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Growth performance of broilers fed with coconut apple as primary feed ingredient

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ABSTRACT

The rising cost of commercial feed poses a persistent challenge to the economic sustainability and profitability of poultry production. This study addresses the general topic of sustainable broiler nutrition by specifically investigating the efficacy of coconut apple (Haustorium), an agricultural by-product, as a primary feed ingredient in broiler diets. While previous research has explored various coconut by-products in poultry diets, a critical gap remains regarding the scientific validation and optimal inclusion level of the soft, nutrient-dense coconut apple as a primary component. The rationale for this research is to fill this empirical gap, providing farmers with a strategy to reduce production costs and efficiently utilize agricultural waste. A Randomized Complete Block Design (RCBD) was used, involving eighteen-day-old broilers assigned to two dietary treatment groups: T1 (Commercial Feed) and T2 (Coconut Apple-based Feed I), replicated three times over a 35-day feeding trial. Data were collected on final live weight, average daily gain (ADG), average daily feed intake (ADFI), Feed Conversion Ratio (FCR), and feed cost per kilogram of gain. The main findings indicate that coconut apple is tolerable without detrimental effects on growth. Although the FCR was marginally higher in T2, the critical finding was the economic viability: the coconut apple-based diets resulted in a slightly higher cost (₱38.60/kg) compared to the commercial feed (₱38/kg). These results signify that coconut apple is a viable primary feed ingredient, offering a scientifically-backed pathway for enhanced profitability and promoting a circular economy within the poultry sector.

Contribution/Originality: This study documents the stability of coconut apple-based feed, showing it can be a viable alternative. However, the production cost is much higher than that of commercial feeds, resulting in lower profitability for poultry raisers. Nonetheless, promoting resource efficiency by utilizing agricultural waste leads to more sustainable benefits.

1. INTRODUCTION

The animal production sector is currently facing challenges as the demand for meat increases. Advanced agricultural practices have risen to meet the world's expanding demand for meat as one of the basic food sources, especially chicken. Broiler chicken farming involves raising birds that have been carefully developed for high muscle deposition for meat, ranging from fast-growing to slow-growing breeds [1]. Cobb 500 broilers, for example, are frequently used as a model in research examining dietary changes or management techniques to evaluate effects on growth performance and FCR [2]. Accumulations in the number of animals and improved productivity per animal are necessary to meet the high future demand for livestock products that come with a growing global population [3]. Approximately 70 billion broiler chickens are killed each year, making broiler chickens the world's largest commercial animal production business [4]. Considering that production costs are low (in comparison to, say, pork) and that there are essentially no religious restrictions, the poultry industry is likely the most widespread food production industry globally [5]. Chicken meat is one of the main producers of animal protein as it gives consumers both meat and eggs, and has a higher protein content than other meats [6]. The primary suppliers have increased their breeding and hatchery facilities by 65% to meet the rising demand for poultry meat, which has also increased local output [7]. However, feed ingredients such as grains, corn, and soybean meal are under a lot of pressure because of the rapid growth. The cost of feed is a significant determinant of profitability [8]. Poultry production, particularly that of broilers, is anticipated to address the severe animal protein shortage because of its capacity to secure food and livelihood [9]. The price of needed feed commodities, which are the sources of carbohydrates, energy, and protein, has increased, creating a drawback for poultry production as the pressing requirements for chicken meat exceed the supply. By supplying high-quality protein, job opportunities, and food security, the chicken business has been vital to economic growth [10].

The cost of ingredients for chicken feed changes and is influenced by market and weather circumstances. A tendency to simplify feeding programs has been observed in Philippine broiler production, frequently reducing the conventional three-phase system (starter, grower, and finisher) to essentially two phases: starter and finisher. The approach is often used by producers aiming to reduce feed costs, which account for a sizable portion of overall production costs, and to streamline operations [11]. Therefore, to reduce reliance on common feed ingredients and address various issues in the animal production industry, such as excessive production costs, researchers are exploring and seeking substitute primary feed ingredients for chickens. Finding alternative primary feed ingredients requires careful consideration of their impact on broilers' growth, weight, and overall health to ensure that the production of disease-free poultry meets the rising demand. The nutrient content of the feed ingredients, their availability in each area, and the cost of feeding them to chickens will primarily determine their use in animal feed [12].

