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Effect of Diets Formulated with Different Apparent Metabolizable Energy Values of Basal Feedstuffs on the Growth and Shank and Keel Lengths of ItikPINAS-Itim (*Anas platyrhynchos*)

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Abstract

The study examined how diets formulated based on the actual (AV), intermediate (IV), and published (PV) apparent metabolizable energy (AME) values of basal feeds (BF), such as corn (local), rice bran (D1), and soybean meal (US), affect the performance of ItikPINAS-Itim (IP-Itim) (Anas platyrhynchos). The AME values for corn, rice bran, and soybean meal were 3690, 3498, and 3100 kcal/kg for AV; 3495, 2949, and 2803 kcal/kg for IV; and 3300, 2400, and 2500 kcal/kg for PV. A total of 190-day-old female IP-Itim ducks were randomly divided into three dietary treatments, with six replicates per group, and raised intensively for 12 weeks. Researchers measured growth performance, feed-related economics, and shank and keel length (SKL). Data analysis involved one-way ANOVA using STAR (v. 2.0.1) and repeated measures (RM) ANOVA. The ducks' growth performance, livability, and uniformity showed no significant differences across diet groups. RM analysis also revealed no interaction effect between diet and week on the weekly measured parameters. Ducks fed AV and IV diets had significantly higher total feed intake ($p < 0.05$) and feed conversion ratios ($p < 0.01$). However, these groups showed significantly lower total feed costs ($p < 0.01$) and feed cost per kilogram of gain ($p < 0.01$). Finally, SKL measurements were statistically similar among all groups. The findings suggest that AV and IV AME values for BF can be used in formulating cost-effective diets for IP-Itim without affecting growth performance.

***Keywords**:* corn, feed cost, least-cost diets, rice bran, soybean meal

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1. Introduction

New breeds of Philippine mallard ducks have been developed to support the country's unique and specialized duck production. These breeds were improved through successive generations of linebreeding and selection and are commonly called ItikPINAS (IP), which includes two pure lines (IP Itim and IP Khaki) and one commercial hybrid (IP Kayumanggi) (Santiago *et al*., 2022). These IPs produce true-to-type Philippine Mallard ducks with superior egg production, specific performance traits, and consistent product quality (Department of Science and Technology – Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD, 2017)). Developing these breeds also requires understanding their nutrition and feeding to maximize their potential and create breed-specific diets, highlighting the importance of precision nutrition. Although it has been claimed that they can perform well using low-cost feeds (Vidad and Duran, 2022), it is still necessary to review their nutritional capacity, which could enhance their value as an animal genetic resource. The first step in understanding the IP bioenergetics and formulating precise diets is establishing the metabolizable energy (ME) values of basal feeds for the breed. However, currently, there is no available ME database for basal feeds specifically for ducks in the country. Wu *et al*. (2020) stated that the ME database for feed ingredients used in duck feed formulation is primarily based on chicken ME bioassays, with data for other poultry species unavailable. In the country, Pinca *et al*. (2019) reported that the energy and nutrient requirements of the IPs are still to be determined. Most IP raisers use commercially formulated layer diets based on chicken requirements. This approach could be mismatched with the genetic profile of the IP, and differences in digestive capacity between ducks and chickens may also lead to variations in nutrient requirements and utilization.

Balancing the energy fraction in poultry diets is crucial because energy is a vital nutrient and the foundation of feed formulation, especially when setting nutrient levels, regulating nutrient intake, and considering the most expensive dietary component, which accounts for 75% of the total feed cost (Kim, 2014; Fouad *et al*., 2018; Owaga *et al*., 2020; Musigwa *et al*., 2021). Basal feeds typically serve as the primary energy source in formulated poultry diets. Common basal feeds include corn, rice bran, and soybean meal. Corn is the most widely used basal feed because of its high energy content, mainly due to its high starch level. Rice bran, a by-product of rice processing, has been used in poultry diets; however, its use is limited by its high fiber and antinutritional factors. Rice bran D1 and D2 contain crude fiber levels of 5.27% and 10.20%, respectively (Feed Reference Standards, 2010). Soybean meal is mainly a protein source but also supplies a significant amount of energy. Determining the energy values in terms of apparent metabolizable energy (AME) and establishing the ME database for these basal feeds are essential for creating breed-specific and accurate diets for IP. Wu *et al*. (2020) explained that the AME system more accurately reflects the true energy levels of feedstuffs available to birds and remains the preferred method for assessing feedstuff energy content. They emphasized that this system should be considered when formulating poultry diets. Furthermore, Abdollahi *et al*. (2021) indicated that using this ME system could improve least-cost feed formulations for poultry.

