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Effect of Betel Leaf Extract *(Piper betle* L.) and Dietary Protein Level on Performance and Carcass Traits of Local Ducks

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ABSTRACT

The restriction of antibiotic growth promoters has increased interest in phytogenic feed additives in poultry production. This study evaluated the effects of betel leaf (*Piper betle* L.) extract and dietary protein level on performance, carcass traits, and income over feed cost of male local ducks. A total of 135 male local ducks were assigned to a 3 × 3 factorial completely randomized design with three replications. The treatments consisted of betel leaf extract levels of 10, 20, and 30 ml and dietary protein levels of 13%, 15%, and 17%. Observed variables included feed intake, body weight gain, feed conversion ratio, slaughter weight, carcass weight, carcass percentage, and income over feed cost. Betel leaf extract significantly affected feed conversion ratio and slaughter weight ($P < 0.05$), whereas dietary protein level and the interaction between both factors had no significant effect on the measured variables. Among the tested extract levels, 20 ml produced the best feed conversion ratio and slaughter weight. Meanwhile, the combination of 20 ml betel leaf extract and 13% dietary protein produced the highest income over feed cost. In conclusion, betel leaf extract at 20 ml improved feed efficiency and slaughter weight, while its combination with 13% dietary protein provided the best economic return in male local ducks.

Keyword: Betel leaf extract, Local duck, Dietary protein, Feed conversion, Carcass traits

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1. Introduction

Local ducks are an important poultry genetic resource for tropical livestock systems because they are adaptable to local environments and can contribute to the supply of animal protein [1,2]. However, growth rate, feed efficiency, and carcass yield remain key constraints in meat-type local duck production. Improvement of feed efficiency is particularly important because feed cost is the dominant component of poultry production costs and strongly determines the economic value of the production system. In duck production, dietary energy and protein balance affects feed intake, body weight gain, and carcass development, while differences among strains, age, and rearing environments can further modify the response to nutrition [3,4].

The restriction of antibiotic growth promoters and growing demand for safer poultry products have increased interest in phytogenic feed additives. Betel leaf (*Piper betle* L.) is a tropical medicinal plant containing phenolics, flavonoids, tannins, eugenol, hydroxychavicol, and other bioactive compounds. Recent studies show that P. betle extracts have antibacterial activity against several pathogenic bacteria and contain phenolic compounds that may support digestive and health-related functions [5]. In poultry, betel leaf extract or meal has been evaluated as a phytogenic additive because its antimicrobial and antioxidant properties may improve nutrient utilization and reduce intestinal microbial challenges [6-9].

Protein level is another determinant of growth performance because protein supplies amino acids required for tissue accretion, enzyme formation, and metabolic functions. In poultry diets, crude protein reduction can reduce feed cost and nitrogen excretion, but performance may decline when amino acid balance is not adequate [10-13]. In ducks, crude protein requirements vary according to age and production phase. Cho et al. [3] estimated high crude protein requirements for early White Pekin ducks, while Zhao et al. [4] showed that energy and protein combinations affected growth, carcass traits, and meat quality in growing Pekin ducks. Therefore, information on local ducks is needed because local breeds may respond differently from commercial strains.

The combined use of betel leaf extract and different dietary protein levels may provide practical information for improving local duck production. Betel leaf extract may support digestive conditions, whereas dietary protein level determines the amount of amino acids available for muscle and carcass development. This study aimed to analyze the effects of betel leaf extract levels and dietary crude protein levels on feed intake, body weight gain, feed conversion ratio, slaughter weight, carcass weight, carcass percentage, and income over feed cost in male local ducks.

2. Materials and Methods

2.1. Study Location and Period

The study was conducted at the experimental house of the Faculty of Animal Husbandry, Universitas HKBP Nommensen, Porlak Simalingkar B, Medan Tuntungan District, Medan, Indonesia. The experiment was carried out for three months from December 2021 to February 2022.