Coconut apple is known as a main waste product in coconut production and is often disposed of in landfills or allowed to decay, which results in environmental pollution and waste of resources. Collected coconuts that were 9–12 months old to produce coconut apples [13]. According to Preethi and Anil [14] coconut apples, commonly known as picked coconut, are edible globular sponges that resemble cotyledons. The coconut apple starts to grow when a coconut begins to germinate, which absorbs the coconut water inside and forms a tight, sponge-like mass. Despite it not being fully utilized, the coconut apple is nutritious and rich in beneficial phytochemicals. Its potential health advantages make it a practical alternative for chicken feed. Odebode, et al. [15] state that dried coconut apples may have a crude protein content of around 5%. Utilizing protein-rich food waste that is thrown by enterprises that would otherwise contaminate the environment is one technique to lower feeding expenses without sacrificing nutritional quality Mugabe, et al. [16]. Valli and Gowrie [17] found that the phytoconstituents found in fresh coconut apples, including proteins, carbohydrates, terpenoids, and flavonoids, have concentrated antibacterial, anti-inflammatory, and antioxidant attributes. It is identified as having high nutrient content, including proteins, low calories, high fiber, an excellent source of omega-3 fatty acids, and enzymes, and is abundant in antioxidants, vitamin C, and vitamin A, and can strengthen our immune system, which in turn supports several metabolic and chemical reactions [18]. A previous study suggests its potential as a feed ingredient for animals like poultry.

This study aimed to examine the impact of coconut apple-based feed on broiler chicken parameters such as growth rate, body weight, and feed conversion efficiency. The development of a pelletized feed with coconut apple as the primary ingredient was proposed to address the challenges faced by poultry production.

2. EXPERIMENTAL METHODS

2.1. Research Design

An experimental design was used by the researchers to provide a comprehensive evaluation of the effect of coconut apple as the primary feed ingredient for broilers.

2.2. Breed of Chicks

The experimental chickens used in this study were Broiler Cobb 500, a fast-growing commercial broiler strain well-known for converting feed efficiently, gaining weight fast, and producing consistent meat. Cobb 500 broilers are common in modern poultry production because they can reach market weight in a short period of time while still maintaining acceptable carcass characteristics such as good breast yield and good feed-to-meat efficiency. These broilers are also adaptable to different management conditions, which accounts for their preference among poultry raisers all over the world.

For this study, eighteen-day-old Cobb 500 chicks were purchased from Mojica Feeds Store, a local feed supply store in Calauag, Quezon. For the first week, they were given water with Vitmin Pro as an electrolyte. The chicks were being brooded and raised under consistent management conditions until four weeks of age, and then put into experimental feeding treatments for two weeks.

2.3. Research Locale

The research was conducted at Brgy. Pinagtalleran Calauag Quezon, which experiences a tropical climate with wet and dry seasons. The average temperature was approximately 27°C, changing throughout the day, cooler in the mornings and evenings. The chosen location offered ideal conditions for broiler production and was located near barangays with readily available sources of coconut apple, the primary ingredient. This location was also chosen to facilitate close observation and monitoring of the broilers, using available equipment for feed consumption and growth performance analysis. Furthermore, the proximity to coconut farms ensured easy acquisition of the primary ingredient. The presence of local expertise in chicken husbandry provided valuable support in monitoring broiler growth performance.

2.4. Treatment

This study used the Experimental Design and had two treatments replicated three times in a Randomized Complete Block Design with three chickens in each replicate.

Treatment 1 - (Control Treatment) - Conventional Feeds.

Treatment 2 - (Experimental Treatment) - Coconut Apple-based Feeds.

Table 1. Cage layout.

T1R3	T2R1	T1R1
T2R2	T1R2	T2E3

Table 1 illustrates the cage layout for 18 Broiler Cobb 500 chicks, arranged according to a randomized complete block design (RCBD). The two treatments, Conventional feeds and Coconut Apple-based Feed, were each replicated three times.

2.5. Housing Procedure, Feed Preparations, and Coconut Apple-based Feed Process

2.5.1. Housing Preparation

1. Cage Construction

- Two 18-square-foot brooder cages were constructed, with each cage being divided into three blocks.

- Each block will house three chicks, resulting in a total capacity of 18 chicks.
- A floor space of 6 square feet was provided per block, ensuring 1 square foot of space per chick.
- The cages were elevated 2 feet from the ground using available coconut lumber or wood supports.
- Cage walls were constructed using green screen/net, squared wire, and bamboo slats, incorporating small gaps for ventilation.
- Green screen was utilized for the floor within each cage. Cardboard, old carpet, and tarpaulin were installed on the walls to keep the chicks warm for the initial week.

2. Roofing and Covering

- A galvanized iron roof was installed over the brooding area to protect from rain and sun.
- A movable tarpaulin (trapal) cover was provided for adjustable shade and protection from drafts.

3. Bedding and Floor Management

- During the initial week of the brooding stage, cardboard was placed on the green screen floor to prevent the chicks' feet from slipping.
- In the second week, rice hulls were added over the cardboard.
- From the third week onward, the cardboard was removed from the green screen floor.
- Simultaneously, a 2-4-inch layer of rice hulls was maintained as bedding underneath each cage.