Vidad *et al*. (2024) found that AME values of corn, rice bran, and soybean meal for IP-Itim are higher compared to the literature for broilers, layer chickens, and other breeds of ducks, irrespective of energy assay procedures used. Similarly, it is higher than the values presented by the Philippine Society of Animal Nutritionists (PHILSAN), a primary reference standard for feed ingredients in the country. The recorded AME is 3.70, 3.50, and 3.10 kcal/g as fed for corn, rice bran, and soybean meal. This suggests that common basal feeds have a higher energetic value when used in the formulation of diets for IP-Itim and such a breed is efficient in harnessing basal feed energy. This could convey the formulation of a precise diet for IP-Itim and possibly reduce the cost of formulated diets, reducing excessive nutrient excretion. However, since the study was conducted through a metabolizable energy bioassay, particularly the direct method via force feeding, this might overestimate the actual energy value. In that way, utilizing the generated AME values of the basal feeds for IP-Itim for feed formulation to be tested in an actual biological growth trial is necessary to confirm the result; hence, this study. It was conducted to determine the effects of diets formulated with different AME values of the basal feedstuffs on the growth and keel and shank lengths of IP-Itim. The AME values were based on the actual bioassay values for IP-Itim, published AME values based on national feed reference standards, and their intermediary values obtained by the mean between the actual and published values.

2. Methodology

2.1 Ethics Statement

This study was conducted following the animal care protocol approved by the Institutional Animal Care and Use Committee (IACUC) at Mariano Marcos State University (MMSU) in Batac City, Ilocos Norte, Philippines. Additionally, the study received an Animal Research Permit, reference number AR-2022-077, from the Bureau of Animal Industry (BAI) of the Department of Agriculture, Regional Field Office 1, located in San Fernando City, La Union, Philippines.

2.2 Experimental Design, Diets, and Duck Husbandry

One hundred eighty-day-old female IP-Itim ducks were obtained from a BAI-accredited duck breeder farm in Zaragoza, Nueva Ecija. These ducks were randomly assigned to three treatments in a completely randomized design (CRD). Ten ducks per replicate were used, with sixty ducks per treatment. The nutrient recommendations for ducks provided by Feed Reference Standards (2010) were used to formulate the experimental diets. Diets were formulated (see Table 1) based on actual (3690, 3498, and 3100 kcal/kg), intermediate (3495, 2949, and 2803 kcal/kg), and published (3300, 2400, and 2500 kcal/kg) AME values of corn, rice bran, and soybean meal, which served as the treatment groups for the experiment. These diets were prepared using Microsoft Excel and mixed manually. Starter diets were provided from weeks 0 to 8, and grower diets from weeks 8 to 12.

The experimental ducks were raised in an intensive system and housed in an elevated plastic wire-floor cage measuring 6 × 3 × 1.5 feet. They were brooded for 21 days, with artificial heat supplied by a 50-watt incandescent bulb. All ducks had unlimited access to water and feed. Water was provided through a plastic pan with an individual PVC faucet, and mash feeds were offered in tube feeders. The experimental house is naturally ventilated, and artificial light was provided at night. Every day, the manure beneath the wire-floor pens was manually removed.

Table 1. Composition, calculated values, and proximate analyses of the test diets for 0-8 and 8-12-week-old ItikPINAS-Itim (*Anas platyrhynchos*).