2.2. Animals, Housing, and Experimental Diets

A total of 135 male local ducks were used. The ducks were reared in 27 experimental units, each measuring 1 m x 1 m x 0.5 m and equipped with feeders and drinkers. Each experimental unit contained five ducks. Feed was offered twice daily at 08:00 and 16:00, and drinking water was available throughout the rearing period. Feed residues were collected before feeding, dried when necessary, and weighed to determine feed intake.

The experimental diets were formulated to contain three crude protein levels, namely B1 (13.64%), B2 (15.20%), and B3 (17.04%), with metabolizable energy ranging from 3007.2 to 3056.9 kcal/kg. The composition and calculated nutrient content of the diets are presented in Table 1.

Table 1. Composition and calculated nutrient content of experimental diets

Ingredient or Nutrient	B1	B2	B3
Corn (%)	60	57	56
Rice bran (%)	18	15	11
Soybean meal (%)	7	10	12
Coconut meal (%)	9	11	11
Fish meal (%)	2	3	6
Cooking oil (%)	3	3	3
Premix (%)	1	1	1
Total (%)	100	100	100
Nutritional Composition			
Metabolizable energy (kcal/kg)	3007.2	3020.4	3056.9
Crude protein (%)	13.64	15.20	17.04
Ether extract (%)	7.33	7.21	7.14

Crude fiber (%)	4.11	4.36	4.34
Calcium (%)	0.72	0.79	1.00
Available phosphorus (%)	0.47	0.51	0.61

Note: B1, B2, and B3 indicate dietary crude protein treatments corresponding to approximately 13%, 15%, and 17%, with calculated crude protein contents of 13.64%, 15.20%, and 17.04%, respectively

2.3. Betel Leaf Extract Preparation

Betel leaves used in the study were obtained from Hilimbowo Village, Botomuzoi District, Nias Regency. Fresh leaves were air-dried during transportation and then sun-dried after arrival in Medan. The dried leaves were ground into meal using a blender and sent to the Organic Chemistry Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Sumatera Utara for extraction and qualitative phytochemical screening. The powdered material was mixed with solvent at a 1:10 ratio (100 g sample in 1 L solvent), macerated for three days, and separated using a rotary evaporator. The resulting extract was incorporated into the experimental rations according to the treatment levels.

2.4. Experimental Design and Treatments

The experiment used a completely randomized design arranged as a 3 x 3 factorial with three replications. The first factor was betel leaf extract level (A): A1 = 10 ml, A2 = 20 ml, and A3 = 30 ml. The second factor was dietary crude protein level (B): B1 = 13%, B2 = 15%, and B3 = 17%. The nine treatment combinations were A1B1, A1B2, A1B3, A2B1, A2B2, A2B3, A3B1, A3B2, and A3B3.

2.5. Observed Variables

1. Feed Intake. Feed intake was calculated as the difference between the amount of feed offered and the remaining feed at the end of the feeding period and was expressed as g/head/day.

$$\text{Feed Intake} = \text{feed given} - \text{leftover feed}$$

2. Average Daily Gain (ADG). Average daily gain was calculated as the difference between final body weight and initial body weight divided by the rearing period and was expressed as g/head/day.

$$\text{Daily weight gain} = \frac{\text{final weight} - \text{initial weight}}{\text{time (weeks)}}$$

3. Feed Conversion Ratio (FCR). Feed conversion ratio was calculated as the ratio of feed intake to body weight gain.

$$\text{Daily weight gain} = \frac{\text{feed intake}}{\text{daily weight gain}}$$

4. Slaughter Weight. Slaughter weight was determined by weighing each duck immediately before slaughter after a 12-hour fasting period and was expressed as g/head.