4. Heating

- A 50-watt incandescent bulb was installed above each 6-square-foot block, positioned to provide radiant heat to the chicks.
- A temperature range of 32-35°C (90-95°F) was maintained directly under the heat source.
- Chicks were continuously monitored and observed for behavioral indicators of thermal comfort:

a. Cold: Huddling directly under or very close to the light, accompanied by loud chirping, necessitated an increase in heat or a reduction in light height.

b. Hot: Spreading out, moving away from the light, panting, and lethargy indicated a need to raise the light or provide additional ventilation.

c. Comfortable: Even dispersion, activity, and quiet exploration within their space confirmed optimal conditions.

- The temperature was gradually reduced by approximately 2.8°C (5°F) per week through adjustments in the light's vertical placement.

5. Lighting

This schedule is flexible and may be adjusted based on the chicks' behavior; if they spread out and move away from the light, the lights will be turned off regardless of the schedule. However, if the chicks are evenly scattered, the supposedly light schedule will be followed:

- Day 1 to 3 - 23 hours (Lights off: 12:00 PM to 1:00 PM).
- Day 4 - 22 hours (Lights off: 12:00 PM to 2:00 PM).
- Day 5 - 21 hours (Lights off: 11:00 AM to 2:00 PM).
- Day 6 - 20 hours (Lights off: 10:00 AM to 2:00 PM).
- Day 7 - 19 hours (Lights off: 10:00 AM to 3:00 PM).
- Day 8 onwards - 18 hours (Lights off: 10:00 AM to 4:00 PM).

6. Ventilation

- Enough ventilation was ensured through the bamboo slats, green screen/net, and square wire walls, as well as via open areas, while avoiding direct drafts.
- Airflow will also be contributed to by the elevated floor.

2.5.2. Feed Preparation for Each Treatment

1. Conventional Feed (Control Treatment)

The conventional feeds (Booster, Starter, and Finisher) were purchased in Mojica Feed Store, the local conventional feed store in Calauag, Quezon.

2. Coconut Apple-based Feed (Experimental Treatment)

Ingredients:

- Coconut Apple.
- Soybean Meal.
- Rice Bran.
- Mulberry Leaves.
- Moringa Leaves.
- Molasses.
- Salt.

2.5.3. Coconut Apple-Based Feed Process

Step 1: The collected coconut apples were washed thoroughly to remove dirt and debris.

Step 2: The coconut apples were cut into thin slices or finely ground using a blender or food processor.

Step 3: If finely ground, the liquid is removed from the finely ground coconut apple by straining it through a cloth.

Step 4: The strained, finely ground, or thinly sliced coconut apples were spread on clean trays, screens, or mats.

Step 5: A dehydrator was used to dry the ground coconut apple.

Step 6: After drying, a feed grinder machine was used to pulverize the dried, ground coconut apple.

Step 7. The powdered coconut apple was mixed with other feed ingredients, including soybean meal, rice bran, mulberry leaves, moringa leaves, molasses, and salt.

Step 8. After thorough mixing, the feed was pelletized into crumble and pellet forms using a pelletizer machine.

2.6. Management Practices for Disease Prevention

1. Strict Biodiversity: A mandatory waiting period for strangers or new birds before activity with the flock was followed. Hands, shoes, and tools were always clean.
2. Optimal Coop Hygiene: The house was washed and often disinfected. The bedding was kept dry. Rats, bugs, and pests were prevented from getting in.
3. Ventilation & Environmental Control: Good air flow inside the chicken coop was ensured. Standing water was removed to control mosquitoes.
4. Feed & Water Management: Clean water and fresh feed were given every day. Feed was stored properly so rats and wild birds cannot reach it. Moldy grains were fed to the broilers.
5. Observation & Stress Reduction: Broiler's health was regularly monitored. Overcrowding was avoided to minimize stress for better productivity.

2.7. Specified Broiler Nutrient Requirements

A good source for broiler nutrient requirements, reflecting modern standards, is usually found in academic papers or industry guides. The researchers used the Nutrient Requirements of Broiler Chickens (often summarized from NRC or similar standards) as found in recent agricultural extension publications or review articles.

- Crude Protein (CP): 18-19% (For comparison, the researchers used 21%)
- Metabolizable Energy (ME): 3100-3200 kcal/kg (equivalent to 300 kcal/100g)

2.8. Computation of Coconut Apple-based Feed Using the Pearson Square Method

The following table details the calculation of the crude protein and metabolizable energy (Derived from carbohydrates) content of the proposed coconut apple-based broiler feed. This computation aims to evaluate whether the given formulation meets the specified nutrient requirements for broiler chickens.

