Chilean J. Agric. Anim. Sci., ex Agro-Ciencia (2024) 40(2): 399-406.
https://doi.org/10.29393/CHJAAS40-34PCRJ30034

ISSN 0719-3890 online

PROFITABILITY AND POTENTIAL OF PAPAYA LEAF EXTRACT AS PRETREATMENT IN FEEDS DURING THE EARLY GROWTH PERFORMANCE OF PHILIPPINE NATIVE CHICKENS

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ABSTRACT

Feeds given to native chickens are characterized by low protein, available minerals and vitamins, and low palatability and digestibility. Aside from the feed wastage during feeding, the undigested portion and unutilized protein of feeds are excreted through the feces, which has been a long-time challenge for the poultry industry. This study aimed to assess the profitability and effects of papaya leaf extract (PLE) as pretreatment in feeds, and to determine its impact on feed utilization and early growth performance in Philippine native chickens. A completely randomized design was used, with four treatments and four replicates. The experimental treatments were: pure commercial feeds (control; T0); commercial feeds + 5% PLE + 50 h incubation (T1); commercial feeds + 10% PLE + 50 h incubation (T2); and commercial feeds + 15% PLE + 50 h incubation (T3). Significant differences (p<0.01) were found in terms of cumulative voluntary feed intake during the early growth stage , with T3 recording the highest intake throughout the feeding trial period. Similarly, weekly cumulative weight gain and body weight reached the highest values in T3. Although the feed conversion ratio was not significant, the profitability analysis revealed that birds fed with T3 yielded the highest profit with Php 97.92, while T0 was the least profitable, with Php 81.51. The obtained results revealed that when the percentage of crude protein (CP) decreases and the percentage of moisture increases, it could likely indicate that PLE may have pre-digested the crude protein in the feeds, breaking it down into individual amino acids. This study provides insights into the potential of PLE as a pretreatment on feeds to maximize the utilization of nutrients for increased growth and profits in Philippine native chicken production.

Keywords: Digestibility, growth performance, feed additives, papaya leaf extract, Philippine native chickens.

INTRODUCTION

One of the significant endeavors in animal nutrition is to provide the right mixture of feed ingredients that could supply the nutrients for physiological activities, growth, and overall production at a reasonable cost. Generally, feed costs account for about 50 to 70% of the overall cost of poultry production (Wongnaa et al., 2023). Unfortunately, feeds provided to poultry animals are not effectively converted into meat, eggs, and other poultry products, as the undigested portion of the feeds eaten is often excreted in the feces and urine. In 2010, the world's poultry population was estimated at 18 billion birds, which yielded about 22 million tons of manure containing sufficient digestible energy and protein (Ghaly and MacDonald, 2012). Furthermore, Latshaw and Zhao (2011) pointed out that only 50% of chicken's total nitrogen and amino acid intake is

Received: April 12, 2024 Accepted: August 14, 2024

converted into protein, with the other 50% being undigested and expelled in the feces. In fact, feed wastage during feeding, the unabsorbed portion, and the unutilized protein of feeds have been a long-time challenge for the poultry industry (Pestil and Choct, 2023).

In rural farming, native chicken, also known as village or local chicken in some countries, is one of the most important sources of protein, and it also gives extra income despite the growing population of commercial chicken breeds (Manyelo et al., 2020). As of June 30 of 2023, the estimated chicken inventory in the Philippines was 200.1 million birds. This was 2.8% higher than the previous year's same period count of 194.71 million birds, of which 45% corresponded to native/improved type (Philippine Statistics Authority, 2023). The Philippine native chicken is raised free-ranged and can adapt, reproduce, and survive under adverse conditions with low production inputs and marginal care (Lopez et al., 2014), compared to commercial hybrids (Baguio, 2010). It is also a stable and reliable protein source for rural communities, directly meeting their immediate needs (Pestil and Choct, 2023).

