05$); however, the digestibility of organic matter (87.52% vs 77.55%), crude protein (79.63% vs 72.31%), ether extract (79.74% vs 64.77%) and nitrogen-free extractives (46.42% vs 35.47%) in paddy rice were lower than those in brown rice ($P<0.05$). Paddy rice contained higher apparent metabolizable energy (3,212 vs 2,867 kcal/kg air DM) and nitrogen-adjusted metabolizable energy (3,014 vs 2570 kcal/kg air DM) than those in brown rice. In conclusion, brown rice contains higher nutritive value than paddy rice for broiler chicken, however, two feed ingredients can be a good energy source for poultry.

Keywords: Brown rice, Digestibility, ME value, Paddy rice, Poultry.

*Corresponding author: Nguyen Vu Thuy Hong Loan , Faculty of Veterinary Medicine and Animal Science, HUTECH University, Binh Thanh District, Ho Chi Minh City 700000, Viet Nam. Email: nvth.loan@hutech.edu.vn. ORCID: 0000-0001-8632-1662.

Article history; *received manuscript: 15 July 2024,*
revised manuscript: 30 August 2024,
accepted manuscript: 10 September 2024,
published online: 25 September 2024
Academic editor; *Saowaluck Yammuen-art*

INTRODUCTION

Viet Nam has imported a lot of rice varieties in order to improve rice productivity and quality, in which, IR50404 rice variety was imported from IRRI in 1992, and widely developed in the country, particularly in the Mekong River Delta (Tam et al., 2020). In present, these authors reported that average yield of IR50404 was 5-5.5 tons/ha/crop and an estimated cultivated area of 300 thousand ha in the Mekong River Delta. However, as compared with other varieties, rice quality of IR50404 was lower so that impaired to export this rice production. Therefore, the study on using IR50404 rice as feeding livestock is a way to sustainably develop this variety for long-term. In fact, some countries with a long tradition of rice cultivation, such as India, China and Bangladesh, have studied on the use of rice for feeding animals. More-ever, Vietnam still has to import about 10,32 million tons of feed ingredients annually and nearly half of them are energy-rich feed (3.9 million tons) for animal feed (MARD, 2023). In addition, the price of energy-rich feeds recently like corn, cassava meal and wheat has risen consistently, partly due to their use in producing bioethanol.

Luong Phuong chicken is a colored feathered meat chicken breed imported into Viet Nam. This chicken breed has made an important contribution to hybrid formulas to improve productivity for local chicken breeds in the country (Desvaux et al., 2008). Luong Phuong chicken has delicious meat quality, adapts well to farming conditions in Viet Nam and is widely raised, particularly for free range (Son et al., 2021). However, to our knowledge, there is no publication on the use of paddy and brown rice variety IR50404 for feeding poultry in general and Luong Phuong broiler chicken in particular.

This study aimed therefore to create a database on the digestibility of nutrients as well as the metabolizable energy values of paddy and brown rice as broiler feed. The objective of this experiment is to conduct a digestibility trial to determine the digestibility of key nutrients (dry matter, organic matter, crude protein, crude fiber, natural detergent fiber, nitrogen-free extractives, total ash) and the metabolizable energy values of paddy and brown rice for chicken feeding.

MATERIALS AND METHODS

Animal ethics

The study was conducted with ethical approval for animal care, housing, sample collection under the Animal Welfare Assessments granted by the Council for Science and Education, Faculty of Veterinary Medicine and Animal Husbandry, HUTECH University under No. DT202101/KTYCN.

Materials

In this experiment, two feed ingredients were used including: Paddy IR50404 and Brown rice IR50404.

Luong Phuong cockerels aged 35-42 days and weighing 558 g had their ceca removed using the method described by Payne et al. (1971) and Ragland et al. (1999). Before surgery, the chickens were fasted for 24 hours and deprived of water for 12 hours. They were fully anesthetized during the procedure. Following surgery, the chickens underwent a 24-hour fasting period and were provided only with glucose water. The chickens were allowed a 2-week recovery period before the start of the experiment.

