Journal of Applied Life Sciences International

Volume 26, Issue 4, Page 31-41, 2023; Article no.JALSI.99250
ISSN: 2394-1103

Raw Jackfruit (*Artocarpus heterophyllus*) Seedmeal: Effect on Growth Performance, Organ Weight, Carcass Yield, and Economic Production of Guinea Fowl Keets

I. M. Aroh [a,b,c*], C. N. Odukwe [a], B. P. Macartan [b,d], C. A. Agida [a], Kashif Ullah [e], and B. U. Archibong [f]

[a] Department of Animal Nutrition and Forage Science, Michael Okpara University of Agriculture, Umudike, PMB 7267, Umuahia, Abia State, Nigeria.
[b] School of Biosystems and Food Engineering, University College Dublin, Ireland.
[c] Pig Development Unit, TEAGASC, Fermoy, Cork, Ireland.
[d] Environment, Soil, and Land Use Department, TEAGASC, Wexford, Ireland.
[e] Department of Zoology, University of Peshawar, Pakistan.
[f] Department of Animal Production and Health, Federal University of Technology, Akure, Nigeria.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JALSI/2023/v26i4612

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/99250

Original Research Article

Received: 10/04/2023
Accepted: 12/05/2023
Published: 20/07/2023

**Corresponding author: E-mail: martin.izuaroh@gmail.com, Izuchukwumartin.aroh@teagasc.ie;*

ABSTRACT

Ensuring food security and sustainable agriculture is vital as the global population expands, leading to increased protein demand. However, competitive demand for feed ingredients such as maize and soybeans has driven up costs. As a result, alternative feed sources, including Jackfruit by-products like seeds, have been explored. This study aimed to assess the effects of incorporating raw jackfruit seedmeal (JSM) into the diet of guinea fowl keets, specifically regarding growth performance, carcass yield, organ weights, and economic production. The seven-week study involved 120 keets divided into different treatments, each replicated three times. Treatments 2, 3, and 4 included JSM at 10%, 15%, and 20%, respectively, while treatment one served as the control without JSM. Increasing the level of JSM resulted in a consistent decline in all relevant indicators, as observed through proximate analysis. Treatment four, which included 20% JSM, exhibited the best performance in terms of final weight (745g) and daily weight gain (15g). Notably, the gizzard was the most significant parameter among carcass features, with treatment four showing the highest value (3.95%), while the control diet had the lowest value (2.83%). Diets containing 15% and 20% JSM had the most favorable outcomes in terms of feed cost per weight gain, with the 20% JSM diet demonstrating the highest gross margin and revenue. Importantly, dietary inclusion of JSM did not significantly impact the performance of guinea fowl keets, and incorporating 20% JSM into their diet resulted in a significant increase in productivity and feed utilization.

Keywords: Alternative feedstuff; carcass analysis; guinea fowl; nutrition; by-product; farmers.

1. INTRODUCTION

In terms of animal protein intake, guinea fowl production has enormous potential for achieving food security. The human population in affluent countries is stable, however, the population in underdeveloped countries such as Nigeria continues to grow fast. Thus, it is crucial to identify alternative protein sources to meet the need of the growing population [1]. Economic indicators show that as the population grows, more people will need to be fed. Agricultural outputs must be boosted rather than food imports into such countries [2]. Due to their widespread availability and cheap market price, guinea fowl have recently emerged as a significant source of animal protein [3]. The primary function of guinea fowl is as a source of eggs. The bird may lay up to 190 eggs in a single season, which is a rather large output that might sustain the population for up to three years [4]. While laying qualities can vary by breed [5], guinea fowl eggs stand out due to their thick shell, large amount of yolk, high vitamin, and mineral content, and extended shelf life when compared to chicken eggs [6]. Eggs have many applications, including both culinary and industrial uses [7]. Meat from guinea fowl is known for its distinctive flavor and darker color. Its appropriate texture is due to the white muscular fibers, which are similar in number to chicken muscles but larger in size than geese muscles [8]. Compared to other poultry, guinea fowl have a better slaughter performance [9] a decent ratio of essential portions in the carcass, and acceptable sensory features [10]. Nutritionally, guinea fowl flesh stands out from other types of poultry due to its greater protein and lower fat composition [6]. The amount and quality of guinea fowl meat produced are affected by several factors. The genotype (variety) and sex of guinea fowl are essential factors in determining the quality of the meat, as was noted by Baéza et al., [11]. Also, age and husbandry conditions are highlighted as crucial factors in assessing the quality of meat obtained in guinea fowls as observed by Yamak et al., [12]. Yet, the quality and nutritional richness of the meal continuously influence the output outcomes of these birds. Guinea fowl can adapt to different sources of protein and energy because they consume a wide variety of plant and animal foods in the wild. Some feeding criteria are adopted in nations where guinea fowl are a common meat-type poultry species [13], normalizing compound feed. Although often grown on small-scale farms, in many countries these birds are viewed as an attraction and potentially employed to collect eggs primarily for self-supply of the farm [14]. To enhance food production and protein needs, alternative livestock species and non-conventional feedstuff that have not yet had a huge impact on Nigerian animal production need to be explored and adopted. Fast-growing birds, such as guinea fowl, have several advantages that may be explored in smallholder subsistence farms. Jackfruit seedmeal (JSM) is a promising alternative feedstuff for poultry. It is a by-product of jackfruit intake in which the fleshy half of the fruit is consumed but the seeds are discarded as garbage [15]. The seeds of the jackfruit tree are high in both fiber (3.19%) and starch (22%) by [16]. Even though some people roast and consume the seeds from jackfruits, there is not much demand from humans or livestock for the seeds themselves. Akinmutimi, [17]; Ravindran et al., [18] have both confirmed the presence of antinutrients in Jackfruit seed, however, studies looking at methods for eliminating these compounds are still in their infancy. The jackfruit un-used feed resources both the leaves as fodder and pulp are available for livestock feeding. Regardless of the availability of Jackfruit seed and its anti-nutritional components, minimal or no research work has been carried out to include the seed meal in poultry diets. Hence, the optimal amount of processed and raw Jackfruit seedmeal inclusion in poultry diets has not been well investigated. More unconventional feedstuff must be assessed to close the gap between the high cost of feed components and the lack of non-conventional feedstuff availability, as well as to promote food security and sustainable farming. El-Saadany et al., [19] conducted a study on the use of pumpkin (PK) and garden cress (GC) seed oil in poultry diets, and they discovered that adding PK and GC seed oils to the diets of laying birds as natural feed additives, either independently (0.5%) or in combination (0.25%+0.25%), improved several physiological functions and productive traits of birds. Further study into the use of non-conventional feedstuff in livestock and poultry nutrition and production is essential, both to lessen competition between poultry and people for conventional feedstuff and for economic purposes. Consequently, the purpose of this study was to ascertain the impact of raw Jackfruit seed meal on the growth performance of the birds, the carcass features, the internal organs of the birds, and the economics of production of feeding guinea fowl keets using Jackfruit.