As chicks cannot regulate their body temperature during the first few weeks of life, brooding is one of the crucial phases of chicken development. In addition, some studies have found that a chick's ability to survive while being brooded depends on the amount of nutrients and water it consumes (National Farmers Information Service, undated). This has also been linked to diets that include inedible components or the presence of other compounds that interfere with stomach-related chemicals (Khattak et al., 2006; Café et al., 2002; Abudabos, 2010; and Awati, 2014), such as indoles and phenols (Apajalahti and Vienola, 2016), which decrease digestibility and may lead to growth retardation and poor development of internal organs. Papaya (*Carica papaya*), a tropical fruit found in the Philippines, is a protein-rich fruit with 11.3% crude protein (CP) (Devendra et al., 1970; Oyenuga, 1968), which contains papain, a proteolytically active constituent in the latex of the said fruit (Storer and Ménard, 2013). The extracted papain from unripe papaya fruits or leaves has an exogenous enzyme that will simplify the nutrients when absorbed in the digestive tract of the chicken gut (Rumokoy et al., 2016). Previous studies have explored the nutritional and phytogenic potential of the dietary inclusion of papaya by-products, such as papaya seed and leaf meal, on the growth performance of poultry (Saleh et al., 2018; Rahman et al., 2023). However, there is a lack of literature on the use of papaya leaf extract as a pretreatment in feeds. Therefore, this study aims to assess the profitability and effects of papaya leaf extract (PLE) as a pretreatment in feeds, and to determine its impact on feed utilization and early growth performance of Philippine native chickens.

MATERIALS AND METHODS

Experimental animals, treatment and design

A total of 96-day-old Philippine native chicks were procured at TAALRUTZ Farm, Ibaan, Batangas. The study was laid out in a Completely Randomized Design (CRD) with four (4) treatments replicated four (4) times with six birds per replication. The experimental treatments that were used in the study are the following (Fig. 1).

T_0 – Pure commercial feeds
T_1 – Commercial feeds + 5% PLE + 50 h incubation
T_2 – Commercial feeds + 10% PLE + 50 h incubation
T_3 – Commercial feeds + 15% PLE + 50 h incubation

T2R1	T3R3	T0R2	T1R4
T0R4	T1R1	T2R4	T3R1
T3R2	T2R3	T1R3	T0R3
T1R2	T0R1	T3R4	T2R2

Fig. 1. Distribution of treatments and replicates.

Preparation of experimental cages

During the brooding period, four (4) cages were prepared with 24 chicks for each dietary treatment. After two weeks, initial weight was recorded and the chicks were distributed to their respective treatment replication, which utilized sixteen (16) cages with a floor area of 0.30 by 0.60 m (0.30 x 0.60 m). The cages were adequately cleaned and disinfected before the arrival of the experimental native chickens. All necessary facilities, such as feeders, drinkers, light bulbs, and litter materials, were adequately installed during the brooding period.

Brooding

The brooder cage was made of scrap wood, chicken wire, and net. Electric bulbs were used to provide artificial heat to the chicks to provide proper temperature and ventilation during brooding. A 1-watt per bird requirement was assured throughout the brooding period. Shifting of temperatures followed the brooding temperature from Enos (1990) study: During 0 to

1 week is 93°-95°F (33.9°35°C); 1 to 2 weeks 88°-90°F (31.1°-32.2°C); 2 to 3 weeks 83°-85°F (28.3°-29.4°C); and 3 to 4 weeks 78°-80°F (25.6°-26.7°C). The temperature of the brooder decreases as chicks grow. The chicks were provided with commercial feeds treated with varying levels of PLE during the brooding stage and were given water on an *ad libitum* basis.

Growth stage

The experimental native chickens were placed inside the experimental cages after brooding with six (6) chicks per replicate for 75 days. The initial weight of the chicks was obtained in order to determine the total weight gain of the experimental animals after termination. The standard procedure for gradual shifting from their unusual ration to the experiment diets was strictly followed. Standard health and sanitation practices for poultry were fulfilled during the study. Thus, before the start of the feeding trial, a commercially available dewormer was given in the water to remove intestinal parasites. Other pre-conditioning requirements were met, like controlling intestinal parasites and providing supplemental vitamins and minerals. The necessary biosecurity measures were strictly followed throughout the study.

