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# PERFORMANCE AND ECONOMIC CONSIDERATION OF BROILER CHICKENS FED ENZYME SUPPLEMENTED CASSAVA FIBRE MEAL

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## ABSTRACT

The search for alternative energy source to substitute for the expensive conventional energy feed resources in broiler chicken diet is the driving force of this study. Thus, the study assessed the performance and economics of the production of broiler chickens fed enzyme supplemented cassava fibre meal (CFM) in a 56-day feeding trial. A batch of three hundred and sixty (360) day-old Arbor acre broiler-chicks was allotted to twelve (12) diets replicated five (5) times of six (6) birds in a complete randomization. Cassava fibre was sun dried for 5 days with constant turning to prevent fermentation, reduce the moisture content and possibly reduce the cyanide content. Proximate composition, phytochemical components and cyanide contents were determined using appropriate standard methods. Cassava fibre meal was substituted for maize at 0, 20, 40, and 60% levels and Roxazyme® G2 supplementation was at 0, 100 and 200 mg/kg. Data collected on feed intake and weight gain were analysed using the General Linear Model (GLM), and differences in means where observed were separated using Duncan option of the SPSS 2006 version 15.0. The Economics of broiler chicken production was determined using economic tools such as gross margin and economic efficiency analyses. Results showed that CFM contained appreciable levels of nutrients that could promote broiler growth when substituted at optimum level as an energy source in broiler chicken diet. Substitution of CFM at 40 and 60% levels for maize led to a decrease ($p<0.05$) in weight gain and feed conversion of broiler chickens. Feed intake and weight gain were not influenced by dietary substitution of CFM for maize in the broiler starter and broiler finisher stages of growth. The effect of enzyme supplementation was not significant in the birds' physiological growth at both starter and finisher stages. The effect of interaction was not significant ($p>0.05$) indicating that birds' performance were not dependent on the two factors under investigation. Economics of broiler chicken production revealed that total cost was lower in birds fed CFM with or without enzyme supplementation compared with those fed the maize-based diets. Net revenue, economic efficiency and profitability ratio analysis showed better economic viability and profitability in birds fed CFM with or without enzyme supplementation compared with those fed maize-based diets.


**Key words**: Broiler chickens, Cassava fibre meal, Profitability ratio, Roxazyme® G2, Weight gain

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## INTRODUCTION

Poultry production is constrained by several limiting factors, of which the cost of finished feeds is a major challenge. Under intensive production, feeding costs account for over 60% of the total cost of production [1]. The resultant effect is the high cost of poultry products such as egg, meat and live chickens. This has inadvertently resulted in less demand for chicken products by the average citizens resulting in protein malnutrition, particularly among the resource-poor citizens. Food and Agriculture Organization recommends the consumption of 56 g of protein per day per caput, of which two-thirds (2/3) should come from animal sources. However, an average Nigerian consumes less than 10 g of protein of which 3.2 g is from animal sources [2], which is grossly inadequate. To mitigate this challenge, animal scientists, nutritionists, and other related professionals are aggressively sourcing for alternative feed resources that could reduce the cost of animal production, viz a viz the cost of feed, and improve animal protein intake at affordable cost with a consequential improvement in the net revenue of poultry farmers. Several alternative feed resources are constrained by high anti-nutritional constituents, high fibre contents, low and poor protein content and variability in nutrients arising from climatic and edaphic factors. To mitigate these challenges and improve the nutritive quality of these alternatives as suitable and acceptable feed ingredients, several feed technologies, such as fermentation [3], enzyme supplementation [4, 5] and many others had been employed.

Cassava is a major staple food crop in almost all households in Nigeria. Aside from this, it is also a significant raw material in starch production. Recently, the worldwide cassava production stands at 278 million metric tons, out of which Africa's share was about 61% (192 million metric tons) with Nigeria taking the lead with a production of over 60 million metric tons in 2020. According to FAO projections, by 2025, about 62% of global cassava production will come from sub-Saharan Africa [6]. Table 1, shows 2020 estimate of cassava production with leading countries like Nigeria, Congo DR, Thailand, Ghana, Brazil, Indonesia among others [6].

Cassava fibre, a waste generated from cassava processing Factory is a potential feed source to reduce cost in broiler chicken diet. In addition, the wastes contains substantial level of energy, if harnessed could be a good energy source in broiler chicken diet. However, cassava fibre contains high cyanide, high fibre and low protein contents [7], limiting their biological use in the broiler chicken diet. Thus, the need to improve the nutritive value of the waste as energy source becomes imperative.