Experimental design

A total of 210 Luong Phuong cockerels were randomly assigned to metabolic cages (3 diets with 5 replicates of 14 birds each). The diets used in the experiment included:

Basal diet (Table 1);

Experimental diet 1 (T1): 80% basal diet + 20% paddy, and

Experimental diet 2 (T2): 60% basal diet and 40% brown rice (Table 2)

Table 1 Ingredients and nutritive value of basal diet (%)

No.		g/100 g air DM
Ingredients		
1	Corn	70.10
2	Soy bean meal 47% CP	22.80
3	Fish meal 55% CP	3.00
4	Premix	0.30
5	Lysine	0.16
6	Methionine	0.17
7	Seashell powder	0.48
8	DCP	1.17
9	Salt	0.36
10	Celite	1.50
	Total	**100**
Nutritive value (%)		
1	Dry matter	89.21
2	Crude protein	18.74
3	Crude fiber	1.70

Table 2 Ingredients and nutritive value of experimental diet (%)

No.		T1	T2
Ingredients (g/100 g air DM)			
1	Basal diet	80	60
2	Paddy rice	20	-
3	Brown rice	-	40
Nutritive value (%)			
1	Dry matter	88.16	91.18
2	Crude protein	16.06	15.39
3	Crude fiber	3.04	1.22

Feeding and fecal collection methods

According to Farrell (1978) method, chickens were trained to consume their entire daily feed intake within two hours, twice a day, for ten days, with each feeding session lasting one hour (Table 3). During training, feed intake was gradually increased to meet daily requirements. Chickens were fasted for 32 hours before the start of the experiment, and feces were collected 8 hours after food withdrawal. Each chicken received 30g of glucose per head mixed with drinking water to limit amino acid decomposition for energy supply. After the 32-hour fasting period, experimental feeding commenced. Feeding was completed within one hour, and feces were collected. Feces were collected twice daily, and after each collection, feeding was resumed for one hour. This process continued until the fourth day, with feces collected up to 32 hours after the last feeding. Fecal collection trays were placed below the chicken cages, lined with nylon paper (pre-weighed) to collect the feces. After each collection, the trays were removed, and the feces were carefully separated from feathers and scales, then weighed along with the nylon paper. The initial weight of the nylon paper was subtracted to determine the feces weight. Feces collected over three days were pooled, cooled, dried at 56°C for three days, refrigerated, and subsequently analyzed.

Table 3 Allocating time to perform the experiment

Day	Hour	Time after withdrawal of food (hours)	Works running
1	8:00	0	Withdrawal of food: Fasted for 32 hours
1	16:00	8	Fed 30g of glucose/head (mixed with water)
2	16:00	32	Feeding experimental feed and collecting feces
3	8:00	48	Feeding experimental feed and collecting feces
3	16:00	56	Feeding experimental feed and collecting feces
4	8:00	72	Feeding experimental feed and collecting feces
4	16:00	80	Feeding experimental feed and collecting feces
5	8:00	96	Collecting feces
5	16:00	104	Collecting feces
6	8:00	120	Collecting feces - end of experiment

Digestibility calculations

Digestibility of the basal diet and experimental diet

Apparent digestibility of diet (AD) was calculated as follows:

$$AD (\%) = 100[(NI - FN)/NI] \times 100$$

In which, NI was nutrient intake (g/day) and FN was nutrient in waste (g/day).

Digestibility (%) of test feed ingredient was calculated by the difference method

$$A (\%) = [100(T-B)]/a + B$$

In which: A was the digestibility of the test feed ingredient (%);
B was the digestibility of the basal diet (%);
T was digestibility of the experimental diet composed by test ingredient and basal diet (%);
a was the percentage of test feed ingredients in the experimental diet.