	0-8 Weeks			8-12 Weeks		
	Diet 1[1]	Diet 2[2]	Diet 3[3]	Diet 1[1]	Diet 2[2]	Diet 3[3]
Corn (local)	29.00	31.20	34.05	32.91	33.95	32.51
Fishmeal (Peruvian)	5.50	5.50	6.00	0.00	0.00	0.00
Rice bran (D1)	38.56	36.54	28.95	48.95	48.04	48.34
Soybean meal (US)	23.45	23.50	24.47	14.00	14.00	12.24
Vegetable oil	0.00	0.00	3.55	0.00	0.00	3.10
Limestone	1.40	1.30	1.30	1.90	1.90	1.95
Monocalcium phosphate	1.40	1.30	1.10	1.40	1.30	1.10
Salt	0.25	0.25	0.25	0.40	0.40	0.40
Mineral premix[4]	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix[5]	0.03	0.03	0.03	0.03	0.03	0.03
DL Met	0.11	0.15	0.10	0.11	0.15	0.10
Lysine	0.10	0.03	0.00	0.10	0.03	0.03
Toxin binder	0.05	0.05	0.05	0.05	0.05	0.05
Total	100	100	100	100	100	100
Calculated Analysis						
ME Kcal/Kg	3303	2981	2901	3369	3002	2810
Crude Protein (%)	21.94	21.87	21.88	15.63	15.58	14.64
Crude Fiber (%)	4.09	4.02	3.64	4.56	4.53	4.45
Crude Fat (%)	4.00	3.96	7.21	4.18	4.16	7.21
Calcium (%)	1.02	0.97	0.95	1.03	1.01	0.99
Phosphorous, (%)	0.66	0.64	0.60	0.47	0.45	0.40
Lysine (%)	1.34	1.29	1.28	0.87	0.81	0.75
Met-Cys (%)	0.89	0.93	0.87	0.69	0.73	0.65
Threonine (%)	0.84	0.84	0.84	0.58	0.58	0.54
Tryptophan (%)	0.26	0.26	0.26	0.18	0.18	0.17
Methionine (%)	0.52	0.55	0.51	0.39	0.42	0.36
Cost/Kg (PhP)	27.80	27.96	31.86	23.52	23.57	25.93
Proximate Analysis[a]						
Dry matter (%)	88.06	88.20	88.31	89.31	88.59	88.27
Ash (%)	8.10	7.54	7.14	7.64	7.72	7.25
Crude protein (%)	22.65	22.72	22.27	15.15	14.90	14.39
Crude fiber (%)	4.03	4.00	4.34	3.96	4.19	14.42
Crude fat (%)	5.44	5.66	7.64	7.92	7.00	8.46
Nitrogen-free extract (%)	47.84	48.28	46.92	54.64	54.72	53.75
Gross energy[b], kcal/kg	3470	3509	3628	3662	3587	3663
Metabolizable energy[c], kcal/kg	2811	2842	2938	2966	2906	2967

Actual for IP-Itim[1]; Intermediate/Average[2]; Published[3] AME values of corn, rice bran, and soybean meal; [4]Each kg contains: iron 125 g, manganese 25 g, zinc 125 g, copper 7.5 g, iodine 0.175 g, selenium 0.30 g, cobalt 0.50 g; [5]Each kg contains: vit. A 50,000,000 I.U., vit. D3 9,000,000, vit. E 200 g, vit. K3 9 g, vit. B1 9 g, vit. B2 22g, vit. B6 14 g, vit. B12 0.10 g, pantothenic acid 70 g, niacin 150 g, folic acid 10 g and biotin 1 g

[a]Obtained via AOAC Official Methods of Analysis, 20th Edition, 2016

[b]Estimated total energy (gross energy) based on Atwater's Physiological Fuel Value

[c]Estimated 81% of the gross energy value

2.3 Sampling and Measurements

The experimental ducks' initial weights (IW) and final weights (FW) were determined by weighing them individually at the start and end of the 12-week feeding trial, respectively. Weekly weights (WW) were obtained and recorded by weighing sample ducks per replication, randomly selected in each cage. The total gain in weight (TGW) was computed by subtracting the IW from the FW of the ducks, while the average daily gain (ADG) was obtained by getting the quotient of the TGW and the total number of days of feeding. The feed intake was recorded daily by weighing the excess feed and subtracting it from the quantified volume of feed offered in the morning. The feed conversion ratio (FCR) was computed as the ducks' cumulative feed intake divided by the TGW. Meanwhile, feed cost was expressed as the cost over total feed consumption (ToFC) and the cost per kilogram gain (FC/Kg G). On the other hand, flock uniformity was calculated as the percentage of the individual weights within ±10% of the mean weight of the ducks. The relative livability was calculated as the birds remaining at the end of the feeding period divided by the initial number of ducks. Sample ducks were tape-measured for keel length (from the anterior to the posterior edge of the keel) and shank length (from the hock joint to the lower surface of digit IV at its base).