Table 2. Ingredient composition and nutrient contribution.

Ingredient	Percentage in Feed (%)	Estimated Crude Protein (CP) (%/100g)	Estimated Carbohydrate Energy (kcal/100g)	Estimated Contribution to CP (g/100g feed)	Estimated Contribution to Energy (kcal/100g feed)
Dried coconut apple	38.7	5	320	(38.7/100) × 5 = 1.94	(38.7/100) × 320 =123.84
Soybean meal	34.8	44	220	(34.8/100) × 44 = 15.31	(34.8/100) × 220 =76.56
Rice bran	15	13	280	(15/100) × 13 = 1.95	(15/100) × 280 =42
Mulberry leaves	5	15	180	(5/100) × 15 = 0.75	(5/100) × 180 =9
Moringa leaves	5	20	200	(5/100) × 20 =1	(5/100) × 200 =10
Molasses	1	3	260	(1/100) × 3 =0.03	(5/100) × 260 =13
Salt	0.5	0	0	(0.5/100) × 0 =0.000	(0.5/100) × 0 =0.00
Total	**100**			**20.98g CP**	**274.4kcal**

Table 2 presents that the Rice Bran, Mulberry Leaves, Moringa Leaves, Molasses, and Salt had a fixed amount, which totaled 26.5% of the feed composition with 3.73 CP, leaving (26.5-100) 73.5 of the feed composition with (3.73-21) 17.27 CP. To compute the amount of the remaining ingredients (Coconut, Apple & Soybean Meal), the researchers used the Pearson Square Method.

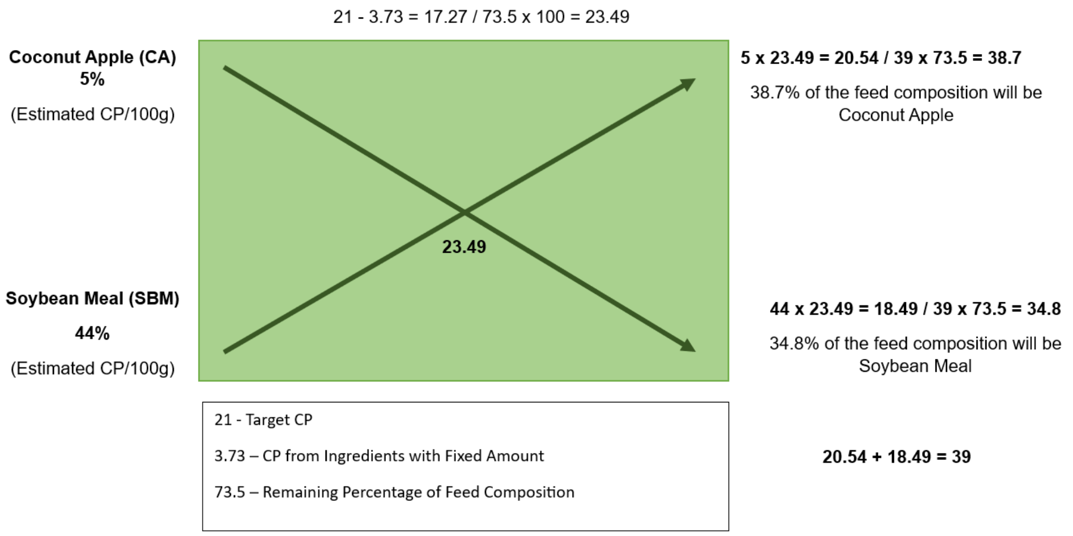

Figure 1. Computation of CA and SBM using the Pearson square method.

Figure 1 highlights the maximized utilization of the main ingredient, this 20-kilogram finisher feed mix, which was good for two weeks, purposefully contains a significant 38.7% (7.74kg) dehydrated coconut apple. When added at a percentage of 34.8% (6.96kg), soybean meal offers protein, although not as much as beginning feeds. At 15% (3kg), rice bran is the main source of energy. 5% (1kg) of mulberry and moringa leaves are added to the feed to improve its nutritional profile by adding important vitamins, minerals, and a small amount of protein. 1% (0.2kg) of molasses is used to increase palatability and energy. Lastly, to guarantee an appropriate electrolyte balance, 0.5% of salt (0.1kg) is added, which totals 100% (20kg) of the Feed Composition with 20.98 CP and 2744 ME, and was fed to nine four-week-old broilers.

Table 3. Summary and comparison to requirements.