Calculating apparent metabolizable energy (AME)

$$AME = GEd - GEe \times AIA\_d/AIA\_e$$ (Scott and Hall., 1998)

In which:
GEd was the gross energy content of the experimental feed (kcal/kg);
GEe was the gross energy content of waste - feces and urine (Kcal/kg);
AIA_d was percentage of indicator in feed (%);
AIA_e was percentage of indicator in feces (%).

Nitrogen-adjusted metabolizable energy (MEn)

The nitrogen-adjusted energy is calculated according to the formula:

$$MEn = AME - 8.22 \times NR$$ (Lammers et al., 2008)

$$\textit{with } NR = (Nd\text{-}Ne \times AIA\_d/AIA\_e) \times 10$$

In which: Nd is the nitrogen content in the experimental diet (g).
Ne is the nitrogen content in the waste (g).

Statistical analysis

All data were processed with descriptive statistics using the Minitab 16.2.0 (2010) and the mean (M) and standard error of the mean (SEM) were taken. Tukey pair-wise comparison were used to determine differences between treatment means at $P < 0.05$. Statistical model:

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$$

Where: μ is the general mean; α_i is the effect of feed ingredients (i: 1-2) or diet (i: 1-3); e_{ijk} is the random effect

RESULTS

Chemical composition of paddy and brown rice

Ingredients and nutritional values of feeds are essential tools for establishing feed formulas that achieve optimal pricing and nutritional balance. To utilize paddy and brown rice as raw materials in industrial animal feed factories, thorough evaluation and analysis are necessary to establish a comprehensive database. Table 4 presents the results of the analysis determining the chemical composition of paddy and brown rice.

Table 4 Chemical composition of paddy and brown rice varieties IR50404

Chemical composition	Paddy	Brown rice
Dry matter (DM, %)	88.74	87.81
Organic matter (% DM)	96.76	98.56
Crude protein (% DM)	7.47	7.83
Ether extract (% DM)	1.80	2.26
Crude fiber (% DM)	9.14	1.12
NDF (% DM)	16.18	9.17
Total ash (% DM)	3.24	1.44
Nitrogen-free extractives (% DM)	66.85	75.78

Feed intake and daily nutrient intake (g/head/day)

The daily feed intake of experimental chickens varied between diets, ranging from 97.67 to 116.67 g/head/day (Table 5). Because feed intake differed among diets, the absorption of nutrients also varied. Specifically, there was a difference in daily crude protein intake between the base diet (18.88 g/head/day) and the two experimental diets (15.99 g/head/day and 14.36 g/head/day). Additionally, there were differences in the daily intake of crude fiber and NDF between the rice diet and the other two diets. Thus, rice-dominant diet had a daily crude fiber intake of 3.03 g/head/day, which was 77.19% higher than that of the base diet and 165.78% higher than that of the brown rice diet. Similarly, the daily NDF intake of experimental chickens in the rice diet was 100% to 224% higher than that in the base diet and the brown rice diet. The chemical composition of different cereal grains varies according to their origin, which is consistent with previous research (Huang et al., 2012; Li et al., 2024). However, the daily intake of organic matter and non-nitrogen derivatives in the experimental diets was similar.

Amount of feces excreted and nutrients in feces excreted daily in experimental chickens

Amount of feces excreted was collected twice daily and thoroughly homogenized over a 3-day period prior to analysis. As presented in Table 6, fecal output and the remaining nutrient content in the waste exhibited significant variability across the dietary treatments. The highest rate of fecal excretion was observed in the control diet, reaching 192.58 g/head/day, followed by the paddy diet at 177.83 g/head/day, and the lowest excretion rate of 167.17 g/head/day occurred in the brown rice diet. This disparity in fecal output can be attributed to several factors, including daily feed intake, efficiency of feed utilization, water consumption, and the amount of uric acid excreted via the feces.