2. MATERIALS AND METHODS

2.1 Location of the Experiment

The research was conducted at the poultry unit of the teaching and research farm of Michael Okpara University of Agriculture, Umudike, Umuahia, Abia state, Nigeria. Umudike is located within latitude $5^{0}29^{1}$ North and longitude $7^{0}32^{1}$ East in the tropical rainforest zone of Umuahia, Abia state, which is characterized by an annual rainfall of about 2169.8mm in 155-228 raindrops and lies at an altitude of 122meters above sea level and has an as the ambient temperature of 26 with a maximum of 36^{0}C and minimum of 27^{0}C with a relative humidity of 57 to 91^{0}C (N.C.R.I, 2018).

2.2 Materials

2.2.1 Jackfruit

Jack fruit seeds were obtained from Southern Nigeria, namely Ogidi in Idemili North Local Government of Anambra State, where they could be easily picked, processed, distributed, and purchased. After drying, the seeds were dehusked and winnowed with a tray and a sieve before being ground to the correct proportion with a hammer mill.

2.2.2 Experimental birds and equipment

206-day-old pearl guinea fowl keets, a dual-type breed for both egg and meat production, were procured in Northern Nigeria (Kaduna) where there is a significant distribution and acquisition of these birds. Prior to the arrival of the chicks, the brooding chamber underwent cleaning. The keets were then placed in the room for a three-week brooding period. Vaccinations and medications used throughout the experiment, from brooding until the end, were obtained from the National Root and Crop Research Institutes (NCRI) in Umudike and Animal World on Bende Road in Umuahia, Nigeria.

2.3 Management of the Keets

The Department of Animal Welfare and Nutrition Committee at Michael Okpara University of Agriculture, Umudike, Nigeria, reviewed and approved the feeding trial. The experiment followed the guidelines provided by this committee. It involved 120 unsexed guinea fowl keets and lasted for 56 days. After three weeks of brooding (on the 21st day), the birds were weighed and randomly distributed into four treatments. Each treatment consisted of 30 birds, replicated three times with ten birds in each replicate. Treatments 2, 3, and 4 included jackfruit seed meals at 10%, 15%, and 20% respectively (JSM 10, 15, and 20%). Treatment one served as the control group and received a JSM-free diet.

2.4 Experimental Design

A completely randomized design was used in the designing of the experiment with the model;

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where;

Y_{ij}= Single Observation; the j^{th} observation in the i^{th} treatment
μ= Overall mean
T_i= Effect of treatment
e_{ij}= Random error; iind**0**,**6**^{2}(Independently, Identically, Normally, Distributed with Zero mean and Constant Variance).

2.5 Experimental Diet and Analysis

The diets used in this study all had a consistent crude protein content of 24%. However, they varied in terms of metabolizable energy densities (ME Kcal/kg), ranging from 2,749 to 2,797 as outlined in Table 1. The diets were formulated with different quantities of milled jackfruit seeds, specifically 0%, 10%, 15%, and 20%, which corresponded to distinct treatment groups. The proximate analysis of both the diets and jackfruit was conducted using the [20] method, and the results can be found in Tables 1 and 2. To evaluate the daily feed intake, feed conversion ratio, and production economics of the guinea fowl keets, SPSS software was utilized at the conclusion of the experiment.