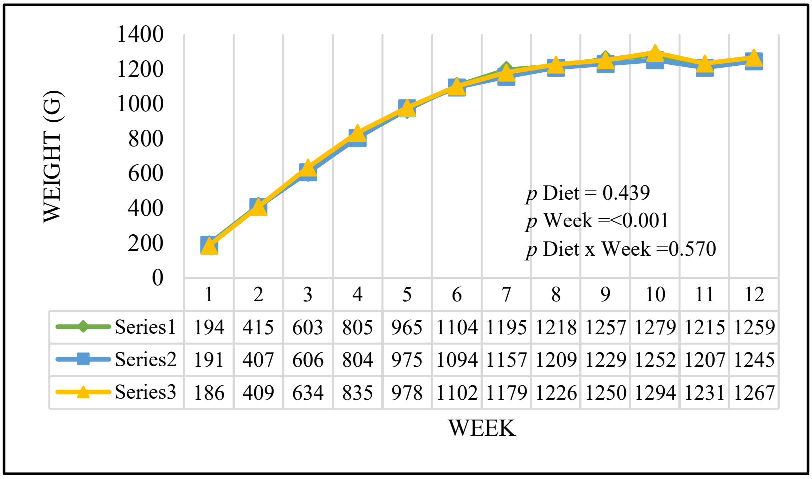
2.4 Statistical Analysis

Data were analyzed using the Analysis of Variance (ANOVA), and significant means ($p < 0.05$) were subjected to the Least Significant Difference (LSD) test. These were performed using the Statistical Tool for Agricultural Research (STAR v. 2.01) software (International Rice Research Institute, 2014). While data gathered weekly, such as weekly weights, weekly average daily feed consumption, and weekly average cumulative feed consumption, were analyzed using Repeated Measures Analysis of Variance using SAS (2018).

3. Results and Discussion

3.1 Growth Performance of the IP-Itim

The growth performance of IP-Itim fed diets formulated with varying AME values of basal feeds is given in Table 2. Before the experiment started, the ducks' initial IW was identical across treatments ($p = 0.956$). On WW, repeated measures analysis showed no significant ($p = 0.507$) week and diet interaction effect on the WW increment of the experimental ducks throughout the 12-week feeding period (Figure 1). In terms of percent flock uniformity, no significant differences (p = 0.213) were detected by ANOVA among the ducks fed with the three test diets. Similarly, with the calculated percent livability of the ducks (p = 0.651).



	1	2	3	4	5	6	7	8	9	10	11	12
Series1	194	415	603	805	965	1104	1195	1218	1257	1279	1215	1259
Series2	191	407	606	804	975	1094	1157	1209	1229	1252	1207	1245
Series3	186	409	634	835	978	1102	1179	1226	1250	1294	1231	1267

Figure 1. Weekly weight increment of the experimental ItikPINAS-Itim (*A. platyrhynchos*) fed diets formulated with varying AME values (actual-Diet 1, intermediate-Diet 2, and published-Diet 3) of corn, rice bran, and soybean meal (analyzed through Repeated Measures Analysis of Variance).

The lack of significant differences in the WW and subsequently the FW, TGW, and ADG of the ducks across diet groups illustrates that the formulated diets did not influence or affect growth performance. It is noteworthy to highlight that the generated AME values of basal feeds for IP-Itim through actual in-vivo energy assay and the intermediate values obtained by getting the mean of generated and published AME values when used in diet formulation did not disrupt the usual growth patterns of the breed, as they were not statistically different. Furthermore, the energy content of the formulated diets based on actual and intermediate AME values of basal feeds are available for absorption and metabolism and might be enough to supply energy demands for the growth of the breed. While the energetic values of basal feeds derived from published data might be high and the possibility of predisposing excess energy when used in compounding diets for the IP-Itim breed. The National Research Council (NRC), the primary source of metabolizable energy (ME) values of feedstuffs worldwide and to some extent in the country, asserted that most ME values of feedstuffs were obtained for chicks and adult male chickens. Few data are available for ME data for chickens and other poultry species at different ages. Hence, it cannot be neglected that diets for ducks in the country are formulated based on the ME values of basal feeds obtained from chickens, aligned with the claim of Pinca *et al*. (2019). It has been well explained that ducks and chickens differ in terms of digestive capacity, which might dictate their differences in terms of utilizing feed nutrients. Moreover, there are published studies that determined AME of corn, soybean meal, broken rice, dehulled oats, wheat, barley, cassava meal, rice bran and fish meal specific for other breeds of ducks mainly Pekin and Cherry Valley ducks (Hoai *et al*., 2011; Adeola, 2003; King *et al*., 1997; Ragland *et al*., 1997) but there is an absence of empirical shreds of evidence on its utilization in compounding ducks' diets, particularly in the country.