5. Carcass Weight. Carcass weight was calculated by subtracting non-carcass weight from slaughter weight and was expressed as g/head.

$$\text{Carcass weight} = \text{Slaughter weight} - \text{Non carcass weight}$$

6. Carcass Percentage. Carcass percentage was calculated by dividing carcass weight by slaughter weight and multiplying the result by 100.

$$\text{Carcass percentage} = \frac{\text{Carcass weight}}{\text{Slaughter weight}} \text{ x } 100$$

7. Income Over Feed Cost (IOFC). Income over feed cost was calculated as revenue from body weight gain minus total feed cost during the feeding period.

$$\text{IOFC} = (\text{Final BW} - \text{Initial BW} \times \text{price}) - \text{total feed cost}$$

2.6. Statistical Analysis

The data were analyzed using analysis of variance (ANOVA) according to the experimental design. When significant differences were detected, means were further compared using Duncan's multiple range test at a significance level of $P < 0.05$.

3. Results and Discussion

3.1. Feed Intake

The average feed intake of local ducks fed different levels of betel leaf extract and dietary protein is presented in Table 2. Feed intake ranged only from 64.99 to 65.07 g/head/day across all treatment combinations. Analysis of variance showed that betel leaf extract level, dietary protein level, and their interaction did not significantly affect feed intake ($P > 0.05$). This indicates that the tested extract levels did not reduce palatability and that the 13-17% crude protein range did not markedly alter voluntary feed intake under the conditions of this study.

The absence of a significant feed intake response is consistent with the very small numerical differences among treatments. Ducks generally regulate feed intake according to energy density and nutrient balance. In this study, metabolizable energy levels were relatively close among diets, which may explain why consumption remained stable. Similar findings have been reported when phytogenic additives did not substantially alter ration palatability or dietary energy balance [7,14].

The stable feed intake across treatments also indicates that betel leaf extract at 10-30 ml did not create a strong negative sensory effect on the ration. This point is important because phytogenic additives may reduce consumption when their aroma, essential oil concentration, or secondary metabolites exceed the tolerance of ducks. In the present study, the similarity of intake suggests that the extract levels were still acceptable for male local ducks. The non-significant effect of dietary protein may also be related to the relatively close metabolizable energy values among diets, because poultry commonly adjusts feed consumption according to dietary energy supply rather than crude protein alone [3,13,14].

Table 2. Feed intake of local ducks during 10 weeks of rearing (g/head/day)

Betel Leaf Extract (A)	B1 (13%)	B2 (15%)	B3 (17%)	Mean
A1 (10 ml)	65.07	65.03	64.99	65.03 ± 0.04
A2 (20 ml)	65.02	65.03	65.04	65.03 ± 0.01
A3 (30 ml)	65.00	65.01	64.99	65.00 ± 0.01
Mean	65.03 ± 0.04	65.02 ± 0.01	65.01 ± 0.03	

Note: Not significant ($P > 0.05$)

3.2. Average Daily Gain (ADG)

The average daily gain of local ducks is shown in Table 3. Betel leaf extract level, dietary protein level, and their interaction did not significantly affect body weight gain ($P > 0.05$). Numerically, the highest mean for betel leaf extract was observed in A2 (17.36 ± 0.23 g/head/day), while the highest mean for dietary protein was observed in B3 (17.19 ± 0.91 g/head/day). These numerical trends suggest that 20 ml extract and the highest tested protein level may support growth, but the response was not strong enough to reach statistical significance.

The non-significant response in body weight gain is closely related to the uniform feed intake among treatments. When feed intake does not differ, the quantity of nutrients entering the digestive tract is also relatively similar. The results suggest that the bioactive compounds in the extract may have been sufficient to support feed efficiency at the 20 ml level, but not sufficient to produce a clear increase in daily gain. In addition, the dietary protein range may have been too narrow or below the optimal requirement for young meat-type ducks to generate a clear growth response. Cho et al. [3] reported higher crude protein requirements for early Pekin ducks, supporting the interpretation that protein levels near or below the requirement may limit growth expression. Comparable variation in local duck growth responses has also been reported in earlier feeding studies [15,16].

Although statistical differences were not detected, the numerical pattern showed that A2 and B3 tended to produce higher body weight gain than the other levels. This tendency should be interpreted carefully because uniform feed intake limits the opportunity for a large growth response. Protein level can influence muscle deposition only when amino acid supply, dietary energy, and digestibility support tissue accretion. Therefore, the absence of significance in this study does not mean that protein is biologically unimportant, but rather that

the tested protein range and ration formulation did not produce a consistent growth advantage among local ducks [10-12].