2.6 Data Collection and Parameters

Data were collected weekly for growth performance, and measurement of daily feed was done daily, whereas, carcass evaluation parameters were measured at the end of the experiment.

2.6.1 Growth performance parameters

The following data were collected weekly:

- **Final weight:** This was obtained from the final weight of the keets in the last week of the experiment. It is measured using a 5kg manual weighing scale.

- **Daily weight gain:** This was obtained using the formulae

$$DWG = \frac{\text{Final weight} - \text{initial weight}}{\text{Number of birds x number of days}}$$

- **Daily feed intake (DFI):** This was calculated as follows:

$$DFI = \frac{\text{Quantity of feed given} - \text{leftover}}{\text{Number of birds x number of days}}$$

- **Feed conversion ratio:** This was computed as the ratio of daily feed intake to daily weight gain.

$$FRC = \frac{\text{Quantity of feed consumed (g)}}{\text{Weight gain}}$$

2.6.2 Carcass Evaluation and parameters measured

After the experiment, a total of thirty-six guinea fowls were randomly chosen, with three birds selected from each replication in all treatment groups, for the purpose of evaluating their carcasses. Following the feeding trial, the birds were individually slaughtered to examine their carcass features. To empty their gastrointestinal tracts, the birds underwent a 24-hour fasting period prior to slaughter, although they had continuous access to water. Slaughtering involved making a clean incision across the jugular vein of each bird, allowing them to bleed for a minimum of two minutes. The weights of the birds were measured both before and after slaughter. Each bird was then immersed in hot water at a temperature of approximately 60°C for around one minute to facilitate feather removal. After de-feathering, the weights of the birds were measured again. The carcass was subsequently divided into various pieces using the techniques specified by Ojewole & Longe, [21]. These included sections such as the neck, thighs, wings, and other body parts, and their weights were recorded and expressed as a percentage of the dress weight.

$$\textbf{Carcass evaluation} = \frac{\text{Cut parts}}{\text{Dressed weight}} \times 100$$

2.7 Economics Parameters

Economic analysis was evaluated using the following parameters:

- **Cost per kg feed (₦)**

  This was obtained by dividing the total cost of a 100 kg diet by 100.

- **Cost of feed consumed (₦/bird)**

  This was obtained by multiplying total feed intake by cost/kg feed.

- **Feed cost per kg weight gain (₦/bird)**

  This was obtained by multiplying the feed conversion ratio by cost/kg feed.

- **Cost of production (₦/bird)**

  This was computed as a summation of the cost of feed consumed and other costs.

- **Price per kg (₦/bird)**

  This arbitrarily arrived based on the prevailing price of a bird on a per kg basis.

- **Revenue (₦/bird)**

  This was computed by multiplying price/kg live weight by mean weight per guinea fowl.

- **Gross margin (₦/bird)**

  This was computed by deducting feed per kg weight gain from revenue.

2.8 Statistical Analysis

Data collected were analyzed using a completely randomized design and subjected to analysis of variance (ANOVA) according to d Steel & Torrie, [22]. Significant differences among treatments were separated using Duncan's Multiple Range Test [23].

3. DISCUSSION

3.1 Proximate Analysis of Jackfruit Seedmeal

The composition of diets containing raw jackfruit seed meal is presented in Table 3. Significant differences (P<0.05) were observed in the levels of crude protein, ether extract, ash, and metabolizable energy. However, no significant difference (P>0.05) was found in the parameters of dry matter, moisture content, crude fiber, and nitrogen-free extract, indicating that the inclusion levels of raw jackfruit seed meal did not affect these variables. T1 exhibited the most significant (P<0.05) values for crude protein, ether extract, and ash, while T2 had the highest (P<0.05) values for crude protein and metabolizable energy. Notably, all significant parameters showed a gradual decline as the level of raw jackfruit seed meal increased. The presence of anti-nutritional factors in raw jackfruit seed is well-known, and these factors likely contributed to the decrease in the values of beneficial nutrients. Consequently, diets with lower levels of raw jackfruit seed meal contained higher levels of protein, fat (ether extract), and mineral matter (ash). The metabolizable energy was significantly improved in T2, which contained 10% raw jackfruit seed meal, compared to the control diet. However, a more pronounced reduction in metabolizable energy was observed in T4, which contained 20% raw jackfruit seed meal. In terms of crude protein, diets T1 and T2 had higher values (p>0.05) at 24.50% each, compared to diets T3 and T4, which had values of 21.50% and 21.88%, respectively. Dei & Karbo, [24] provided nutritional recommendations for keets aged 0-3 weeks and 4-8 weeks. For the 0-3 week age group, they suggested an energy range of 2900-3000 kcal/kg, crude protein between 23% and 24%, calcium at 1.1%, phosphorus at 0.6%, and a vitamin/trace mineral premix at 0.50%. For keets aged 4-8 weeks, the recommended diet consisted of 2700-2800 kcal/kg of energy, crude protein at 38-1.1%, calcium at 0.5%, phosphorus at 0.5%, and a vitamin/trace mineral premix at 0.5%. The crude protein and metabolizable energy values used in this study align with these recommendations. Odukwe et al; [15] reported a crude protein value of 22.60% in raw jackfruit seed with 10% inclusion in feed, which is lower than the value obtained in this study. Ocloo et al., [25] also reported a crude protein value of 13.50%, which is lower than the values obtained in this study. On the other hand, [26] obtained a higher crude protein value of 31.90% in raw jackfruit seed meal compared to this study. Tulyathan et al., [27] reported a crude protein content of 11% in jackfruit seed meal, which is lower than the protein content found in this study. Jackfruit seed meal exhibited a higher protein content compared to other non-traditional feedstuffs in this study, including bakery cracker residue (9.41%), cassava husk (2.90%), and sweet potato (4.37%). The crude protein in this study even surpassed the protein contents of cooled sword bean, cooked Bambara groundnut, and cooked lima bean, which were reported by Arijeniwa, [28] to be 19.50%, 18.85%, and 21.50% respectively. The ether extract content of 2.70% in this study is lower than the value of 4.10% reported by Odukwe et al., [15], while [25] reported a fat content of 1.27% lower than the figures found in this study. The control diet in this study had higher ash content compared to the JSM-containing diets, and as the amount of JSM in the diet increased, the ash content also increased. The ash contents obtained in this study were higher than those reported by Akinmutimi, [17]; Ocloo et al., [25], which were 2.70% and 4% respectively. Although the crude fiber in this study did not show statistical significance, there was a trend of decreasing fiber content from T4 to the control group, making T4 have the highest fiber content. Akinmutimi, [17] reported lower crude fiber levels of 4.03% and 3.19% in raw jackfruit seed meal, while [15] reported a higher crude fiber value of 13.80% compared to the value of 12.10% obtained in this study. The differences between this study and previous works could be attributed to variations in other ingredients used in diet formulation, processing methods, and the maturity stage of the jackfruit seed meal (young, ripe).