Nutrient	Calculated content in feed	Specified broiler finisher feed requirement
Crude protein (CP)	20.98%	18-19%
Metabolizable energy (ME)	2744 kcal/kg	3100-200 kcal/kg

Table 3 shows that the feed's calculated crude protein content is 20.98%, which falls slightly above the required range of 18-19%. Similarly, the calculated metabolizable energy of the feed is 2744 kcal/kg, which is significantly lower than the specified broiler requirement of 3100-3200 kcal/kg. Overall, the table shows that the feed's nutrient levels do not fully meet the specified nutritional requirements for broiler chickens, particularly in terms of energy content.

2.9. Feeding Management

Feeding management of the 18 broiler Cobb was implemented in two phases to test the effects of coconut apple feed versus commercial feed. Weeks 1 to 4 had all 18 broilers uniformly fed with commercial feed (booster, starter, and finisher) to ensure a common nutritional base and uniform growth for that early stage of production. By Week 5, the flock was then stratified into two groups: an experimental group of 9 broilers on a formulated feed based on coconut apple, with the primary ingredients of coconut apple, soybean meal, rice bran, mulberry leaves, moringa leaves, molasses, and salt. The control group, which consisted of another 9 broilers, continued on the commercial finisher feed as the yardstick for growth performance and efficiency. Feed and clean water were provided ad libitum, and feed intake, body weight, and feed conversion ratio were diligently monitored during Weeks 5 and 6. The experiment was thus able to compare growth performance, feed efficiency, and meat quality of broilers raised conventionally on a diet against those raised on alternate coconut apple feed.

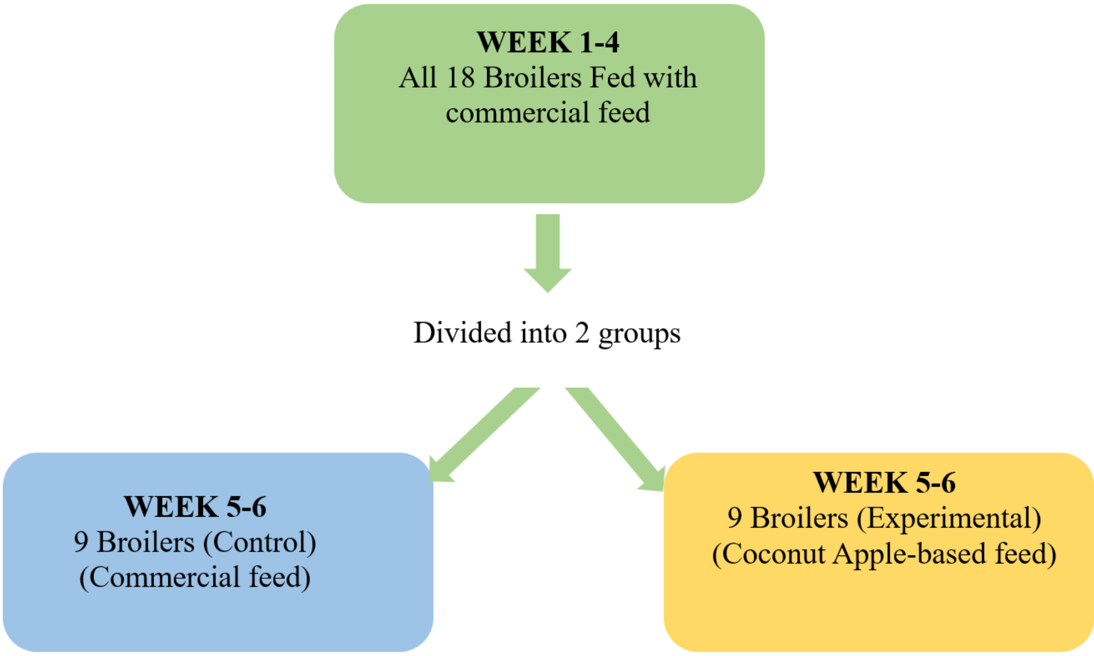

Figure 2. Feeding management of broiler Cobb.

Figure 2 illustrates that all 18 broiler chicks were fed commercial feed for a four-week brooding period to provide them with essential nutrients for growth before the experimental phase, as chicks are highly sensitive during their initial growth stage.

2.10. Feeding Practices

The feeds had been formulated to meet the nutrient conditions of broilers based on National Research Council [19] guidelines. The preparation and feeding process had included.

1. Feeding broilers ad libitum to ensure good access to feeds.
2. Giving clean, fresh drinking water at all times.
3. Broiler Cobb 500 consumed about 13-14 grams during the first day and gradually increased. Approximately 50-60 grams of feed per day was consumed during the starter phase, and around 130-160 grams of feed or even higher during the finisher phase.