Table 5 Daily feed and nutrient intake (g/head/day)

Items	Basal diet	T1	T2
Daily feed intake (g air DM)	112.92 ± 12.81	116.67 ± 21.83	97.67 ± 16.90
Daily nutrient intake (g/head/day)			
Dry matter	100.73 ± 11.43	99.55 ± 17.26	93.31 ± 13.72
Organic matter	84.76 ± 9.61	83.09 ± 11.14	78.83 ± 11.59
Crude protein	18.88 ± 2.14	15.99 ± 2.77	14.36 ± 2.11
Ether extract	1.46 ± 0.17	1.26 ± 0.22	1.33 ± 0.20
Crude fiber	1.71 ± 0.19	3.03 ± 0.52	1.14 ± 0.12
NDF	5.95 ± 0.68	10.24 ± 1.62	6.22 ± 0.92
Total ash	5.11 ± 0.58	4.58 ± 0.79	3.16 ± 0.27
Nitrogen-free extractives	62.71 ± 7.11	62.81 ± 10.89	61.97 ± 9.11

Table 6 Amount of feces and nutrients in excreted feces (g/head/day)

Items	Basal diet	T1	T2
Amount of feces excreted	192.58 ± 29.91	177.83 ± 23.97	167.17 ± 22.76
Nutrients in feces			
Dry matter	25.87 ± 5.05	27.35 ± 4.16	23.43 ± 3.71
Organic matter	11.01 ± 2.15	13.02 ± 1.98	9.74 ± 1.54
Crude protein	2.91 ± 058	3.00 ± 0.46	2.42 ± 0.38
Ether extract	0.23 ± 0.04	0.26 ± 0.04	0.23 ± 0.04
Crude fiber	0.75 ± 0.13	1.53 ± 0.23	0.53 ± 0.08
NDF	1.64 ± 0.32	3.14 ± 0.48	1.73 ± 0.27
Total ash	0.84 ± 0.16	1.01 ± 0.15	0.76 ± 0.12
Nitrogen-free extractives	7.13 ± 1.39	8.24 ± 1.25	6.56 ± 1.04

The nutrient composition of the excreta was markedly influenced by the dietary treatments. Broilers fed the paddy-based diet exhibited significantly higher levels of nutrient excretion compared to the other dietary groups. Specifically, the protein content of the waste from the paddy diet was 3 g/bird/day, exceeding that of the control diet at 2.91 g/bird/day and the 40% brown rice diet at 2.42 g/bird/day. Similarly, the daily fiber output of broilers consuming the paddy ratio was 2-3 times greater than those fed the control and brown rice diets. This disparity in fiber excretion is likely attributed to the inherently higher fiber fraction in paddy rice compared to the other dietary ingredients. Elevated dietary fiber levels are known to impair nutrient digestibility and increase the excretion of undigested fiber and associated nutrients.

Digestibility of nutrients in basal and experimental diets

The digestibility of nutrients in the base diet and the experimental diets is summarized in Table 7. Overall, most of the nutrients showed similar digestibility across the diets, except for fat and minerals. However, the basal diet exhibited higher levels of crude fiber and minerals compared to the diet containing 20% paddy and 40% brown rice. This difference can be attributed to the inclusion of paddy rice, particularly its husk, which contains high levels of silicon, impacting the digestibility of these nutrients.

Conversely, substituting 40% of the base diet with brown rice reduced the crude fiber content and increased crude fat proportions. Notably, there was no statistically significant difference in crude fat digestibility between the diet with paddy rice and that with brown rice substitution. The digestibility of non-nitrogen derivatives was highest among nutrients, ranging from 87.12% to 88.83%, followed by organic matter at 84.60% to 86.95%. Crude fiber digestibility in the diets was the lowest, ranging from 50.46% to 54.21%.