3.2 Growth Performance of Guinea Fowl Keets fed Raw Jackfruit Seedmeal (JSM)

Table 4 displays the growth performance outcomes of young guinea fowls that were fed raw jackfruit seed meal (JSM). While there were no significant differences observed in the initial weights of the guinea fowls, notable variations (P<0.05) were found in their final weight, daily weight gain, daily feed consumption, and feed conversion ratio. As the quantity of raw JSM in the diets increased, there was a substantial (P<0.05) improvement in the final weight and daily weight gain. The highest final weight (745g) and daily weight gain were achieved with T4, which contained 20% raw JSM (15g). The daily feed consumption of the diets containing JSM (T2, T3, and T4) was similar to that of the control diet (T1), and it was higher (P<0.05), indicating that raw JSM enhanced the intake of feed. However, when comparing only the diets with JSM, the varied levels of raw JSM did not have a significant impact on intake. The Feed Conversion Ratio (FCR) value in T1 (3.57) was considerably lower (P>0.05), suggesting that the guinea fowls fed the control diet were more efficient in converting feed into meat. As the amount of raw JSM in the diets increased, the FCR values of the JSM-containing diets decreased. Despite the anti-nutritional properties of raw JSM, the diet with a higher percentage of raw JSM (20%) in T4 exhibited better feed conversion compared to the diet with 10% raw JSM in T2. The results indicated that the inclusion of 20% raw JSM in the guinea fowl keets' diet led to improved performance, as evidenced by better final weight, daily weight gain, and increased intake compared to the control diet. With increasing proportions of raw jackfruit seed meal in the diets, both the final weight and daily weight gain increased significantly (P>0.05). Therefore, T4, which contained 20% raw jackfruit seed meal, achieved the highest significant final weight (745.00g) and daily weight gain (15g). This suggests that the intake of JSM improved at inclusion levels of 10%, 15%, and 20%. The daily feed intake of the diets containing JSM (T2, T3, and T4) was consistently higher (P>0.05) than that of the control diet, indicating that raw JSM did not have variable effects on the daily feed intake of the birds. The Feed Conversion Ratio (FCR) in this study was significantly lower (P>0.05) in T1 (3.57%), indicating that the keets fed the control diet had a more efficient conversion of feed to meat. A lower FCR value signifies better meat production. As the level of raw Jackfruit seed meal increased in the diets, the FCR values of the diets containing JSM decreased. The inferior FCR of the JSM-containing diets suggested the potential effects of anti-nutritional factors like trypsin inhibitors. This finding supports the idea that raw JSM had no significant impact on the daily feed intake of the birds, which aligns with the study conducted by Odukwe et al., [15], where a 10% inclusion level of JSM did not affect the daily feed intake of the birds. The FCR in this study was substantially lower (P>0.05) in T1 (3.57%), indicating that the keets fed the control diet had a better conversion of feed to meat. Other anti-nutritional factors such as lectins, oxalates, phytates, and alkaloids, even after processing techniques, may have contributed to the lower FCR Akinmutimi, [17]; Ravindran et al., [18]. Another possible reason for the low FCR is feed wastage by the keets. Although processing reduced tannins and oxalates in raw jackfruit seed meal by over 85% as shown in broiler research by Ndyomugyenyi & Ebong, [29], it resulted in decreased growth and feed conversion. Furthermore, (Ndyomugyenyi & Ebong, [29] reported that soaking, boiling, and fermenting treatments did not appear to effectively enhance the nutritional content of jackfruit seeds for broiler chickens. Additionally, [17] found that boiling, roasting, soaking, or fermentation decreased the protein content and increased the carbohydrate content of jackfruit seeds. Therefore, jackfruit seed meal can be used as an energy source. Anti-nutritional factors in diets containing unconventional feedstuffs like jackfruit have been associated with adverse effects in chickens, including reduced feed intake, poor nutrient utilization, and growth depression [17]. The high feed conversion ratio reported by Odukwe et al., [15] at a 10% JSM inclusion level in their diets differed from the findings of this study. Despite the presence of anti-nutritional elements in raw jackfruit seed meal, diet T4 had a higher FCR value compared to diet T2, which contained 10% JSM.

