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Impact of honey-supplemented high-fiber diets on growth performance, nutrient digestibility and production costs in broiler chicks

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ABSTRACT

A 28-day feeding trial assessed the effects of high-fiber diets with honey on the growth performance, nutrient digestibility, and production costs of broiler chicks. One hundred and fifty a day-old Abor acre plus chicks were randomly assigned to five dietary treatments, each with three replicates of ten chicks. The control diet (T1) included 3 kg of rice offal (RO) with a crude fiber (CF) content of 4.64%. The other treatments varied in RO content: T2 (4 kg, 4.96% CF), T3 (5 kg, 5.24% CF), T4 (6 kg, 5.55% CF), and T5 (7 kg, 5.82% CF). Results showed a significant ($p<0.05$) reduction in final body weight, daily feed intake, and feed conversion ratio with increasing fiber levels. Nutrient digestibility was not significantly ($p>0.05$) affected by the diets, but feed costs per kilogram decreased with higher fiber. The birds in T1 group had the highest feed costs per weight gain, while T4 had the lowest. In conclusion, rice offal with honey can be included up to 4 % of the diet, with 150 g/kg of honey for optimal growth. Notably, including 6% rice offal improved feed costs per weight gain compared to the control.

Keywords: rice offal; organic honey; growth performance; digestibility; production cost

INTRODUCTION

Fiber is a vital nutritional component in poultry feed, although it can negatively impact feed intake and nutrient absorption (Jimenez et al., 2015). Dietary fiber is categorized as soluble, including β-glucans from barley and oats, and arabinoxylans from wheat and rye, or insoluble, comprising cellulose, non-starch polysaccharides (NSP), and lignin. Moderate fiber inclusion can enhance intestinal function, regulate nutrient digestion, and promote gut health in birds (Hetland et al., 2004).

In addition to traditional energy and protein sources such as corn, wheat, and soybean meal, various cereal grains and fiber-rich by-products, including maize offal, wheat offal, Bambara groundnut offal, and rice bran, can serve as viable alternatives feedstuff in monogastric diets (Jha and Berrocoso, 2015). Also, Sundu and Chao (2018) conclude that non-conventional feed ingredients can be effective alternatives to traditional feed sources in monogastric diets. The authors emphasize that these ingredients often have favorable nutritional profiles, can reduce feed costs, and enhance sustainability in animal production.

Fiber-rich ingredients enhance poultry digestive health by improving gut motility and promoting beneficial bacteria growth. Alternative feed sources, often locally available, reduce costs and support sustainability by decreasing reliance on conventional crops. For instance, alfalfa meal provides essential vitamins and minerals while its fiber content fosters gut health, leading to better digestion and nutrient absorption (van der Meer and de Jong, 2018; Sarker et al., 2019; Jha and Berrocoso, 2015).

Rice offal, a by-product of milled rice, has a dry matter content of 91.09% to 94.42%, with crude protein ranging from 5.09% to 7.32%, and crude fiber from 18.00% to 33.18% (Maikano, 2007; Ani et al., 2013; Adeyina et al., 2016). However, its nutrient utilization is limited by poor digestibility, primarily due to high viscosity in the gastrointestinal tract (Jimenez et al., 2015). Therefore, nutritional strategies to enhance nutrient bioavailability are crucial.

Commonly used enzymes in high crude fiber poultry diets include Polyzyme®, which enhances nutrient absorption and feed efficiency (Kim, 2012). Maxigrain® improves digestion of fiber-rich grains like barley and wheat (Hesselman and Bjorck, 1992). Other manufactured enzymes like Multizyme®, OptiFiber®, and Digestarom® also aim to enhance nutrient digestibility in fiber-rich diets (Van der Meer, 2012; Zhan, 2007; Kiarie, 2013). Research by Yakubu et al. (2007) and Ihenkwumere et al. (2001) indicated that urea-treated rice milling waste resulted in lower feed intake compared to untreated waste. Additionally, Tuleun et al. (2009) recommended enzyme treatments, such as Roxazyme®, to improve the efficacy of high rice offal diets.