On the other hand, the recorded data on the performance parameters of the IP-Itim across diet groups exceeds some published data (Table 2). For instance, the recorded WW of the experimental ducks across diet groups were higher than the reported bi-weekly weight increments of female IP-*Kayumanggi* raised in a semi-intensive production system at 216, 439, 583, 935, 914, and 1114 grams for weeks 2, 4, 6, 8, 10 and 12, respectively (Santiago *et al*., 2022). Similarly, WW increments are also higher than the report of Padhi (2014) on indigenous ducks of India; however, identical weights in weeks 11 and 12. Furthermore, the experimental ducks in the present study recorded a commendable 19-fold weight increment from day 0 to 44, higher than the 16-fold weight increment recorded by Murawska *et al*. (2016) at the same age for farm-raised mallard ducks. However, the calculated ADG of the experimental ducks across test diets was lower than the data obtained by Ampode *et al*. (2020), ranging from 17.43 to 18.44 grams for IP-*Kayumanggi* supplemented pinto peanut meal, conversely, in a shorter feeding period (49 days).

Flock uniformity is an important indicator of production performance. Although there is no statistical significance recorded among the ducks across diet groups, ducks under diet groups 2 and 1 have a higher uniformity rate compared with ducks under diet group 3. The recorded percent uniformity of the ducks across diet groups was higher than the report of Heo *et al*. (2015) for two-way crossbreed commercial Korean ducks at 72.5% observed at eight weeks of age. Hudson *et al*. (2001) pointed out that initial flock uniformity increased egg production in broiler breeder hens. Abas *et al*. (2010) added that broiler breeder hens with a high uniformity rate (70-80%) consistently recorded the highest hen-day and hen-house production.

Table 2. Growth performance of ItikPINAS-Itim (*A. platyrhynchos*) fed diets formulated with varying AME values (actual for ItikPINAS-Itim, intermediate, and published)[x] of corn, rice bran, and soybean meal

Performance Indicator	Treatments			SEM[1]	p Value[2]
	Diet 1	Diet 2	Diet 3		
Initial weight (g)	56.95 ± 2.00	56.55 ± 2.90	56.98 ± 2.72	1.48	0.956
Final weight (g)	1258.61 ± 15.61	1244.53 ± 24.98	1266.80 ± 35.14	15.29	0.362
Total gain in weight (g)	1201.66 ± 17.17	1187.98 ± 23.85	1210.22 ± 32.96	14.72	0.339
Average daily gain (g)	14.31 ± 0.20	14.14 ± 0.29	14.41 ± 0.39	0.18	0.343
Uniformity (%)	93.17 ± 8.26	96.67 ± 5.16	86.50 ± 13.62	5.58	0.213
Livability (%)	98.33 ± 4.08	96.67 ± 5.16	95.00 ± 8.37	3.35	0.651

[1]*SEM: Standard error mean*

[2]*P value for one-way ANOVA. Values in the same row that share the same superscripts are not statistically different (p > .05) according to LSD comparison test.*

[x]*Actual for IP-Itim, intermediate and published AME values of corn, rice bran and soybean meal: 3690, 3490 and 3100 kcal/kg; 3494, 2949 and 2803 kcal/kg; and 3300, 2400 and 2500 kcal/kg, respectively.*

3.2 Feed Consumption and Economic Parameters

Figures 2 and 3 present the weekly average daily feed consumption (ADFC) and average cumulative feed consumption (ACFC) of the experimental ducks. Repeated-measures analysis revealed no significant interaction between week and diet on the recorded ADFC (p = 0.630) and ACFC (p = 0.630) of the experimental ducks. On the other hand, Table 3 presents the total feed consumption (ToFC), feed conversion ratio (FCR), and feed cost incurred by the experimental ducks. Statistical differences (p = 0.0188) were detected in the total feed consumption of the experimental ducks. Specifically, ducks fed diets 1 and 2 consumed more feed than ducks fed diet 3; however, the recorded ToFC for ducks fed diet 2 is not statistically different from the recorded ToFC of ducks fed diet 3. Relative to the statistical significance recorded on the ToFC of the experimental ducks, a similar observation on the calculated FCR, wherein ANOVA detected statistical significance (p = 0.0009). Ducks fed with diet 3 have lower FCR (6.57 ± 0.09 g/g) compared with ducks fed diets 1 (6.93 ± 0.09 g/g) and 2 (6.87 ± 0.21 g/g). This insinuates that they require a lower amount of feed to produce a kilogram of body weight. For the feed cost, ANOVA revealed a statistical significance among ducks fed with the three experimental diets in terms of the calculated total feed cost (TFC) (p = 0.0000) and feed cost per kilogram gain (FC/kg G) (p = 0.000). Ducks fed diet 2 incurred the lowest TFC at 215.40 ± 6.63 pesos, followed by those fed diet 1 at 218.83 ± 5.10 pesos and these values were statistically insignificant. While ducks fed diet 3 incurred the highest TFC at 236.06 ± 5.26 pesos, and were statistically significant with ducks fed diets 1 and 2. In the same manner, with the calculated FC/kg G of the experimental ducks.