Table 1. Gross composition of experimental diets

Items	Control (T1)	JSM 10% (T2)	JSM 15% (T3)	JSM 20% (T4)
Ingredients (%)				
Yellow maize	45.78	39.80	36.82	33.80
Soya bean	40.42	36.40	34.38	32.40
Jack fruit Meal	-	10	15	20
PKC	10	10	10	10
Bone meal	3.00	3.00	3.00	3.00
Salt (NaCl)	0.25	0.25	0.25	0.25
L-Lysine	0.10	0.10	0.10	0.10
DI-Methionine	0.20	0.20	0.20	0.20
Vitamin/mineral premix*	0.25	0.25	0.25	0.25
Total	100	100	100	100
Nutrient composition **,***				
Metabolizable energy (Kcal/kg)	2749.06	2773.28	2,785.50	2,797.28
Protein (%)	24.01	24.00	24.00	24.00
Ether extract (%)	2.96	2.88	2.75	2.70
Fibre (%)	10.15	10.90	11.05	12.10
Nitrogen-free extract (%)	42.99	43.12	45.72	45.30

***Vitamin/mineral premix (1.2kg) contained: Vitamin A (15,000 i.u); Vit. D3 (3,500,000 i.u); Vit. E (30,000mg); Vit. K3 (3,000mg); Folic acid (1,000mg); Niacin (30,000mg); Calpan (10,000mg); Vit. B2 (8,000mg); Vit. B12 (20mg); Vit. B1 (3,000mg); Vit. B6 (4,000mg); Biotin (30mg); Antioxidant (125,000mg); Cobalt (240mg); Selenium (300mg); Iodine (1,400mg); Iron (46,000mg), Manganese (96,000mg), Copper (6,000mg); Zinc (80,000mg), Choline Chloride (500,000mg).*

***Dry-matter basis*

******* *Hortwitz (AOAC) (2010) method*

Table 2. Proximate composition of jackfruit

Parameter	Composition
Nutrient compositions ** & ***	
Dry matter (%)	87.70
Moisture content (%)	12.30
Crude protein (%)	12.25
Ether extract (%)	0.85
Crude fibre (%)	5.50
Ash (%)	5.00
Nitrogen Free Extract (%)	64.10
Metabolizable energy (Kcal/kg)	3,103.23 (kcal/kg)

***Dry-matter basis*

******* *Hortwitz (AOAC) (2010) method*

Table 3. Chemical compositions of experimental diets

Parameter	Control (T1)	JSM 10% (T2)	JSM 15% (T3)	JSM 20% (T4)	SEM
Dry matter (%)	90.70	90.10	89.70	89.10	0.76
Moisture content (%)	9.30	9.90	10.30	10.90	0.30
Crude protein (%)	24.50^{a}	24.50^{a}	21.88^{b}	21.00^{b}	0.53
Ether extract (%)	2.96^{a}	2.88^{ab}	2.75^{b}	2.70^{b}	0.04
Crude fibre (%)	10.15	10.90	11.05	12.10	0.32
Ash (%)	10.10^{a}	8.70^{ab}	8.30^{ab}	8.00^{b}	0.35
Nitrogen Free Extract (%)	42.99	43.12	45.72	45.30	0.83
Metabolizable energy (Kcal/kg)	3259.95^{b}	3286.84^{a}	3255.63^{b}	3237.24^{c}	5.40

^{abc} Means within the rows with different superscripts differ significantly (P<0.05)

SEM pooled standard error of the mean

Table 4. Performance of guinea fowl keets fed diets containing varied percentages of raw jackfruit seedmeal

Parameter	Control (T1)	JSM 10% (T2)	JSM 15% (T3)	JSM 20% (T4)	SEM
Initial weight (g)	218.33	210.00	210.00	220.00	1.41
Final weight (g)	661.67^{c}	650.00^{d}	703.33^{b}	745.00^{a}	11.29
Daily weight (g/bird)	12.67^{b}	12.57^{b}	14.10^{ab}	15.00^{a}	0.39
Daily feed intake (g/bird)	45.20^{b}	57.36^{a}	58.37^{a}	60.32^{a}	1.94
Feed Conversion Ratio	3.57^{b}	4.56^{a}	4.14^{ab}	4.02^{ab}	0.13

abcd Means within the rows with different superscripts differ significantly (P>0.05); SEM pooled standard error of the mean

Table 5. Carcass analysis of guinea fowl keets fed varied percentages of raw jackfruit seed meals (JSM)