Honey is gaining attention as poultry feed additive due to its health benefits and nutritional properties. Rich in sugars, vitamins, minerals, and antioxidants, it helps reduce oxidative stress and enhance immune function (Moussa et al., 2019). Honey improves diet palatability, encouraging feed intake in young or recovering birds. Its natural antimicrobial properties may control gut pathogens, reducing diseases like coccidiosis (Alzawqari et al., 2020). Additionally, honey may promote beneficial gut bacteria growth, enhancing digestive health and nutrient absorption in poultry (Rizvi et al., 2018). Overall, honey is a valuable supplement for improving poultry health and performance.

Despite the recognized advantages of high-fiber diets and honey supplementation, research on the combined effects of organic honey and high-fiber diets in broiler nutrition is limited. This study aims to investigate the synergistic effects of high-fiber diets supplemented with organic honey on growth performance, nutrient digestibility, and production costs in broiler chickens.

MATERIALS AND METHODS

Experimental site

The study was carried out at the Poultry Unit of the Livestock Teaching and Research Farm at Joseph Sarwuan Tarka University in Makurdi, Nigeria. This city is situated within the Guinea Savanna Zone, specifically at latitude 7°44′1.50″ N and longitude 8°31′17.00″ E. The region experiences an annual rainfall from March to October, varying between 508 and 1,016-mm. Temperature ranges from a minimum of 22.8°C to a maximum of 40.0°C. Additionally, relative humidity fluctuates between 37.3% and 59.2% (Audu et al., 2022).

Management and disease control

Ten days before the experimental birds were due to arrive, the poultry house was disinfected using Izal solution mixed at a ratio of 100 ml per 20 liters of water, following manual dusting to remove cobwebs. On the seventh day prior to the birds' arrival, all equipment including feeders, drinkers, buckets, and footwear was disinfected. Thick black plastic was then used to cover the windows to retain warmth inside the brooding area. Care was taken to source fresh wood shavings from sawmill to prevent pathogen buildup. After covering the windows and sealing other openings, all equipment and wood shavings were placed in the poultry pen while fumigation was performed using a mixture of formalin and potassium permanganate at a ratio of 20 ml to 5 grams. Three days post-fumigation, windows and entrances were opened to allow the escape of residual gas. The day before the birds' arrival, 200-watt heat bulbs were installed and turned on to warm the pen. Upon arrival, the birds were provided with fresh water mixed with glucose to reduce stress, followed by weighing them and assigning them to replicates based on their weights. After one hour, compounded feeds were given to the respective groups. Throughout the trial, strict biosecurity protocols were observed, and thorough records were maintained during the entire period.

Experimental design and diets formulation

A total of 150 mixed-sex day-old Abor Acre Plus strain broiler chicks were procured from a reputable hatchery located in Ibadan, Oyo State, Nigeria. Out of these, 120 chicks were selected for the study. The initial weights of the chicks were recorded using a sensitive scale (Metler scale), and the average initial weight was calculated by dividing the total weight by the number of chicks. The chicks were divided into four dietary treatment groups, each consisting of three replicates with ten birds per replicate. The experimental diets were formulated with varying levels of rice offal (RO) and crude fiber (CF) content. The control diet (T1) contained 3 kg of rice offal, equating to approximately 4.64% CF, the other treatments included T2 with 4 kg (5.00% CF), T3 with 5 kg (5.24% CF), T4 with 6 kg (5.60% CF), and T5 with 7 kg (5.82% CF) as in Table 1.

Fresh organic honey was sourced from local vendors in the Makurdi metropolis and was stored in a clean, airtight 25-liter container in a cool, dry location to maintain its purity. Fresh rice offal was obtained from a rice processing factory within Makurdi.

Following the recommendations of Obun et al. (2009), honey was incorporated at a rate of 15 g per kg of feed. To enhance its consistency and facilitate mixing, 15 g of honey was pre-diluted with 1 kg of rice offal. The specified quantities of rice offal for each treatment group were blended with the honey to ensure that nutritional targets were met before being mixed with the complete feed to create compounded diets.