Table 7 Nutrient digestibility of the basal and experimental diets (%)

Items	Basal diet	T1	T2	*P*
Dry matter	73.06 ± 2.60	73.01 ± 3.42	73.48 ± 0.64	9.959
Organic matter	86.38 ± 1.31	84.60 ±1.95	86.95 ± 0.32	0.077
Crude protein	83.86 ± 1.56	81.55 ± 2.34	82.17 ± 0.43	0.162
Ether extract	83.84 ± 1.56[a]	80.02 ± 2.53[b]	82.20 ± 0.43[ab]	0.028
Crude fiber	54.21 ± 4.41	50.46 ± 6.27	51.09 ± 1.19	0.471
NDF	71.10 ± 2.79	69.88 ± 3.53	70.59 ± 0.72	0.806
Total ash	82.73 ± 1.66[a]	78.23 ± 2.67[b]	74.65 ± 0.61[c]	0.000
Nitrogen-free extractives	88.07 ± 1.15	87.12 ± 1.63	88.83 ± 0.27	0.157

[a,b:] *Mean numbers in the same row with different letters are statistically different at P≤0.05*

Nutrients' digestibility of paddy and brown rice

The digested results of the basal diet and the experimental diets were calculated using the difference method to determine the digestibility of the chemical compositions. The calculated results are summarized in Table 8. The digestibility of nutrients in paddy varied significantly. Nitrogen-free extractives showed the highest digestibility at 83.29%, while CF had the lowest at 35.47%. It is noteworthy that the fiber digestibility results in this experiment were lower compared to those reported by Sittiya et al. (2011). The remaining nutrients exhibited digestibility rates ranging from 60.23% to 77.55%, falling within the normal range, similar to other ingredients. This indicates that the digestibility of nutrients in paddy was lower compared to both the experimental diet containing 20% paddy and the base diet.

In contrast, brown rice demonstrated high digestibility for certain nutrients: nitrogen-free extractives at 89.96%, followed by organic matter at 87.82%. Crude fiber had the lowest digestibility at 46.42%, with total ash at 62.54% (Table 7). Dry matter digestibility of brown rice was higher compared to paddy, as well as both the basal diet and the diet containing brown rice.

Table 8 Nutrient digestibility of paddy rice and brown rice (%)

Items	Paddy rice	Brown rice	SEM	*P*
Dry matter	72.80 ± 4.13	74.11 ± 4.54	4.34	0.646
Organic matter	77.55 ± 3.68[b]	87.82 ± 2.29[a]	3.07	0.001
Crude protein	72.31 ± 4.33[b]	79.63 ± 2.76[a]	3.63	0.013
Ether extract	64.77 ± 4.68[b]	79.74 ± 2.76[a]	3.85	< 0.001
Crude fiber	35.47 ± 3.60[b]	46.42 ± 7.80[a]	6.07	0.021
NDF	64.96 ± 6.83	69.83 ± 4.49	5.95	0.232
Total ash	60.23 ± 4.85	62.54 ± 3.13	4.08	0.397
Nitrogen-free extractives	83.29 ± 4.32[b]	89.96 ± 2.00[a]	3.37	0.014

[a,b:] *Mean numbers in the same row with different letters are statistically different at P≤0.05*

Apparent and nitrogen-adjusted metabolizable energy of paddy and brown rice

The apparent metabolizable energy values of paddy and brown rice were 2,876 and 3,212 kcal/kg, respectively, while the nitrogen-adjusted metabolizable energy values were 2,570 and 3,041 kcal/kg (Table 9).

Table 9 Metabolizable energy of paddy rice and brown rice (kcal/kg)

Feedstuff	Paddy Rice	Brown Rice	SEM	*P*
AME (Scott and Hall., 1998)	2,876	3,212	165	0.01
MEn (Lammers et al., 2008)	2,570	3,041	259	0.01

AME: apparent metabolizable energy; MEn: Nitrogen-adjusted metabolizable energy

DISCUSSION

Chemical composition of paddy and brown rice

The Table 3 reveals significant differences in nutrient content between paddy and brown rice, particularly in crude fiber (CF) and Neutral Detergent Fiber (NDF) ratios, which are notably higher in paddy rice. This disparity is attributed to the presence of rice husk in the paddy, which increases fiber content.