Preparation of papaya leaf extract (PLE)

Fresh, mature green papaya leaves were collected from one of the nearest farms in the area and thoroughly washed with running water. A 300-watt electric blender was used to grind the material finely. The ground papaya leaves were thoroughly mixed with water at a 1:1 ratio and stored for 24 h to allow cell wall disruption, which would allow the release of intracellular products. Subsequently, the suspension was carefully decanted to separate the liquid from the solid components. Furthermore, the liquid was filtered using a cheesecloth, and the extracted products were stored in the refrigerator at 2 to 4 degrees Celsius before use.

Pretreatment of commercial feeds with PLE

Papaya leaft extract was added to the commercial feeds at 5, 10, and 15% for T_1, T_2, and T_3, respectively. The feeds were incubated for 50 h inside a sealed plastic container to facilitate enzymatic pre-digestion of feed nutrients at room temperature. The experimental ration was prepared every day to have a fresh ration for the daily requirement.

Feeding and water management

During the brooding period, booster mash treated with PLE at varying levels was given to the chicks for the first thirty (30) days of the experiment. Grower mash was given on the 31st day until the study was completed. The feeding trial lasted for 90 days. The voluntary feed intake (or the amount of feed which is eaten when the animal has access to feed on a truly ad-lib basis) of the experimental birds was established before the start of the experiment, which served as the basis for the amount of daily feed ration requirements. The feed given and leftovers were recorded daily to calculate the voluntary feed intake. A twice-a-day feeding schedule (every 7:00 AM and 4:00 PM) and other management practices were ensured to be similar to all treatments throughout the study.

Analysis of the feeds

For crude protein and moisture content analysis, a 250-g feed sample was obtained per treatment and sent to the Regional Animal Feed Laboratory at Marauoy, Lipa City, Batangas. Moisture analysis was done by oven-drying the feeds at 135˚C. Kjeldahl method was used to determine the percent CP of the treated feeds. The analysis of feeds treated with PLE was done only once throughout the experiment.

Growth performance parameters evaluated

a. **Body weight –** body weight was measured weekly with the use of a digital weighing scale.
b. **Cumulative voluntary feed intake (CVFI)** – the cumulative amount of feed that is voluntarily consumed by the birds every week. CVFI was measured by deducting the feed refuse from feed given.
c. **Weekly cumulative weight gain (WCWG)** – the gain in weight by birds in every week with reference to their corresponding initial weights. WCWG was calculated using the following formula:

$$\text{WCWG} = \Sigma\,(BW_i - BW_0)$$

Where:
Σ = summation
BW_i = body weight at the period of measurement
BW_0 = initial body weight

d. **Feed conversion ratio (FCR) –** the ratio of inputs to outputs. FCR was calculated using the following formula:

$$\text{FCR} = CVFI/CWG$$

Where:
CVFI = Cumulative Voluntary Intake
CWG = Cumulative Weight Gain

e. Return Above Feed and PLE cost – the Return Above Feed and PLE Cost (RAFEC) was calculated by subtracting the total cost of feed and the PLE from the price of Philippine native chicken.

RAFEC = (Live weight of birds in kg x price per kg live weight) – (total feed given x price/kg feed + cost of PLE)

Data analysis

The data were analyzed by One-Way Analysis of Variance (ANOVA) using the general linear model of the Statistical Package for Social Science (SPSS) version 17. Means were compared using Tukey's Honestly Significant Difference (HSD) Test. RAFEC, CP and feed moisture were evaluated by descriptive analysis.

RESULTS AND DISCUSSION

Crude protein and moisture content of pretreated feeds

The results revealed that as the level of papaya leaf extract (PLE) increases in the feeds, the percentage of crude protein (CP) decreases, and the rate of moisture increases (Table 1). This indicates that PLE may have pre-digested the crude protein in the feeds, breaking it into individual amino acids. The moisture content of the feeds may also have increased due to the use of PLE. Enzymes in the feeds require moisture to be effective, since it helps with the mobility and solubility of the enzyme and substrate (Ravindran, 2013).