Parameter	Control (t1)	JSM 10% (t2)	JSM 15% (t3)	JSM 20% (t4)	SEM
Live weight (g)	808.33	716.67	800.00	766.67	29.43
Slaughter weight (g)	788.00	693.33	777.00	743.67	29.40
De-feathered weight (g)	747.00	666.67	750.00	716.67	28.47
Dressed weight (g)	680.33	597.33	682.00	636.00	27.90
Cut-parts					
Wings (%)	13.14	13.94	13.52	14.17	0.38
Chest muscle (%)	24.13	22.75	23.85	25.13	0.59
Back cut (%)	16.56	17.19	17.56	18.17	0.63
Internal organs					
Heart (%)	0.46	0.51	0.50	0.61	0.03
Kidney (%)	0.37	0.42	0.38	0.39	0.03
Liver (%)	1.75	2.00	1.94	2.01	0.10
Gizzard (%)	2.83^{b}	3.31^{ab}	2.87^{ab}	3.95^{a}	0.19
Others					
Neck (%)	4.88	5.79	5.25	6.38	0.29

abcd Means within the rows with different superscripts differ significantly (P>0.05); SEM pooled standard error of the mean

Table 6. Economic analysis of guinea fowl keets fed varied percentages of raw jackfruit seed meals (JSM)

Parameter	Control (T1)	JSM 10% (T2)	JSM 15% (T3)	JSM 20% (T4)	SEM
Total feed intake (kg/bird)	1.58^{b}	2.01^{a}	2.04^{a}	2.11^{a}	0.07
Weight gain (kg/bird)	0.44^{c}	0.44^{c}	0.49^{b}	0.53^{a}	0.01
Cost/kg feed (₦)	158.11^{a}	135.10^{b}	127.46^{b}	127.65^{b}	3.97
Cost of feed consumed (₦/bird)	250.13^{c}	271.55^{a}	260.40^{b}	269.34^{ab}	2.83
Feed cost per weight gain (₦/bird)	564.20^{b}	616.38^{a}	527.84^{c}	513.29^{c}	12.24
Price of bird ((₦/kg)	1300.00	1300.00	1300.00	1300.00	0.00
Revenue (₦/bird)	554.17^{c}	550.00^{c}	616.67^{b}	656.25^{a}	13.63
Gross margin (₦/bird)	-10.04^{c}	-66.38^{d}	88.83^{b}	142.96^{a}	24.69

abcd Means within the rows with different superscripts differ significantly (P>0.05); SEM pooled standard error of the mean

3.3 Carcass Characteristics of Guinea Fowl Keets fed Raw Jackfruit Seedmeal (JSM)

The carcass characteristics of guinea fowl keets fed raw jackfruit seed meal are presented in Table 5. Apart from the relative gizzard weight, there were no significant differences (P>0.05) observed in any of the other parameters. Comparing the diets containing JSM to the control diet, the gizzard weights of the test diets showed significant improvement with the inclusion of raw JSM. T4, which contained 20% raw JSM, recorded the highest significant value (3.95%), while the control diet had the lowest significant value (2.83%). The similarity in gizzard contents between T2 and T3 suggests that the increased gizzard weight in treatment four may be attributed to its high fiber content. Despite the presence of anti-nutritional factors, their negative impact was not significant when considering the similarities in other parameters. Although there was a non-significant increasing trend among the diets with JSM as the level of raw JSM increased, Table 3 did not indicate any notable effect on crude fiber. The lack of substantial differences in many carcass parameters suggests that, to a large extent, the control treatment performed similarly to the diets containing JSM. Consequently, variations in the concentration of raw JSM had minimal to no impact on the carcass features of guinea fowl keets. It is worth noting that a healthy gizzard plays a role in preventing harmful bacteria from entering the small intestine, thereby reducing the risk of developing coccidiosis and other enteric disorders [30]. The increased rate of gizzard contraction facilitated by the presence of JSM may have contributed to the higher gizzard weights observed at higher JSM levels. Similar results were found when whole grains were incorporated into poultry diets [31].