Conversely, brown rice contains higher levels of fat and crude protein compared to paddy rice. However, international publications indicate wide variations in nutrient content, such as dry matter ranging from 83.6% to 92.4% (calculated under specified conditions) for rice. Crude protein (CP) content ranges from 5.9% to 11.8%, CF from 8.6% to 14.8%, and NDF from 15.0% to 32.2% (all calculated based on dry matter). Corresponding values for brown rice show dry matter percentages ranging from 85.4% to 94.2%, CP from 7.5% to 14.3%, CF from 0.30% to 10.5%, and NDF from 0.40% to 9.3%. These variations stem from differences in documentation sources, rice varieties, cultivation methods, and soil conditions (FAO, 2014).

The comprehensive understanding of these nutritional variations is crucial for formulating balanced diets that meet the specific nutritional needs of animals while optimizing cost-effectiveness in feed production.

Feed intake and daily nutrient intake (g/head/day)

The findings in feed intake and daily nutrient intake in the current study underscore the significant impact of diet composition on nutrient intake by chickens. The higher crude fiber and NDF content in rice-dominant diet indicates a greater fiber load, potentially affecting digestibility and overall nutrient utilization. Understanding these dietary differences is crucial for optimizing feed formulations that meet nutritional requirements efficiently. The results of the NDF composition in our experiment for the T1 diet were like the report by Li et al. (2024). The DM and CP contents were higher compared to the report by Li et al. (2024). On the other hand, the NDF composition in the T2 diet was lower than the study by Li et al. (2024). The DM and CP contents were also higher compared to the report by Li et al. (2024). This is also reasonable, as their study used corn to replace wheat in the broiler diet formulation. Compared to the nutrient content of the T1 diet containing paddy, the T2 diet containing Brown rice tends to have lower CP and NDF. This suggests that replacing paddy with brown rice in the formula will lead to savings in protein components.

Amount of feces excreted and nutrients in feces excreted daily in experimental chickens

The importance of considering the fiber composition of feed ingredients when formulating poultry diets is underscored by the findings from this study. Optimizing the balance of dietary fiber is crucial for maximizing nutrient utilization efficiency and minimizing nutrient waste output in commercial broiler production systems. Previous research has consistently demonstrated the significant impact of diet composition on fecal output characteristics and nutrient excretion patterns in chickens. A comprehensive understanding of these diet-excreta relationships is essential for developing feeding programs and waste management strategies that enhance production sustainability.

Digestibility of nutrients in basal and experimental diets

The digestibility of nutrients in the different treatments, leading to variations in crude fiber components, nutritional constituents, and minerals, has been reported to impact the growth performance of livestock in numerous studies. The inclusion of various feed ingredients, such as paddy rice and brown rice, can alter the crude fiber content and mineral composition of the diets, consequently influencing the digestibility and utilization of these nutrients by the animals (NRC, 1994; Choct, 1997; Leeson and Summers, 2005; Selle et al., 2006; Jimenez-Moreno et al., 2009; Sarikhan et al., 2010).

Take everything into consideration, the influence of dietary composition, particularly fiber content, on nutrient digestibility in poultry diets. Understanding these variations is essential for formulating balanced diets that maximize nutrient utilization and support optimal poultry performance.

Nutrients' digestibility of paddy and brown rice

The digestibility of OM, CP, CF, and NFE was similar and comparable to the experimental and basal diets. Significant variations were observed in the digestibility of OM, CP, EE, CF and NFE between paddy and brown rice (P<0.05). These findings have also been mentioned in several previous studies (NRC, 1994; Sauvant et al., 2004; Sittiya et al., 2011; Mateos, et al., 2012; Francesch and Cartañà, 2018).

Apparent and nitrogen-adjusted metabolizable energy of paddy and brown rice

Our study's energy values for paddy were lower than those calculated using formulas from the Institute of Animal Husbandry (2001): 2,943 kcal/kg, and Kinh (2003): 2,905 kcal/kg. However, our apparent metabolizable energy value for paddy was higher than the results published by Sittiya et al. (2011): 2,790 kcal/kg. Conversely, the metabolizable energy value of brown rice in our experiment was higher than that calculated by Kinh (2003): 3,067 kcal/kg, and lower than the calculation from the Institute of Animal Husbandry (2001): 3,301 kcal/kg. Nevertheless, the nitrogen-adjusted metabolizable energy value from our experiment was higher than the calculated value from the Institute of Animal Husbandry (2001): 2,941 kcal/kg, and comparable to the research results of Chau (2014): 3,028 kcal/kg.