Cumulative voluntary feed intake (CVFI)

No significant differences ($p>0.05$) were observed in terms of voluntary feed intake among treatments in weeks 3-6 and week 12 of the early growth stage (Table 2). However, T3 consistently had the highest intake levels throughout the feeding trial period. During the brooding period (week 2), the lowest and highest feed intakes were recorded in T2 and T3, respectively. During weeks 7 and 8, T3 had the highest feed intake, while T2 recorded the lowest value. During weeks 9 and 10, the highest feed intake was observed in T3, while the lowest feed intake was observed in T1. For week 11, T3 showed the highest feed intake, while T0, T1, and T2 showed no significant differences. T1 showed the lowest feed intake in weeks 13 and 14, while T3 still had the highest intake among the treatments. These results indicate that increasing levels of PLE treated in feeds increased the palatability of feeds, leading to a higher voluntary feed intake. This agrees with the findings of Sari et al. (2020), who reported that papain extract improved the palatability of the mash form of feeds. The addition of papain crude extract as an exogenous protease source in mash diets significantly increased the feed intake. This performance could have been caused by particle size (Chewning et al., 2012; Rumokoy et al., 2016) or due to its bulky character, which birds consume more to satisfy their needs, including feed flavor that may have influenced feed intake.

Body weight

The weekly body weight of Philippine native chickens did not show significant differences ($p>0.05$), except during weeks 2 and 3, where T3 (15% PLE) had the highest body weight of 529.87 grams (Table 3). In week 4, the control group, T1 and T3, showed the heaviest weight ($p>0.05$). The significant differences observed during weeks 2 and 3 may be attributed to the birds being in the brooding stage and still developing their internal organs responsible for digestion. As previous studies have shown, nutrient digestibility increases in the post-hatch period due to the development of the gastrointestinal tract and adequate enzymatic activity (Ravindran et al., 2021). In this case, PLE added to the feeds could have simplified crude protein for easier absorption and utilization by the animal. In the succeeding weeks of the early growth stage, the birds had fully developed internal organs that digested the available nutrients more efficiently, resulting in no significant differences in body weight. This situation was observed in weeks 9 through 14, where birds supplied with PLE showed a sudden increase in weight compared to the control group (T0). This agrees with the findings of Rumokoy

Table 1. Percent crude protein (CP) and moisture of grower mash pretreated with varying levels of papaya (*Carica papaya* L.) leaf extract (PLE).

Treatments	% Crude Protein	% Moisture
T_0 – 0% PLE	14.84	11.65
T_1 – 5% PLE	14.54	14.10
T_2 – 10% PLE	13.80	16.77
T_3 – 15% PLE	13.64	19.04

Table 2. Weekly cumulative voluntary feed intake (g) of Philippine native chicken (*Gallus gallus domesticus* L.) fed with feeds pretreated with varying levels of papaya (*Carica papaya* L.) leaf extract (PLE).

Treatment	Week						
	2	3	4	5	6	7	8
T_0 – 0% PLE	58.54b	61.46	63.96	79.84	116.88	155.50ab	172.79ab
T_1 – 5% PLE	57.83c	61.37	63.92	79.59	113.42	156.38ab	170.29b
T_2 – 10% PLE	56.79d	61.67	64.21	79.36	115.04	154.58b	170.21b
T_3 – 15% PLE	59.79a	61.38	64.33	79.67	114.54	157.12a	173.71a
p-value	0.0001	0.8910	0.7826	0.6531	0.1513	0.0099	0.0030

Treatment	Week					
	9	10	11	12	13	14
T_0 – 0% PLE	177.67bc	183.33ab	248.38b	252.25	255.71b	218.84c
T_1 – 5% PLE	176.50c	181.42b	248.00b	252.50	256.54ab	219.63bc
T_2 – 10% PLE	179.21b	182.71ab	248.21b	254.33	257.46ab	220.96ab
T_3 – 15% PLE	182.71a	184.50a	251.75a	254.87	257.96a	221.75a
p-value	0.0001	0.0471	0.0001	0.0975	0.0292	0.0004

Columns with the same letter are not significantly different.