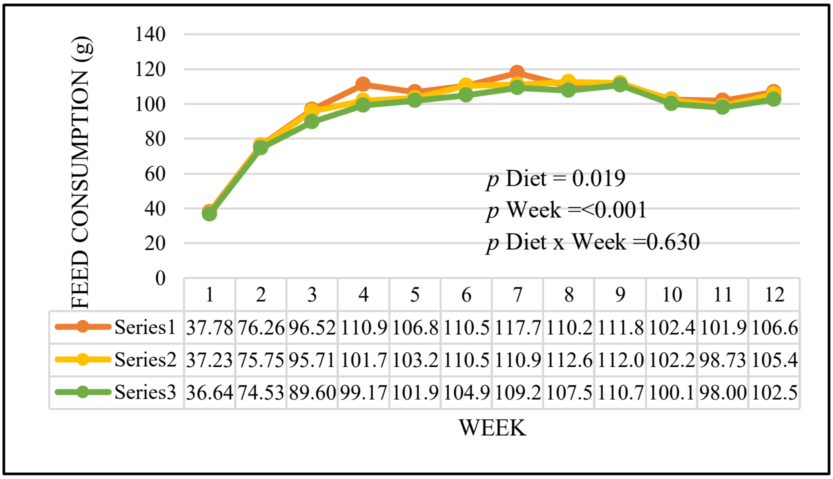


Figure 2. Weekly average daily feed consumption of the experimental ItikPINAS-Itim (*A. platyrhynchos*) diets formulated with varying AME values (actual-Diet 1, intermediate-Diet 2, and published-Diet 3) of corn, rice bran, and soybean meal (analyzed through Repeated Measures Analysis of Variance).

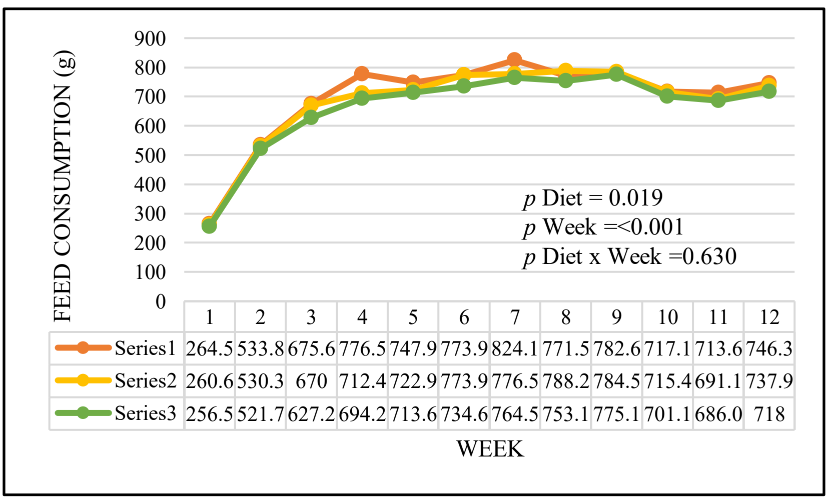


Figure 3. Weekly average cumulative feed consumption of the ItikPINAS-Itim (*A. platyrhynchos*)fed diets formulated with varying AME values (actual for IP-Itim-Diet-1, intermediate-Diet 2, and published-Diet 3) of corn, rice bran and soybean meal (analyzed through Repeated Measures Analysis of Variance)

Table 3. Feed consumption and economic parameters of ItikPINAS-Itim (*A. platyrhynchos*) fed diets formulated with varying AME values (actual for IP-Itim, intermediate, and published)[x] of corn, rice bran and soybean meal