Table 3. Average daily gain of local ducks during 10 weeks of rearing (g/head/day)

Betel Leaf Extract (A)	B1 (13%)	B2 (15%)	B3 (17%)	Mean
A1 (10 ml)	15.42	15.96	17.81	16.40 ± 1.26
A2 (20 ml)	17.20	17.26	17.62	17.36 ± 0.23
A3 (30 ml)	16.04	16.86	16.14	16.35 ± 0.45
Mean	16.22 ± 0.90	16.69 ± 0.67	17.19 ± 0.91	

Note: Not significant (P > 0.05)

3.3. Feed Conversion Ratio

Feed conversion ratio differed significantly among betel leaf extract levels (P < 0.05), whereas dietary protein level and the interaction between factors were not significant (Table 4). The lowest and therefore most efficient feed conversion ratio was observed in A2 (4.06 ± 0.13), followed by A1 (4.46 ± 0.45) and A3 (4.93 ± 0.62). Duncan test indicated that A2 differed from A3, while A1 was intermediate.

The improvement in feed conversion at 20 ml extract may reflect a more favorable balance between phytogenic bioactive compounds and feed utilization. Betel leaf contains phenolic compounds and other metabolites with antimicrobial potential; however, phytogenic responses are dose-dependent. Moderate inclusion may support gut conditions and nutrient use, while excessive levels may depress palatability or digestive efficiency due to tannins and other compounds. Basit et al. [6] similarly noted that appropriate P. betle leaf meal supplementation improved feed efficiency in broilers, whereas higher supplementation may not always be beneficial. The higher feed conversion ratio in A3 suggests that 30 ml was less efficient than the moderate 20 ml level.

Feed conversion ratio was the most responsive performance parameter in this study. Because feed intake was almost the same among treatments, the lower feed conversion ratio in A2 indicates that ducks receiving 20 ml extract converted consumed feed into body weight more efficiently. This response is consistent with the expected role of betel leaf bioactive compounds in supporting intestinal conditions and nutrient utilization. However, the poorer value in A3 shows that increasing extract level did not produce a linear improvement. Higher levels of phytogenic extracts may supply more tannins and phenolic compounds, which can reduce nutrient availability if they exceed the optimal level. Thus, 20 ml appears to be the most effective level within the tested range [5,6,15].

Table 4. Feed conversion ratio of local ducks during 10 weeks of rearing

Betel Leaf Extract (A)	B1 (13%)	B2 (15%)	B3 (17%)	Mean
A1 (10 ml)	4.95	4.38	4.05	4.46 ± 0.45^{ab}
A2 (20 ml)	4.01	4.21	3.96	4.06 ± 0.13^{b}
A3 (30 ml)	5.58	4.36	4.84	4.93 ± 0.62^{a}
Mean	4.85 ± 0.79	4.32 ± 0.09	4.28 ± 0.49	

Note: Different superscripts in the same column indicate significant differences (P < 0.05)

3.4. Slaughter Weight

Slaughter weight was significantly affected by betel leaf extract level (P < 0.05), whereas dietary protein level and interaction effects were not significant (Table 5). The highest slaughter weight was obtained in A2 (1224.61 ± 22.53 g/head), followed by A1 (1119.97 ± 20.64 g/head) and A3 (1114.72 ± 64.60 g/head). This result follows the same pattern as feed conversion ratio, indicating that ducks receiving 20 ml extract utilized feed more efficiently and reached higher slaughter weight.

Slaughter weight is strongly related to live body weight and nutrient utilization during rearing. The significant effect of extract level on slaughter weight, despite the lack of significant body weight gain response, indicates that cumulative growth and individual variation may have favored the 20 ml treatment. The decreased value at 30 ml supports the interpretation that a higher extract level was not advantageous. Sonphakdi et al. [5] reported that P. betle extract contains antibacterial and phenolic constituents, but also showed toxicity at certain experimental concentrations, reinforcing the need to identify safe and effective inclusion levels for animal feeding applications.