The formulation of the diets was facilitated using the Feedwin software application. The macro ingredient nutrient compositions (including maize, soybean meal, groundnut cake, brewer's dried grain, rice bran, blood meal, and palm oil) were analyzed for their proximate compositions prior to inputting the data into the software. The micro ingredients i.e methionine, premix, lysine, and salt were included at a fixed rate of 0.25 % of the total diet. All diets were formulated to comply with the standard nutrient requirements for broiler chicks as outlined by the NRC (1994) for the initial 28 days of growth, as detailed in Table 1.

Production performance and growth data collection and calculation

Data were collected weekly on body weight, weight gain, feed intake, and feed conversion ratio, calculated using the formulas provided below by (Sunmola and Tuleun, 2023b).

$$\text{Average initial weight (g)} = \frac{\text{Total weight of birds at initial}}{\text{Total no of birds}}$$

$$\text{Average final weight (g)} = \frac{\text{Total weight of birds in a replicate}}{\text{Total no of birds in the replicate}}$$

$$\text{Average daily weight gain (g)} = \frac{\text{Average final weight} - \text{Average initial weight}}{\text{Experimental period}}$$

Average weight gain (g) = average final weight – average initial weight

Feed Intake (g) = feed supplied – feed left over

$$\text{Average feed intake (g)} = \frac{\text{Total feed intake}}{\text{Number of birds}}$$

$$\text{Average daily feed intake (g)} = \frac{\text{Average feed intake}}{\text{Number of the experimental days}}$$

$$\text{FCR} = \frac{\text{Average daily feed intake (g)}}{\text{Average daily weight gain (g)}}$$

Table 1. Gross composition of the experimental diets

Ingredients (kg/100kg)	**T1**	**T2**	**T3**	**T4**	**T5**
Maize	55.00	54.50	54.00	53.50	52.00
SBM	28.00	27.50	27.00	26.50	27.00
GNC	8.00	8.00	8.00	8.00	8.00
Rice offal	3.00	4.00	5.00	6.00	7.00
Blood meal	2.00	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00	2.00
palm oil	1.00	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Total	**100**	**100**	**100**	**100**	**100**
Organic honey	1.50	1.50	1.50	1.50	1.50
Calculated analysis					
ME (Kcal/kg)	2876	2860	2844	2828	2802
Crude protein	22.58	22.38	22.17	22.14	22.11
Crude fibre	4.64	5.00	5.24	5.60	5.82
Ether extract	3.85	3.87	3.89	3.90	3.92
Lysine	1.47	1.46	1.45	1.44	1.44
Methionine	0.58	0.57	0.57	0.57	0.57
Calcium	1.32	1.33	1.34	1.35	1.37
Available phosphorus	0.70	0.70	0.70	0.71	0.71

**To provide the following per kg of diet vitamin A – 15,000.00IU, Vitamin D3 - 3, 000,000IU, Vitamin E- 30,000IU, Vitamin K3,000mg, Vitamin B1 3000,mg Vitamin B2-6000mg, Vitamin B6-5,000mg, Vitamin B12-40mg, Biotin 200mg, Niacin-40,000mg, Pantothenic acid 15,000mg, Folic acid 2,000mg, choline 300,000mg, Iron 60,000mg, manganese 80,000mg, copper 25,000mg, Zinc 80,000mg cobalt 150mg, Iodine 500mg. (feed formulation was done using the feedwin software application);* Ctrl = control, ME – metabolizable energy, BDG - Brewer dried grain, Ph – Phosphorus, Vit./min. – vitamin/mineral

Production cost

Upon completion of the experiment, the birds were promoted for sale through the University website and various social media platforms to ensure a swift transaction and minimize additional feeding costs that could adversely affect profitability. The costs associated with each experimental diet were calculated based on ingredient prices obtained in 2024, during the course of the study. The unit price for each day-old chick was set at ₦650.00. To determine the final value of each bird, the final weight was multiplied by the price per kilogram of live weight, which was ₦3,200.00. All production cost indices were assessed using the formulas provided by Sunmola and Tuleun (2023b).