Table 3. Body weight (g) of Philippine native chicken (*Gallus gallus domesticus* L.) fed with feeds pretreated with varying levels of papaya (*Carica papaya* L.) leaf extract (PLE).

Treatment	Week					
	2	3	4	5	6	7
T_0 – 0% PLE	40.92c	59.17c	92.75a	125.21	156.11	168.03
T_1 – 5% PLE	39.67d	62.50b	88.33a	123.34	147.08	157.17
T_2 – 10% PLE	41.13b	57.75d	75.71b	110.50	138.17	150.08
T_3 – 15% PLE	42.63a	63.29a	91.76a	117.93	139.42	153.73
p-value	0.0001	0.0001	0.0060	0.1505	0.2726	0.3333

Treatment	Week							
	8	9	10	11	12	13	14	Final Weight
T_0 – 0% PLE	200.73	232.63	267.58	307.81	341.82	386.01	416.00	473.61
T_1 – 5% PLE	190.88	233.59	273.24	330.67	359.14	403.38	436.81	510.83
T_2 – 10% PLE	176.07	224.34	262.39	309.85	343.64	400.36	453.63	515.83
T_3 – 15% PLE	193.46	245.13	288.48	340.02	381.74	417.76	462.83	529.87
p-value	0.1053	0.4378	0.3235	0.0690	0.0436	0.3251	0.1563	0.0711

Columns with the same letter are not significantly different.

et al. (2016) in broilers, which tend to gain more body weight when papain is added in mash form. This may be because the feeds are more palatable, leading to greater feed intake.

Weekly cumulative weight gain (CWGW)

Varying levels of PLE treatment in feeds did not significantly affect the CWGW of Philippine native chickens, except for weeks 1, 2, and 3. During week 6, all treatments demonstrated a decrease in weight gain (Table 4). This may be due to the negative effect of environmental temperature changes on bird performance (Munonye et al., 2023), especially when it falls below or rises above the thermal comfort zone. During weeks 1 to 5, cold temperatures were observed, and a shift to warmer temperatures occurred during week 6, which may have affected the birds' ability to adjust, resulting in low weight gain. When the environmental temperature

Table 4. Weekly cumulative weight gain (g) of Philippine native chicken (*Gallus gallus domesticus* L.) fed with feeds pretreated with varying levels of papaya (*Carica papaya* L.) leaf extract (PLE).

Treatment	Week						
	1	2	3	4	5	6	7
T_0 – 0% PLE	24.65c	18.25c	33.58a	30.73	32.69	11.92	32.46
T_1 – 5% PLE	23.40d	22.83a	25.83ab	35.01	23.74	10.08	33.71
T_2 – 10% PLE	24.86b	16.62d	17.96b	34.79	27.79	11.92	25.99
T_3 – 15% PLE	26.36a	20.66b	28.47ab	26.18	21.48	14.32	39.73
p-value	0.0001	0.0001	0.0209	0.1352	0.1727	0.7976	0.6763
Treatment	Week						
	8	9	10	11	12	13	14
T_0 – 0% PLE	31.90	34.96	40.23	34.01	44.19	29.99	57.61
T_1 – 5% PLE	42.71	39.65	57.43	28.48	44.24	33.43	74.03
T_2 – 10% PLE	48.28	38.05	47.46	33.79	56.72	53.27	62.20
T_3 – 15% PLE	51.67	43.36	51.54	41.73	35.27	45.08	67.16
p-value	0.4898	0.4184	0.3254	0.5914	0.1921	0.2948	0.5726

Columns with the same letter are not significantly different.

decreases, the chicken's body temperature also decreases (Munonye et al., 2023). In the first week (brooding), 15% PLE (T3) resulted in the highest cumulative weight gain, while 5% PLE (T1) showed the lowest. During the second week, which is the last week of brooding and the start of supplementation of papaya leaf extract, T1 gave the highest cumulative weight gain, followed by T3 and T0, while the lowest was observed in T2. This observation implies that the exogenous enzyme present in the papaya leaf extract does not act immediately after the bird intakes the treated feeds, leading to inconsistent weight gain per week.