3.4 Economics of Production of Guinea Fowl Keets Fed Raw Jackfruit Seedmeal (JSM)

Table 6 presents the economic aspects of guinea fowl keet production when fed raw jackfruit seed meal. The price of the bird per kilogram was the only parameter where significant changes (P<0.05) were not observed as expected. In comparison to the control diet, the total feed intake of the JSM-containing diets was significantly higher (P<0.05). When comparing the weight gain in this study, the control and T2, and T3 diets showed significantly greater weight gain (P<0.05). Therefore, it can be inferred that higher levels of raw JSM incorporation led to increased intake and weight gain. The significant change in cost per kilogram of feed reveals that including raw JSM in the diets reduces feed costs. This indicates that the cost of feed consumed was higher in the JSM-containing diets, with the highest cost observed in T2 compared to the control diet. The lower concentration of JSM (10%), which is a significantly cheaper source of protein and energy compared to maize and soybean, maybe the reason for the higher value of ₦271.55 reported in treatment two. The two main indicators for assessing production economics are feed cost per weight gain and gross margin, which measures profitability. A much lower feed cost per weight gain value indicates better performance. Higher quantities of raw JSM in T3 and T4 resulted in the lowest significant (P<0.05) feed cost per weight gain values, ₦527.84 and ₦513.29, respectively. Treatment two had the highest feed cost per kilogram gain (₦616.38), making it less favorable for recommendations. Treatment four had the highest gross margin and revenue (P<0.05), ₦142.96 and ₦656.25, respectively, followed closely by T3 containing 15% raw JSM. T1 and T2 had the lowest revenues, ₦554.17 and ₦550.00, respectively. Treatment two suffered a loss of -₦66.38, followed by T1 with - ₦10.04. Gross margin is considered one of the most important economic criteria for determining profitability, as noted by Ojewola, [32]; Olomu, [33]; Rajaguru et al., [34]. Treatment four yielded the highest profit among all dietary treatments. Therefore, T4 containing 20% raw jackfruit seed meal demonstrated the best performance, suggesting that incorporating 20% raw jackfruit seed meal in the diets of guinea fowl keets may be more cost-effective and economical.

4. CONCLUSION AND RECOMMENDATION

4.1 Conclusion

Based on the result of this study, incorporating higher levels of raw jackfruit seed meal tends to decrease the nutritional composition of the meals, including crude protein, ether extract, ash, and metabolizable energy. The meal containing 20% raw JSM showed superior performance, with the highest final weight (745g) and daily weight gain (15g/bird). Except for the gizzard, raw JSM did not have any significant effect on carcass performance parameters. Among the dietary treatments, T4, which contained 20% raw JSM, generated the highest profit and had the lowest feed cost per weight gain. T4 outperformed the other treatments across all indicators, despite its higher content of anti-nutritional components. Therefore, guinea fowl keets can tolerate the inclusion of 20% raw JSM without experiencing negative effects on performance and can adapt to the higher fiber content in the T4 diet (12.10%). Additionally, no mortality was observed due to the inclusion of JSM in the keets' diets.

4.2 Recommendation

Farmers are recommended to incorporate a diet with 20% raw jackfruit seed meal (T4) in guinea fowl keets' diets as it offers several advantages, including significantly higher final weight and gross margin. However, it is important to note that the response to raw jackfruit seed meal may vary among different poultry species, so further research on higher levels of JSM inclusion is warranted. Additionally, it would be valuable to investigate the effects of feeding processed jackfruit seed meals compared to raw jackfruit seed meals.

DATA AVAILABILITY

The data that support this study will be shared upon reasonable request to the corresponding author.

ACKNOWLEDGEMENT

I would like to express my gratitude to the authors for their diligent efforts in producing this article. Additionally, I would like to acknowledge the support and favorable working environment provided by the staff at Michael Okpara University of Agriculture in Umudike, Nigeria. I am particularly grateful to Mrs. Edet Regina, my project partner, for her significant contributions. Lastly, I extend my thanks to Mrs. Bibian A. Aroh, Rev. Fr. Dr. Emeka P. Aroh, and Dr. Mrs. Catherine N. Odukwe for their generous financial and moral support throughout this project.

COMPETING INTERESTS

The authors have declared that no competing interests exist.

REFERENCES

1. Mailafia S, Onakpa M, Owoleke O. Problems and prospects of rabbit production in Nigeria-A review. Bayero Journal of Pure and Applied Sciences. 2010;3(2):20-25.
2. Allen CE. New horizons in animal agriculture: Future challenges for animal scientists. Journal of Animal Science. 1983;57(suppl_2):16-27.
3. Obike O, Oke U, Azu K. Comparison of egg production performance and egg quality traits of Pearl and Black strains of guinea fowl in a humid rain-forest zone of Nigeria. International Journal of Poultry Science. 2011;10(7):547-551.
4. Gwaza D, Elkanah H. Assessment of external egg characteristics and production indices of the dual purpose French guinea fowl under semi-arid conditions in Nigeria. J Res Rep Genet. 2017;1 (1): 13-17.
5. Onunkwo D, Okoro I. External and internal egg quality characteristics of three varieties of helmeted guinea fowl (*Numida meleagris*) In Nigeria. International Journal of Current Research and Review. 2015;7(7):10.
6. Ayorinde K. Carcass yield and chemical composition of four Indigenous guinea fowl varieties at different areas. Bulletin of Animal Health and Production in Africa. 1989;37:361-366.
7. Agbolosu AA, Ahunu BK, Aboagye GS, Naazie A, Kayang BB. Variation in some qualitative traits of the indigenous guinea fowls in northern Ghana; 2014.
8. Bernacki Z, Bawej M, Kokoszyński D. Carcass composition and breast muscle microstructure in guinea fowl (*Numida meleagris* L.) of different origin. Folia Biologica (Kraków). 2012;60(3-4): 175-179.
9. Ebegbulem VN, Asuquo BO. Growth performance and carcass characteristics of the black and pearl guinea fowl (*Numida meleagris*) and their crosses. Global Journal of Pure and Applied Sciences. 2018;24(1):11-16.
10. Kyere C, Jnr P, Twumasi G, Korankye O. Effect of vitamin c supplementation on egg quality, carcass characteristics and sensory properties of meat of the pearl guinea fowl (*Numida meleagris*) in Ghana. Asian Journal of Research in Animal and Veterinary Sciences. 2020;5(1):38-45.
11. Baéza E, Juin H, Rebours G, Constantin P, Marche G, Leterrier C. Effect of genotype, sex and rearing temperature on carcass and meat quality of guinea fowl. British Poultry Science. 2001;42(4):470-476.
12. Yamak U, Sarica M, Boz M, Ucar A. Effect of production system (barn and free range) and slaughter age on some production traits of guinea fowl. Poultry Science. 2018;97(1):47-53.
13. Yildirim A. Nutrition of guinea fowl breeders: A review. Journal of Animal Science Advances. 2012; 2(2):188-193.
14. Batkowska J, Drabik K, Karwowska M, Ahsan U, Raza I, Adamczuk A, Horecka B. Growth performance and meat quality of meat-type guinea fowl fed different commercial diets. Archives Animal Breeding. 2021; 64(2):325-334.
15. Odukwe C, Onunkwo D, Eburuaja A, Mathias V. Carcass and internal organ