The significant increase in slaughter weight at A2 supports the feed conversion result and shows that the efficiency response was reflected in final marketable live weight. The difference between A2 and A3 is also biologically relevant because the 30 ml level did not maintain the same advantage. This indicates that the response of local ducks to betel leaf extract depends on dose balance rather than simple additive quantity. Since slaughter weight is an important determinant of selling value, the improvement at 20 ml has direct practical relevance for local duck production [15,16,19].

Table 5. Slaughter Weight of Local Ducks at 10 Weeks of Age (g/head).

Betel Leaf Extract (A)	B1 (13%)	B2 (15%)	B3 (17%)	Mean
A1 (10 ml)	1096.83 ± 23.44	1136.50 ± 95.91	1126.57 ± 98.00	1119.97 ± 20.64[b]
A2 (20 ml)	1203.50 ± 32.31	1222.00 ± 61.63	1248.33 ± 72.95	1224.61 ± 22.53[a]
A3 (30 ml)	1045.17 ± 71.87	1126.17 ± 73.70	1172.83 ± 118.78	1114.72 ± 64.60[b]
Mean	1115.17 ± 80.74	1161.56 ± 52.60	1182.58 ± 61.47	

Note: Different superscripts in the same column indicate significant differences ($P < 0.05$)

3.5. Carcass Weight and Carcass Percentage

Carcass weight was not significantly affected by betel leaf extract level, dietary protein level, or their interaction ($P > 0.05$), as shown in Table 6. Although slaughter weight was highest in A2, carcass weight did not follow the same significant pattern. This indicates that the increased slaughter weight did not translate proportionally into carcass tissue under the tested treatments. Carcass weight is influenced by live weight, non-carcass components, physiological maturity, and nutrient deposition patterns.

Carcass percentage was also not significantly affected by the treatments (Table 7). The values ranged from 45.65% to 55.44% across treatment combinations. The lack of significance suggests that betel leaf extract and dietary protein levels did not alter the relative distribution between carcass and non-carcass components. Similar interpretation applies to the protein treatments: even though B3 numerically increased slaughter weight, its carcass percentage was not higher than the lower protein treatments. In poultry, protein and amino acid levels influence muscle accretion, but the effect depends on whether the amino acid balance, energy-to-protein ratio, growth phase, and carcass tissue distribution are appropriate [10,11,17-21].

The lack of a significant carcass response, despite the significant effect on slaughter weight, suggests that the additional live weight was not consistently translated into carcass tissue. Carcass yield is influenced not only by live weight but also by feathers, blood, digestive tract contents, head, feet, and internal organs. Local ducks may also show greater biological variation in carcass partitioning than highly selected commercial meat strains. Therefore, slaughter weight, carcass weight, and carcass percentage should be interpreted together. In this study, betel leaf extract improved slaughter weight, but did not significantly alter carcass deposition or relative carcass yield [17-21].

Table 6. Carcass weight of local ducks at 10 weeks of age (g/head).

Betel Leaf Extract (A)	B1 (13%)	B2 (15%)	B3 (17%)	Mean
A1 (10 ml)	608.00 ± 14.31	568.50 ± 45.27	565.33 ± 26.95	580.61 ± 23.77ns
A2 (20 ml)	583.50 ± 89.41	581.17 ± 47.12	570.83 ± 82.20	578.50 ± 13.98ns
A3 (30 ml)	500.00 ± 21.74	550.67 ± 40.99	574.33 ± 82.15	541.67 ± 37.98ns
Mean	553.83 ± 54.00ns	566.78 ± 15.32ns	570.17 ± 4.54ns	

Note: Not significant ($P > 0.05$)

Table 7. Carcass percentage of local ducks at 10 weeks of age (%).