In general, the AME ranged 2,876-3,212 kcal/kg air DM, and MEn ranged 2,570-3,041 kcal/kg air DM; and these values were higher in brown rice than in paddy rice (P<0.05). As per 1 kg DM calculation, paddy rice contained 3,240 kcal AME and 2,890 kcal MEn; and brown rice of 3,658 kcal AME and 3,463 kcal MEn.

CONCLUSIONS

The values of digestibility of dry matter, neutral detergent fiber and total ash were not different between paddy and brown rice; however, the digestibility of organic matter, crude protein, ether extract and nitrogen-free extractives in paddy rice were lower than those in brown rice. Paddy rice contained higher apparent metabolizable energy and nitrogen-adjusted metabolizable energy than those in brown rice.

DATA AVAILABILITY

All data generated or analyzed during this study are included in this published article.

AUTHOR CONTRIBUTIONS

La Van Kinh, Phan Van Sy: Conceptualization and design the experiment, investigation, supervision, editing and finalization.

Nguyen Vu Thuy Hong Loan: Investigation, methodology, formal analysis, manuscript preparation.

CONFLICT OF INTEREST

The authors have declared that no competing interests exist.

REFERENCES

Choct, M., 1997. Feed non-starch polysaccharides: Chemical structures and nutritional significance. Feed. Milling. Int. 6, 13-26.

Desvaux, S., Dinh Ton, V., Dang Thang, P., Thi Thanh Hoa, P., 2008. A general review and description of the poultry production in Vietnam. Agricultural Publishing House, Ha Noi, pp. 1-38.

FAO, 2014. Feedipedia - Animal feed resources information system. Available online: http://www.feedipedia.org/node/12524

Farrell, D.J., Thomson, E., Du Preez, J.J., Hayes, J.P., 1991. The estimation of endogenous excreta and the measurement of metabolizable energy in poultry feedstuffs using four feeding systems. four assay methods and four diets. Br. Poult. Sci. 32(3), 483–499.

Francesch, M., Cartañà, M., 2018. Nutritional factors affecting the digestibility of nutrients and the energy content of poultry feeds. J. Appl. Poult. Res. 27(4), 544-549.

Chau, H.L.Q., 2014. Determine the metabolizable energy value with nitrogen correction. Ileal digestibility of nutrients of some types of feed and application in establishing broiler rations (Doctoral thesis). Hue University. (In Vietnamese)

Huang, Q., Piao, X.S., Ren, P., Li, D.F., 2012. Prediction of digestible and metabolizable energy content and standardized heal amino acid digestibility in wheat shorts and red dog for growing pigs. Asian-Australas. J. Anim. Sci. 25(12), 1748–1758.

Institute of Animal Husbandry, 2001. Ingredients and nutritive value of feedstuff for livestock and poultry. Agriculture Publishing House, Hanoi.

Jimenez-Moreno, E., Gonzalez-Alvarado, J.M., Lazaro, R., Mateos, G.G., 2009. Effects of type of cereal, heat processing of the cereal, and inclusion of fiber in the diet on productive performance and digestive traits of broilers. Poult. Sci. 88(9), 1982-1991.

Kinh, L.V., 2003. Composition and nutritional value of Vietnamese animal feeds. Agriculture Publishing House, Hanoi. (In Vietnamese)

Lammers, P.J., Kerr, B.J., Honeyman, M.S., Stalder, K., Dozier, W.A., Weber, T.E., Kidd, M.T., Bregendahl, K., 2008. Nitrogen-corrected apparent metabolizable energy value of crude glycerol for laying hens. Poult. Sci. 87, 104–107.