$$\text{Cost/kg feed} = \frac{\text{Cost of all Ingrediets}}{\text{Total weight of ingredients (kg)}}$$

$$\text{Feed cost per kilogram live weight} \\ = \text{Feed cost per kilogram x Feed: gain ratio}$$

$$\text{Feed cost per kg weight gain} = \frac{\text{Feed cost per kg x Total feed intake}}{\text{Total weight gain}}$$

$$\text{Feed cost per chicken} \\ = \text{Daily feed intake x Experimetal days x feed cost per kg}$$

$$\text{Operational cost} \\ = \text{Total expenses on each birds} \\ - \text{expenses on feed and chick cost}$$

$$\text{Total production cost} \\ = \text{Cost of day old bird} + \text{feed cost per bird} \\ + \text{operational cost}$$

$$\text{Feed cost (\% Total production cost)} = \frac{\text{Cost of kg feed}}{\text{Total production cost}} \text{ x } 100$$

$$\text{Income per bird} = \text{Average live weight x selling price kg live weight}$$

$$\text{Profit per bird} = \text{Income} - \text{expenses}$$

$$\text{Cost: Benefit} = \frac{\text{Total expenses}}{\text{Total income}}$$

Nutrient digestibility

Nutrient digestibility assessments were conducted from the end of week three through the end of week four. Two days prior to placing the birds in the metabolic cages, all cages, feeders, and drinkers were thoroughly disinfected to prevent microbial contamination. Two birds, selected based on the average weight of the group, were carefully transferred into each metabolic cage.

The initial three days allowed the birds to acclimate to their new environment, during which they were provided with feed and had access to water *ad-libitum*. On the third day, water was left available while feed was withheld for 15 hours to ensure the gastrointestinal tracts were clear of any feed. After the fasting period, known quantities of feed were weighed and given to the birds for three days. On the evening of the third day, the feed was removed to ensure that the gastrointestinal tracts were empty, allowing for accurate measurements of feed offered and feaces voided. Fresh feacal droppings from each replicate were collected and weighed daily in the morning, then transferred to an oven set at 70°C for drying until a constant weight was achieved. Once dried, the fecal samples were weighed, recorded, and combined by replicate. These bulked samples were then ground using a RESCH Hammer mill with a mesh size of 0.8 mm. Proximate analyses of both the diets and fecal samples were performed according to the methods outlined by AOAC (2006). Nutrient digestibility was subsequently calculated using the following formula:

$$\text{Nutrient digestibility} = \frac{\text{Nutrient in feed} - \text{Nutrient in excreta}}{\text{Nutrient in feed}} \text{ x } 100$$

Statistical analysis

The collected data were analyzed using one-way Analysis of Variance (ANOVA) with the SAS (2002) software. For parameters that showed significant differences ($p<0.05$), means were compared using Duncan's Multiple Range Test.

RESULTS AND DISCUSSION

The effect of high-fiber diets supplemented with organic honey on the growth performance of starter broiler chicks is presented in Table 2. Increasing the inclusion of rice offal beyond 4 kg led to a statistically significant reduction in average final body weight (AFBW) and average daily weight gain (ADWG). Interestingly, the feed conversion ratio (FCR) remained stable up to a 6% inclusion of rice offal. The observed declines in AFBW and ADWG at higher inclusion levels are likely attributable to the elevated crude fiber content, which can pose digestibility challenges for chicks during this critical growth phase. This effect may be related to the viscosity and bulkiness of the digesta, as noted by Sadeghi et al. (2015), even in the presence of honey. Consistent with these findings, Jimenez-Moreno et al. (2011) reported reductions in both body weight and daily weight gain in broiler chicks fed high-fiber diets ranging from 2.5% to 7.5% during the first 12 days of life. Conversely, Onuh et al. (2015) demonstrated that urea-treated high-fiber diets could be beneficial when included at levels up to 15%. Furthermore, Tuleun et al. (2009) highlighted the benefits of Roxazyme enzyme-treated rice offal for growing pullet birds. The absence of significant differences in feed intake suggests that the diets were generally well-accepted, likely enhanced by the palatability from the honey's sweetness. Previous research by Ghosh et al. (2023) and Wang et al. (2022) identified honey as an effective binding agent that improves the overall palatability of feed.