2.11. Management Practices

1. Biosecurity - The poultry house, equipment, and all surfaces that came into contact with the broiler were disinfected and cleaned daily. Strict measures were taken to keep a clean and hygienic environment for the broiler to prevent the spread of diseases, improve the broiler's health, and enhance overall productivity.
2. Housing and Environment - Good ventilation control maintained the best possible air quality. The growth cycle was maintained at the right temperature, and appropriate lighting arrangements were put in place at the same time. The comfort, growth, and general health of broilers were maximized by this comprehensive approach, which created a dry and comfortable environment.
3. Nutrition and Feeding - Broiler chickens were fed a high-quality, nutrient-dense diet to promote their best possible growth. For the general health of the birds, clean, fresh water was provided with frequent inspections, and effective feed delivery systems reduced waste and guaranteed steady access.
4. Record Keeping - Mortality, growth rates, feed and water usage, and other aspects of broiler production were all accurately and thoroughly documented in the records. These records' data were analyzed to pinpoint problem areas and maximize overall production efficiency.

2.12. Statistics Analysis

The data gathered on the growth rate, cost of production, and quality of chicken meat were analyzed and observed. A t-test was also used to determine if there were any differences in growth rate, cost of production, and quality of chicken meat.

3. RESULTS AND DISCUSSION

3.1. Average Daily Gain

Table 4 presents the average daily gain (ADG) for broiler Cobb chickens fed a commercial feed versus a coconut apple feed. It compares average weight gains recorded in grams per day during two periods, Week 4-5 and Week 5-6. The table also displays the resulting matched p-values for each period, indicating whether there is any statistical significance to the differences in ADG between the two feed types.

Table 4. Average daily gain of broiler Cobb Fed with commercial and coconut apple-based feed.

Treatment	Week 4-5 (g)	Week 5-6 (g)
Commercial Feeds	68.81 *	37.51
Coconut Apple-based Feed	45.71 *	24.76
P-value	0.0203	0.369461

Note: (*) Significant difference if the P-value is less than 0.05 level of significance.

Table 4 shows that during Week 4–5, broilers fed with commercial feed recorded a significantly higher average daily gain (ADG) of 68.81 g/day compared to only 45.71 g/day in those fed with coconut apple–based feed. The difference between the two treatments was statistically significant (p = 0.0203), indicating that the commercial feed was more effective in supporting rapid growth at this stage. However, in Weeks 5–6, both groups experienced a reduction in ADG as growth naturally slowed with maturity. Broilers on commercial feed averaged 37.51 g/day, while those on the coconut apple–based feed averaged 24.76 g/day. The difference was not statistically significant (p = 0.3695), suggesting that the gap in growth performance between the two diets diminished as the broilers approached market weight.

According to Nicol, et al. [20] conventional commercial broilers generally achieve ADG values of above 60 g/day, while slower-growing or alternative-fed broilers typically average between 50–60 g/day. In this study, the 68.81 g/day ADG of the commercial feed during Week 4–5 closely aligns with industry standards for fast-growing commercial strains, while the 45.71 g/day ADG of the coconut apple–based feed falls within the range expected of slower-growing or alternative diets. The decline in ADG during Week 5–6 is consistent with the natural physiological slowdown in growth as broilers near finishing weight, further confirming the validity of the observed results in relation to established growth performance benchmarks.

3.2. Weight

Table 5 presents the mean weight of Cobb broiler chickens fed on two types of feed: a coconut apple-based meal (Treatment 2) and commercial feed (Treatment 1). It shows the average weights of chickens in grams during Weeks 4, 5, and 6. Moreover, the table displays the resulting matched p-values of each week to show whether the weight differences observed between the two groups were statistically significant.

Table 5. Weight of broiler Cobb Fed with commercial and coconut apple-based feed.

Treatment	Week 4 (kg)	Week 5 (kg)	Week 6 (kg)
Commercial feed	1.23	1.71	1.97
Coconut apple-based feed	1.34	1.67	1.83
P-value	0.285408	0.702606	0.514306

Note: (*) Significant difference if the P-value is less than 0.05 level of significance.

Based on the provided data in Table 5, there is no statistically significant difference in the average weight gain between the broiler chickens fed the commercial feed and those fed the coconut-apple-based feed. This conclusion is supported by the p-values for all three weeks (0.285408, 0.702606, and 0.514306), all of which are above the standard significance level of 0.05.

This finding aligns with research on the use of coconut meal as a feed ingredient for broilers. A study by Ali and Ali [21] found that while high levels of toasted coconut meal could negatively affect growth, a moderate inclusion rate could lead to growth performance similar to that achieved with a standard diet. The fact that the coconut-apple-based feed in the present study yielded comparable results to the commercial feed suggests that the formulation was well-balanced, allowing the chickens to utilize the nutrients effectively without any adverse effects on their growth. Therefore, the coconut-apple-based feed is a viable alternative to commercial feed for promoting weight gain in broiler chickens, as it produced statistically similar results.