Leeson, S., Summers, J.D., 2005. Commercial poultry nutrition, 3rd edition. University Press, Nottingham.

Li, K., Bai, G., Liu, Z., Zhao, Y., Zhong, R., Liu, L., Yan, H., Zhou, J., Chen, L., Zhang, H., 2024. Comparison of metabolizable energy values of wheat, paddy, and brown rice in roosters determined by free-feeding and tube-feeding methods. Anim. Res. One. Health. 2, 193–203.

Mateos, G.G., Jiménez-Moreno, E., Serrano, M.P., Lázaro, R.P., 2012. Poultry response to high levels of dietary fiber sources varying in physical and chemical characteristics. J. Appl. Poult. Res. 21(1), 156-174.

Ministry of Agriculture and Rural Development of Viet Nam, 2023. Available online: https://mard.gov.vn/en/Pages/default.aspx

National Research Council, 1994. Nutrient requirements of poultry, 9th revevised. edition. National Academy Press, Washington, D.C.

Payne, W.L., Kifer, R.R., Snider, D.G., Combs, G.F., 1971. Studies of protein digestion in the chicken. 1. Investigation of apparent amino acid digestibility of fish meal protein using cecectomized. adult male chickens. Poult. Sci. 50, 143-150.

Ragland, D., Thomas, C.R., Elkin R.G., Shafer D.J., Adeola, O., 1999. The influence of cecectomy on metabolizable energy and amino acid digestibility of selected feedstuffs for white pekin ducks. Br. Poult. Sci. 78, 707-713.

Sarikhan, M., Shahryar, H.A., Gholizadeh, B., Hosseinzadeh, M.H., Beheshti, B., Mahmoodnejad, A., 2010. Effects of insoluble fiber on growth performance, carcass traits and ileum morphological parameters on broiler chick males. Int. J. Agric. Biol. 12(4), 531-536.

Sauvant, D., Perez, J.M., Tran, G., 2004. Tables of composition and nutritional value of feed materials: pigs, poultry, cattle, sheep, goats, rabbits, horses and fish. Wageningen Academic, Netherlands.

Scott, T.A., Hall, J.W., 1998. Using acid insoluble ash marker ratios (diet:digesta) to predict digestibility of wheat and barley metabolizable energy and nitrogen retention in broiler chicks. Poult. Sci. 77, 674-679.

Selle, P.H., Ravindran, V., Bryden, W.L., Scott, T., 2006. Influence of dietary phytate and exogenous phytase on amino acid digestibility in poultry: a review. J. Poult. Sci. 43(2), 89-103.

Sittiya, J., Limpanasithikul, W., Sindhusake, T., 2011. Nutrient digestibility and performance of broiler chickens fed diets containing various levels of pangola grass hay. Thai J. Vet. Med. 41(3), 309-316.

Sittiya, J., Yamauchi, K., Morokuma, M., 2011. Chemical composition, digestibility of crude fiber and gross energy, and metabolizable energy of whole paddy rice of momiroman. J. Poult. Sci. 48(4), 259-261.

Son, V.N., Khanh, N.K., Thang, C.M., Linh, N.T.T., Oanh, B.T.K., 2021. Determination of dietary restriction for ZL chicks in the gilt period from 9 to 19 weeks of age. J. Sci. Technol. 129, 49-57. (In Vietnamese)

Tam, N.T., Hue, N.H., Chanh N.V., Tran, K.T.H., 2020. The effect of seasonal and harvesting stages on agronomic traits, yield components and grain quality of IR50404 rice variety. AGU Int. J.Sci. 24(1), 47-58. (In Vietnamese)

How to cite this article;

La Van Kinh, Phan Van Sy and Nguyen Vu Thuy Hong Loan. Determination of digestibility rates of nutrients, apparent metabolizable energy values, and nitrogen-adjusted metabolizable energy values of paddy rice and brown rice for poultry. Veterinary Integrative Sciences. 2025; 23(2): e2025055-1-11.