Table 3 outlines the effects of high-fiber diets with organic honey on nutrient utilization in broiler chicks. None of the measured parameters exhibited significant changes due to the inclusion of rice offal treated with organic honey. This lack of significant effect may be due to the nutritional properties of organic honey, which may help mitigate the fibrous nature of rice offal. Okeniyi (2005) identified key enzymes in honey such as amylase, sucrase, α-glucosidase, and glucose oxidase that assist in breaking down starches, sucrose, and glucose into simpler forms. Additionally, studies by Busserolles et al. (2002) and Okeniyi (2005) have highlighted the growth and health benefits associated with dietary honey in broiler chickens.

The impact of high-fiber diets with organic honey on the production costs for broiler chicks is summarized in Table 4. The inclusion of dietary fiber significantly influenced the feed cost per kilogram ($p<0.05$), while other parameters remained statistically similar. The reduction in feed cost per kilogram at higher fiber levels can be attributed to a decrease in the proportion of maize in the diet as dietary fiber increased. Furthermore, the lack of significant differences in feed cost per weight gain, feed cost per chick, and total production costs at higher rice offal inclusion levels suggests that incorporating dietary fiber up to 7% does not negatively impact overall production costs. Tuleun et al. (2009) also indicated that using rice offal can enhance cost efficiency regarding feed costs per kilogram of weight gain. These findings collectively underscore the complexities of incorporating high-fiber ingredients into broiler diets, emphasizing the need for careful consideration of both growth performance and economic implications.

Table 2. Effect of high fibre diets treated honey on growth performance of broiler chicks

Parameters (g)	T1	T2	T3	T4	T5	SEM	p-value
AIW	40.00	40.00	40.00	40.00	40.00	0.00	0.00
AFBW	545.00^{a}	500^{ab}	486.67^{b}	480.00^{b}	459.63^{b}	9.28	0.05
ADWG	18.04^{a}	16.43^{ab}	15.95^{b}	15.71^{b}	14.98^{b}	0.33	0.05
ADFI	32.25	32.26	30.71	32.38	33.36	0.75	0.90
FCR	1.78^{a}	1.97^{ab}	1.92^{ab}	2.06^{ab}	2.12^{b}	0.05	0.15

^{ab}Means within each row with different superscripts are significantly different ($P< 0.05$). SEM = standard error of mean AIW = average initial weight; AFBW = average final body weight; ADWG = average daily weight gain; ADFI = average daily feed intake; FCR = feed conversion ratio; SEM = standard error of mean;

Table 3. Effect of high fibre diets treated honey on nutrient digestibility of broiler chicks

Parameters (%DM)	T1	T2	T3	T4	T5	SEM	p-value
DM	58.54	67.65	75.84	57.18	65.95	2.76	0.19
CP	50.00	60.99	73.41	50.44	58.39	3.29	0.11
CF	65.60	72.31	68.44	55.41	56.84	2.66	0.09
EE	62.34	74.79	74.56	61.33	60.70	3.00	0.34

NFE	66.98	70.81	76.45	62.89	72.23	2.27	0.42

DM = Dry Matter; CP = Crude protein; CF = Crude Fibre; EE = Ether Extract; NFE = Nitrogen Free Extract

Table 4. Effect of high fibre diets treated honey on production cost of starter broiler chicks

Parameters	T1	T2	T3	T4	T5	SEM	p-value
C of DOC (₦)	750.00	750.00	750.00	750.00	750.00	0.00	0.00
FC/kg (₦)	553.05[a]	548.24[b]	543.44[c]	538.63[d]	532.22[e]	1.94	<0.00
FC/WG (₦/kg)	989.37	1081.16	1046.41	1111.22	1180.11	26.80	0.28
FC/chick (₦)	499.40	495.25	467.36	483.36	497.13	11.23	0.92
OPC (₦)	150.00	150.00	150.00	150.00	150.00	0.00	0.00
TPC (₦)	1399.40	1395.25	1367.36	1388.36	1397.13	11.23	0.92

DOC= Day old chicks; FC= feed cost; FC/WG= feed cost per weight gain; TPC= Total production cost; OP = Operational cost

Conclusion

The study concludes that incorporating rice offal treated with organic honey above 4% negatively affects growth in starter broiler chicks, though nutrient utilization remains stable up to 7%. Production cost indices are unaffected at this level, suggesting a 4% inclusion is optimal for growth performance. While 7% does not yield economic benefits, further research into higher organic honey levels is recommended.

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