Betel Leaf Extract (A)	B1 (13%)	B2 (15%)	B3 (17%)	Mean
A1 (10 ml)	55.44	50.11	50.32	51.96 ± 3.07
A2 (20 ml)	50.85	47.76	45.65	48.09 ± 0.30
A3 (30 ml)	47.91	48.89	48.84	48.55 ± 0.56
Mean	50.54 ± 4.20ns	48.92 ± 1.20	48.92 ± 1.20	

Note: Not significant ($P > 0.05$)

3.6. Income Over Feed Cost

Income over feed cost is presented in Table 8. The highest IOFC was obtained in A2B1 (IDR 1,926.68/head), followed by A2B2 (IDR 1,517.18/head) and A1B3 (IDR 1,549.42/head). The lowest IOFC was obtained in A3B3 (IDR 633.03/head). Economically, the A2B1 combination provided the best margin because it combined moderate betel leaf extract with the lowest feed cost among protein treatments. Although B3 showed a numerical tendency toward higher body weight gain, its higher ration price reduced the economic advantage.

This result highlights that the biologically most favorable treatment is not always the most economical. For local duck production, a practical recommendation should consider feed efficiency, slaughter weight, and ration cost simultaneously. Under the price structure used in this study, 20 ml betel leaf extract with 13% dietary protein produced the highest IOFC, whereas 20 ml extract with 17% protein produced the highest slaughter weight. These results suggest that ration formulation for local ducks should be adjusted according to whether the main objective is biological performance or economic return [19,22].

The IOFC result provides an important economic interpretation of the biological data. The highest economic return was obtained in A2B1, not in the treatment with the highest protein level. This occurred because the lower feed price of the 13% protein ration reduced feed cost while the 20 ml extract level maintained favorable production efficiency. For farmers, this finding is important because increasing crude protein may increase ration price without guaranteeing a proportional increase in performance. Therefore, the practical recommendation from this study should consider both production response and feed cost, especially for smallholder local duck production where feed cost strongly determines profit margin [10,11,19].

Table 8. Income over feed cost of male local ducks during the study

Treatment	Total Feed Intake (g/head)	Feed Price (IDR/kg)	Feed Cost (IDR/ head)	Total BWG (g/ head)	Revenue (IDR)	IOFC (IDR)
A1B1	1561.70	6175.00	9643.50	370.03	10361	717.46
A1B2	1560.63	6460.00	10081.67	383.08	10726	644.65
A1B3	1559.86	6680.00	10419.86	427.47	11969	1549.42
A2B1	1559.80	6175.00	9631.77	412.80	11558	1926.68
A2B2	1560.66	6460.00	10081.86	414.25	11599	1517.18
A2B3	1560.87	6680.00	10426.61	422.87	11840	1413.67
A3B1	1560.00	6175.00	9633.00	385.09	10782	1149.40
A3B2	1560.60	6460.00	10081.48	404.60	11329	1247.24
A3B3	1559.66	6680.00	10418.53	394.70	11052	633.03

Note: BWG = body weight gain; IOFC = income over feed cost. Selling price of male local duck was IDR 28,000/kg body weight gain equivalent in the original calculation.

4. Conclusion

Betel leaf extract level significantly affected feed conversion ratio and slaughter weight of male local ducks, whereas feed intake, body weight gain, carcass weight, and carcass percentage were not significantly affected. Dietary protein level and the interaction between betel leaf extract and dietary protein were not significant for the measured variables. The 20 ml extract level produced the most favorable feed conversion ratio and the highest slaughter weight within the tested range.

Based on the biological response, 20 ml betel leaf extract can be recommended as the most effective extract level for improving feed efficiency and slaughter weight. Based on income over feed cost, A2B1 provided the highest economic margin because it combined the optimal extract level with a lower-cost protein ration. Further studies should evaluate a zero-extract control, standardized phytochemical content, amino acid balance, nutrient digestibility, and gut microbial response to confirm the mechanism of action.

5. Conflict of Interest

The authors declare that there is no conflict of interest related to this manuscript.

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