Feed conversion ratio

The feed conversion ratio measures how efficiently an animal converts feed into weight gain and is calculated by dividing the amount of feed consumed by the amount of weight gained. The smaller the value, the more efficiently the animal converts feed into weight gain. The data collected (Table 5) did not show any significant differences ($p>0.05$) in feed conversion ratio, except during the brooding period (week 2) and the first week of the early growth stage (week 3). During the brooding period, T1 was the most efficient, followed by T3, T0, and T2, which were the least efficient among the treatments observed. As the experimental animals grew older, they utilized the feed containing PLE more efficiently, as seen in the data presented in Table 5. This result was similar to the findings of Morbos et al. (2016), which showed that as birds grow older, they become more efficient in utilizing treated feed. Moreover, male birds were significantly more efficient than females in utilizing the feed consumed.

Return above feed and PLE cost

The farm-gate price per kilogram live weight used was P300, while the PLE price per liter was P39.20. The results revealed that T3 had the highest RAFEC with Php 97.92, followed by T2, T1, and T0 with Php values of 95.45, 93.12, and 81.51, respectively (Table 6). Based on the results, the final weight could be one of the factors why T3 (15% PLE) had the highest RAFEC. T3 recorded the highest final weight with an average of 0.53 kg, while T2, T1, and T0 had final average weights of 0.52 kg, 0.51 kg, and 0.47 kg, respectively.

CONCLUSION

Providing Philippine native chickens with feed treated with 15% papaya leaf extract (PLE) resulted in higher income, which could potentially increase farmers' profits. However, it is recommended to conduct further studies considering the sex of the Philippine native chickens, incorporating organoleptic tests as parameters, and using higher levels of PLE. Validating the results of this study may lead to recommendations for backyard farmers and feed milling companies that produce poultry feeds.

Table 5. Feed conversion ratio of Philippine native chicken (*Gallus gallus domesticus* L.) fed with feeds pretreated with varying levels of papaya (*Carica papaya* L.) leaf extract (PLE).

Treatment	Week						
	2	3	4	5	6	7	8
T_0 – 0% PLE	3.21c	1.85a	2.02	2.60	11.08	6.14	10.25
T_1 – 5% PLE	2.53a	2.64ab	1.86	3.58	20.61	5.80	3.99
T_2 – 10% PLE	3.48d	3.66b	1.89	3.06	10.55	19.75	4.33
T_3 – 15% PLE	2.89b	2.19ab	2.81	3.73	9.40	4.18	3.55
p-value	0.0001	0.0273	0.4030	0.1436	0.2765	0.3636	0.2855

Treatment	Week					
	9	10	11	12	13	14
T_0 – 0% PLE	5.28	5.33	7.62	5.73	8.88	3.93
T_1 – 5% PLE	4.62	3.33	13.54	6.24	18.21	3.08
T_2 – 10% PLE	4.78	4.02	8.03	4.84	5.44	3.88
T_3 – 15% PLE	4.26	3.63	6.23	7.60	6.55	3.54
p-value	0.4843	0.3115	0.2098	0.1816	0.4799	0.6633

Columns with the same letter are not significantly different.

Table 6. Return above feed and PLE cost (Php) for Philippine native chicken (*Gallus gallus domesticus* L.) fed with feeds pretreated with varying levels of papaya (*Carica papaya* L.) leaf extract (PLE).

Treatment	Cost (Php)
T_0 – 0% PLE	81.51
T_1 – 5% PLE	93.12
T_2 – 10% PLE	95.45
T_3 – 15% PLE	97.92

Author contributions

RRJ, IdLM, and JKNL conceptualized and developed the methodology of the study. RRJ performed the experiment with the assistance of JKNL and IdLM. RRJ wrote the first draft with the assistance of IdLM, MNA served as the technical critic. JKNL reviewed the manuscript before submission. All listed authors made substantial direct and intellectual contributions to this work and approved it for publication.

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