Performance Indicator	Treatments Diet 1	Diet 2	Diet 3	SEM[1]	*p* Value[2]
ToFC (g/bird)	8327.31 ± 188.42^{a}	8163.60 ± 255.71^{ab}	7945.4 ± 158.58^{b}	118.34	0.018
FCR (g/g)	6.93 ± 0.09^{a}	6.87 ± 0.21^{a}	6.57 ± 0.09^{b}	0.08	0.000
TFC (Php)	218.83 ± 5.10^{b}	215.40 ± 6.63^{b}	236.06 ± 5.26^{a}	3.29	0.000
FC/kg G (Php)	182.77 ± 2.65^{b}	181.95 ± 5.13^{b}	195.99 ± 3.02^{a}	2.17	0.000

ToFC: total feed consumption; FCR: feed conversion ration; TFC: total feed cost; and FC/kg G: feed cost/kg gain in weight

[1]SEM: Standard error mean

[2]P value for one-way ANOVA. Values in the same row that share the same superscripts are not statistically different (p > .05) according to LSD comparison test.

[x]Actual for IP-Itim, intermediate and published AME values of corn, rice bran and soybean meal: 3690, 3490 and 3100 kcal/kg; 3494, 2949 and 2803 kcal/kg; and 3300, 2400 and 2500 kcal/kg, respectively.

The recorded higher feed consumption of ducks fed diet 1 implies that the bioavailability of energy of the diets formulated based on actual AME values of basal feedstuffs might be lower than diets 2 and 3. Based on the proximate analysis (Table 1), diets 1 and 2 have lower energy content despite the wide margin of energy in the calculated analysis. This might suggest that the bioassay procedure (direct-force/tube feeding) used overestimated the energy value of the basal feeds. Such a feeding procedure for the ME assay tends to yield higher ME values of feeds compared to the conventional addition method via *ad libitum* procedure, as observed in cockerel (Yaghobfar and Boldaji, 2002) and a similar scenario was demonstrated by Hoai *et al*. (2011) for cherry valley ducks. However, it is not parallel to the report of Wu *et al*. (2020) that tube feeding significantly underestimates the AME values of feedstuffs. Though the review report of Wu *et al*. (2020) did not elucidate further the factor of species in the bioassay procedures reviewed. It is a common concept that poultry tend to eat to meet energy requirements, with the prerequisite that the diet is adequate in essential nutrients (NRC, 1994). When the AME values of basal feeds decreased in this case, by getting the average of actual and published values, the ToFC decreased, as manifested by the ducks fed with diet 2. On the other hand, the lower ToFC of ducks fed diet 3 might be attributed to the inclusion of vegetable oil used to balance the diet's energy fraction. Oil is highly digestible (Engberg *et al*., 1996) and has an extra-caloric effect when compounded in poultry diets. It is explained that the increase in the metabolizable energy of the whole ration is higher than the gross energy of the oil included in poultry diets (Murugesan, 2013). Some of the research findings of the extra caloric effects of oils in poultry diets include: increase villus height and villus height: depth ratio which enhances the absorption capacity of small intestines; improves digestive enzymes activities; and reduces the rate of feed digesta passage in the gastrointestinal tract, that permits longer and better absorption of nutrients in the diet (Attia *et al*., 2020; Baião and Lara, 2005).

Comparing the feed consumption of the experimental ducks across test diets with other studies, the recorded ADFC and ACFC from weeks 1 to 7 are higher than the reported values for *IP-Kayumanggi* raised in a semi-intensive system. While identical ADFC and ACFC at eight to 12 weeks (Santiago *et al*., 2022). The erratic ADFC and ACFC values recorded from 8 to 12 weeks were also observed in the report of the latter authors. Moreover, in contrast with the report of Patra and Samanta (2015), the ADFC of IP-Itim for weeks 1-2 (57 g) and 3-4 (88.6 g) are slightly higher than Khaki Campbell at 51.7 and 88.6 g, respectively. However, at weeks 5-8, lower ADFC (113 g) for IP-Itim compared with 133.8 g for Khaki.

On the other hand, the FCR is related to the voluntary intake of the experimental ducks. As previously presented, the feed intake of ducks fed diets 1 and 2 was higher than ducks fed diet 1, which resulted in a higher FCR value for the former. Aside from feed intake, the inclusion of vegetable oil in diet 3 might also influence the recorded FCR of ducks in this diet group. Ao and Kim (2020) found that feeding soybean and palm oils reduced the feed-to-gain ratio or FCR of Pekin ducks. While Nuriyasa *et al*. (2021) presented dissimilar results, wherein the inclusion of 3 percent palm oil has no significant effects on the FCR of male Bali ducks. Nevertheless, the recorded FCR for IP-Itim across test diets is almost similar to the findings of Ampode *et al*. (2020) on female IP-*Kayumanggi* at 6.85 (control) and 6.45 to 6.53 for those supplemented with pinto peanut meal in a shorter feeding period (49 days). Conversely, it is higher than the report of Patra and Samanta (2015) for Khaki at 4.79; however, it is important to emphasize that the feeding period of the latter authors is shorter (53 days) than the study (84 days).