3.3. Feed Conversion Ratio

Table 6 presents the Feed Conversion Ratio (FCR) for broiler chickens raised on two different diets: Commercial Feed and Coconut Apple-based Feed. The data were segmented into two periods of growth, Week 4-5 and Week 5-6, to assess the efficiency of two different feeds with age. The P-value is included to verify if these differences between the two treatments are statistically significant.

Table 6. Feed conversion ratio of broiler Cobb Fed with commercial and coconut apple-based feed.

Treatment	Week 4-5	Week 5-6
Commercial feed	2 *	2.67
Coconut Apple-based Feed	3.67 *	3.67
P-value	0.00749	0.507158

Note: (*) Significant difference if the P-value is less than 0.05 level of significance.

Based on the data provided in Table 6, during the initial period (Weeks 4-5), the commercial feed (FCR = 2) with total feed intake of was superior to the coconut apple-based feed (FCR = 3.67). The p-value of 0.00749, being less than the 0.05 significance level, confirms this statistical difference. This finding is consistent with studies on alternative feedstuffs. For example, Musa, et al. [22] reported that non-conventional ingredients, such as toasted coconut meal, may influence broiler performance adversely at least at first. The low FCR associated with the commercial feed would suggest that it was more palatable and digestible by the chicks at this critical growth phase.

However, a different trend was apparent in the later period (Week 5-6). The commercial feed's FCR increased to a value of 2.67, while that of a coconut apple-based feed remained stable at 3.67. The increase in commercial feed FCR indicates a decline in its efficacy as the birds mature. Within this period, the p-value stands at 0.507158, suggesting a lack of significant difference between the two feeds. This observation suggests that while the coconut apple-based feed was less efficient initially, its performance remained more stable over time. This decline in commercial feed efficiency, along with the stable performance of the alternative feed, accounts for closing the statistical difference. Musa, et al. [22] support this notion by suggesting that the impact of alternate feed ingredients on broiler performance can vary over a feeding period, which agrees with the noted shift in statistical significance.

Table 7. Average weekly feed intake.

Treatment	Week 4-5(g)	Week 5-6 (g)
Commercial feed	963.32	701.04
Coconut Apple-based Feed	1174.4	636.12

Table 7 presents that broilers fed with Coconut Apple-based feed consumed slightly higher compared to broilers fed with Commercial Feed, despite the commercial feed being more palatable and digestible by chickens. However, higher feed intake does not mean higher weight gains. This results in the Coconut Apple-based feed costing quite a bit higher than commercial feed due to the slower growth the experimental feed provides. According to Moss, et al. [23] developing a nutrition regime is expected to improve the sustainability of the industry. This makes the Coconut Apple-based feed viable, yet it needs to be examined in the future, as constant improvement is necessary to achieve one's objective.

3.4. Sensory Attributes and Meat Characteristics

The sensory attributes and meat characteristics of broiler Cobb chickens were compared in Table 8. The sensory attributes assessed were flavor, color, juiciness, and tenderness. The table then compares the numerical scores, descriptive interpretations, and p-values that indicate the statistical significance of the differences observed in the two treatment groups for each parameter.

Based on the p-values in Table 8, there is no statistically significant difference in the meat quality (color, juiciness, tenderness, and flavor) of broiler chickens fed either commercial feed or the experimental coconut-apple-based feed. All recorded probabilities are above 0.05, which would suggest that any small numerical differences would be attributable to random chance.

Table 8. Meat characteristics of broiler Cobb Fed with commercial and coconut apple-based feed.

Treatment	Color	Descriptive Interpretation	P-value	Juiciness	Descriptive Interpretation	P-value
Commercial feed	5.9	Slightly Light	0.86885	6.1	Slightly Juicy	0.95547
Coconut apple-based feed	6	Slightly light		6.1	Slightly juicy	
Treatment	Tenderness	Descriptive interpretation	P-value	Flavor	Descriptive interpretation	P-value
Commercial feed	5.5	Slightly soft	0.760712	6.7	Moderately flavorful	0.867947
Coconut apple-based feed	5.6	Slightly soft		6.8	Moderately flavorful	

Note: (*) Significant difference if the P-value is less than 0.05 level of significance.

The finding is consistent with the emerging reports on others' feed materials for poultry. Ali and Ali [21] showed that the incorporation of toasted coconut meal into broiler diets had no adverse effect on the overall meat quality, thus indicating that coconut-based ingredients can be applied successfully while maintaining the quality of the final product. Likewise, Olugbenga and Omole [24] reported that plantain and cassava peels, as unconventional ingredients, did not adversely affect the sensory attributes of chicken meat. Together, all this research backs the conclusion drawn from Table 6 that a well-formulated experimental feed, such as a coconut apple-based diet, can yield meat with quality characteristics akin to those of birds raised on standard commercial feed.