characteristics of broiler chickens fed soybean diets partially replaced with variable levels of raw jackfruit seed meal. Nigeria Agricultural Journal. 2017;48(1): 190-198.
16. Hettiaratchi U, Ekanayake S, Welihinda J. Nutritional assessment of a jackfruit (*Artocarpus heterophyllus*) meal. Ceylon Medical Journal. 2011;56(2).
17. Akinmutimi A. Nutritive value of raw and processed jack fruit seeds (*Artocarpus heterophyllus*). Chemical Analysis. Agricultural Journal. 2006;1(4): 266-271.
18. Ravindran V, Ravindran G, Sivakanesan R. Evaluation of the nutritive value of Jackseed (*Artocarpus heterophyllus*) meal for poultry. The Journal of Agricultural Science. 1996;127(1): 123-130.
19. El-Saadany AS, El-Barbary AM, Shreif EY, Elkomy A, Khalifah AM, El-Sabrout K. Pumpkin and garden cress seed oils as feed additives to improve the physiological and productive traits of laying hens. Italian Journal of Animal Science. 2022;21(1):1047-1057.
20. Horwitz W. Official methods of analysis of AOAC International. Volume I, agricultural chemicals, contaminants, drugs/edited by William Horwitz. Gaithersburg (Maryland): AOAC International; 2010.
21. Ojewole G, Longe O. Protein and energy in broiler starter diets: Effects on growth performance and nutrient utilization. Nigerian Journal of Animal Production. 1999;26:23-28.
22. D Steel RG, Torrie JH. Principles and procedures of statistics: a biometrical approach. McGraw-Hill New York, NY, USA; 1986.
23. Duncan D. Multiple range and multiple f-test. biometrics, 11. Significance of effects; 1955.
24. Dei H, Karbo N. Improving smallholder guinea fowl production in Ghana: A Training Manual. Cyber Systems, Tamale, Ghana. 2004; 27.
25. Ocloo F, Bansa D, Boatin R, Adom T, Agbemavor W. Physico-chemical, functional and pasting characteristics of flour produced from Jackfruits (*Artocarpus heterophyllus*) seeds. Agriculture and Biology Journal of North America. 2010; 1(5):903-908.
26. Bobbio F, el Dash A, PA B, LR R. Isolation and characterization of the physicochemical properties of the starch of jackfruit seeds (*Artocarpus heterophyllus*); 1978.
27. Tulyathan V, Tananuwong K, Songjinda P, Jaiboon N. Some physicochemical properties of jackfruit (*Artocarpus heterophyllus* Lam) seed flour and starch. Science Asia. 2002;28(1):37-41.
28. Arijeniwa AAOSO. Performance, carcass traits, and relative organ weights of broiler chickens fed processed bambara groundnut (*Vigna subterranea*) meals. Nigerian Poultry Science Journal. 2004; 2:76 - 81.
29. Ndyomugyenyi E, Ebong J. Nutritional assessment of soaked-boiled-fermented Jackfruit (*Artocarpus heterophyllus*) seed meal for broiler chickens; 2016.
30. Bjerrum L, Pedersen K, Engberg R. The influence of whole wheat feeding on Salmonella infection and gut flora composition in broilers. Avian Diseases. 2005;49(1):9-15.
31. Engberg R, Hedemann M, Steenfeldt S, Jensen B. Influence of whole wheat and xylanase on broiler performance and microbial composition and activity in the digestive tract. Poultry Science. 2004; 83(6):925-938.
32. Ojewola GS, Udokainyang AD, Obasi V. Increasing household protein consumption through livestock products: Growth, carcass and economic response of local turkey poults to various levels of dietary energy. Proceedings of the 27th Annual Conf. of Nigeria Society for Animal Production, Akure, Nigeria; 2002.
33. Olomu J. Determination of optimum protein and energy levels for broiler chicks in the tropics. Nigerian Journal of Animal Production. 1976;3(1):177-183.
34. Rajaguru R, Vohra P, Kratzer F. The effects of feeding high protein diets to chickens. Poultry Science. 1966;45(6): 1339-1345.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/99250