Feed cost constitutes a major expense in poultry production, including duck farming. As presented in Table 1, the cost per kilogram of the formulated test diets varies. The calculated cost per kilogram of diets 1 and 2 greatly influenced the TFC and TFC/kgG incurred by the experimental ducks. Lower TFC and TFC/kg G were recorded for ducks under diet groups 1 and 2 compared to diet group 3. Using the actual AME values of basal feeds in formulating balance diets for IP-Itim, a reduction of 7.29 percent (17.23 Php) and 6.74 percent (13.22 Php) for the TFC and TFC/Kg G was realized. While

8.75% (20.66 Php) and 7.16 % (14.04 Php) were calculated using the intermediate AME values, compared to commonly used or published AME databases. Despite the FCR statistically favoring the formulation using published values for AME, the FC/kg G, the best measure for a least-cost formulation, was demonstrated in diets 2 and 3 using the actual and intermediate values and was statistically lower than diet 3. This can be attributed to the non-significant differences in ADG across all diets. The favorable economic parameters generated in this study are a very important observation that will guide the animal nutritionist to formulate cheaper diets because of lower energetic requirements, as biological growth performance was not compromised, as supported by the *in vivo* growth trial of the present study.

3.3 Keel and Shank Lengths

Table 4. Keel and shank lengths of ItikPINAS-Itim (*A. platyrhynchos*) fed diets formulated with varying AME values (actual for IP-Itim, intermediate, and published)[x] of corn, rice bran and soybean meal

Performance Indicator	Treatments Diet 1	Diet 2	Diet 3	SEM[1]	p *V*alues[2]
Keel length (cm)	11.91 ± 0.20	11.68 ± 0.42	11.68 ± 0.36	0.196	0.416
Shank length (cm)	5.19 ± 0.09	5.27 ± 0.12	5.26 ± 0.09	0.058	0.37

[1]*SEM: Standard error mean*
[2]*P values: P ANOVA for one-way ANOVA. Values in the same row that share the same superscripts are not statistically different (p > .05) according to LSD test.*
[x]*Actual for IP-Itim, intermediate and published AME values of corn, rice bran and soybean meal: 3690, 3490 and 3100 kcal/kg; 3494, 2949 and 2803 kcal/kg; and 3300, 2400 and 2500 kcal/kg, respectively.*

The keel and shank lengths of the experimental ducks across diet groups are given in Table 4. ANOVA revealed no significant differences in the shank (p = 0.374) and keel (p = 0.416) lengths of the ducks across diet groups. The absence of statistically significant differences in the keel and shank lengths of the experimental ducks insinuates that these were not affected by the test diets. These are important body structure parameters to assess, as it is associated with production performance. Das *et al*. (2016) revealed that the body weight of Sonali grower chickens is always positively correlated with shank and keel length. Similarly, keel length is highly correlated with the body weight of 49-day-old Pekin ducks (Kokoszyński and Bernacki, 2011) and Leizhou black ducks (Asiamah *et al*., 2020). Agatep *et al.* (2018) reported lower shank measurements for Khaki Campbell and Philippine mallard ducks. On the other hand, the recorded keel length of the ducks across diet groups is almost identical to the data of Diego *et al*. (2021) for 12-18-week-old IP-Itim and Khaki and to the findings of Agatep *et al*. (2018) for Khaki Campbell and Philippine mallard ducks.

4. Conclusions and Recommendation

The initial study showed that using the actual and intermediate AME values of corn, rice bran, and soybean meal can be used as the basis for balancing the energy fraction of starter and grower diets of IP-Itim, without compromising growth performance and keel and shank lengths. However, total feed consumption and feed conversion ratio of ducks fed diets formulated based on actual and intermediate AME values were higher compared to the reference published AME values of basal feeds. Nevertheless, significantly lower total feed cost and feed cost per kilogram gain were observed on ducks-fed diets formulated based on actual and intermediate AME values of the basal feedstuffs. These findings revealed that actual and intermediate AME values of basal feeds can be used in the least-cost diet formulation for IP. Lastly, similar in vivo growth trials are solicited to validate the results of the study.

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