3.5. Economic Analysis

An economic analysis was conducted in Weeks 5 and 6 of the experiment to further evaluate and assess the economic implications of feeding commercial feed versus feeding coconut apple-based feed. The analysis accounted for feed cost, average daily gain (ADG), body weight, feed conversion ratio (FCR), feed intake per bird, total feed cost, and overall profitability. The results reveal that commercial feed was used efficiently throughout the study period and yielded a slightly higher profit margin, especially in terms of FCR and weight gain. Coconut apple-based feed, despite being slightly costlier to process and less efficient, maintained steady performance and enhanced sustainable utilization of agricultural by-products. The economic comparison between the two feeding treatments during the fifth and sixth weeks is summarized in the following tables.

Table 9. Economic analysis.

WEEK 5		
Parameters	**Commercial Feed**	**Coconut Apple-based Feed**
Feed Cost per kg (₱)	38.00	38.60
Average Daily Gain (ADG, g/day)	68.81 *	45.71 *
Average Weight (kg)	1.71	1.66
Feed Conversion Ratio (FCR)	2.00 (better)	3.67 (poorer)
Feed Intake per bird (kg)	1.26	1.30
Number of Broilers	9	9
Total Feed Cost (₱)	430.92	451.62
Remarks	Higher profit, efficient	Lower profit, costly
WEEK 6		
Parameters	Commercial Feed	Coconut Apple-based Feed
Feed Cost per kg (₱)	38.00	38.60
Average Daily Gain (ADG, g/day)	37.51	24.76
Average Weight (kg)	1.97	1.83
Feed Conversion Ratio (FCR)	2.67 (better)	3.67 (poorer)
Feed Intake per bird (kg)	0.72	0.66
Number of Broilers	9	9
Total Feed Cost (₱)	246.24	229.28
Remarks	Higher profit, efficient	Lower profit, costly

Note: (*) Statistically significant at P < 0.05.

The economic analysis results indicated that the broilers given commercial feed in Week 5 had a clear edge over those on coconut apple parameters in terms of growth performance and profitability. The average daily growth achieved in the commercial group was higher (68.81 g/day vs. 45.71 g/day), and the feed conversion ratio was superior (2.00 vs. 3.67), dropping its total feed cost to ₱430.92 vs. ₱451.62. Thus, during this period, commercial feed was evidently efficient for growth and return. However, by Week 6, the commercial group recorded better growth performance (37.51 g/day vs. 24.76 g/day) and feed conversion ratio (2.67 vs. 3.67), yet the coconut apple–based feed recorded lower total feed costs (₱229.28 vs. ₱246.24). This suggested that while being less efficient, the experimental feed began to show potential economic value in cost reduction in the later stage of production.

According to the findings of Lañada, et al. [25], it is the cost of feeds, performance of growth, and mortality rates that determine the profitability of broiler farming. As in many cases, farmers would experience fluctuating or even negative gross margins simply because of inefficiency. This complements the findings of this study because commercial feeds, due to high feed efficiency and lower costs towards Week 5, brought about more profitability, whereas coconut apple–based feed, though showing less feed efficiency, was starting to indicate lower costs at Week 6. These parallels strongly stress the importance for poultry farmers in the Philippines to balance feed efficiency with cost-saving strategies warranted to keep their profitability, particularly when utilizing alternative feed resources such as coconut apple.

4. CONCLUSION

In conclusion, the study showed that despite commercial feed initially helping broiler chickens grow rapidly and achieve higher feed conversion ratios, as the broilers grew older, the performance differences between commercial and coconut apple-based feeds decreased. Throughout the trial, there was no statistically significant difference in weight increase or meat quality between the two diets, suggesting that feed made from coconut apples can be a good substitute without compromising broiler performance or meat quality. The stability of feed made from coconut apples in later weeks shows that it can be a viable alternative, even though commercial feed was more effective in the early growth stage. However, compared to commercial feed, the slightly higher cost for producing feed made from coconut apples and its somewhat lower end weight increase decreased profitability from an economic perspective. Nevertheless, by lowering agricultural waste and promoting resource efficiency, the utilization of coconut apples and other byproducts offers substantial sustainability benefits. More advancements in feed formulation and economical processing techniques are advised for increased commercial viability. All things considered, coconut apple-based feed exhibits promise as a substitute ingredient for chicken feed that strikes a compromise between sustainability and satisfactory results for growth and meat quality.

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