The use of fibre degrading enzyme has been reported to enhance the utilization of fibre rich diet and maximize its nutritive value in broiler chicken diet [1, 8]. Roxazyme® G2, a specific blend of beta-glucanase, cellulase and xylanase improves energy utilization efficiency in cereals and by-products, as well as degrade fibre rich feed materials, releasing entrapped nutrients in the feed ingredient for bird's utilization [1]. The supplementation of Roxazyme G2; a fibre degrading enzyme in diets containing cassava fibre meal could help position the ingredient as an alternative energy source in broiler chicken diet. It is hoped, that supplementation of cassava fibre meal with

Roxazyme® G2 would improve broiler chicken production with possible improvement in the net returns of poultry farmers.

## MATERIALS AND METHODS

### Experiment location

The study was carried out at the Poultry Unit of the Teaching and Research Farm of the Adeyemi College of Education, Ondo State, Nigeria. Ondo is located between $07^0$ 15'N, $05^0$ 05'E with rainfall of 1800-3600 mm per annum, 54-91% relative humidity and mean daily temperature 22-35$^0$C throughout the year [9].

### Processing of cassava fibre meal and procurement of Roxazyme® G2

The cassava fibre was collected from Cassava Processing Factory at km 7, Ondo-Ore Road, Ondo, Nigeria. The wastes were sundried for 5 days with constant turning to prevent fermentation as well as reduce the cyanide content to a tolerable level. Sun drying had been reported to reduce cyanide concentration in cassava products [1]. The sun-dried cassava fibre was milled, bagged and kept in-store before use. The milled cassava fibre meal (CFM) was analysed for its chemical compositions.

The enzyme Roxazyme® G2 is a product of DMS Nutritional Product Europe Ltd. The primary activity of Roxazyme® comes from cellulases, endo- 1,4-beta-glucanase (glutamate) and xylanases, which helps to improve the efficiency of energy utilization and increase the metabolic energy of feed, as well as act as a fibre degrading enzyme.

### Chemical composition determination

The CFM (Table 2) and experimental diets (Table 3) were analysed for their nutrients compositions and mineral constituents according to AOAC [10] methods. Phytate was determined by weighing 0.25 g of the sample into 250 ml conical flask, and soaked in 100 ml of 20% concentrated HCl for 3 h, and later filtered. 50 ml of the filtrate was placed in a 250 ml beaker and 100 ml distilled water was added to the sample. Thereafter, 10 ml of 0.3% ammonium thiocynate solution was added as indicator and titrated with standard iron (III) chloride solution containing 0.00195 g iron per 1 ml [11], tannin was by the method of Makkar and Goodchild [12], flavonoids was determined by the methods of Bohani and Kocipai-Abyazan [13] by blending 1 g of the sample into 10 ml of 60% ethanol aqueous and allowed to stand for 2 h after which it was filtered into a weighed glass petri-dish and oven dried at 40$^o$C to a constant weight. Total flavonoid was calculated as: Mg/100g flavonoid and alkaloids were determined according to the methods of Henry [14]. Cyanide determination was by the silver nitrate method according to Rao *et al.* [15], while oxalate was by the method of Baker and Silverton [16].

### Experimental diets

One basal diet was formulated for the starter and finisher phases to meet the NRC [17] requirements for broiler chickens. The basal (diet 1) had its maize content substituted with cassava fibre meal (CFM) at 20, 40 and 60%. The basal diet, the 20% CFM-based diet, 40% CFM-based diet, and 60% CFM-based diet were individually mixed thoroughly in one lot and divided into three parts, making 12 diets in total. The basal

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diet, 20% CFM, 40% CFM and 60% CFM were supplemented with Roxazyme® G2 at 0, 100 and 200 $mgkg^{-1}$. The gross compositions for the diets are as presented in Table 3 while the analysed phytochemical components of the diets are as presented in Table 4.

**Bird's arrangement and management**

A total of three hundred and sixty (360) day old broiler-chicks Arbor acre breed with group mean weight range 50.68-50.27±0.32 g were randomly distributed to the twelve (12) experimental diets in a completely randomized design of 4 x 3 factorial arrangements of treatments. Thirty (30) broiler chicks were assigned to each dietary treatment replicated five (5) times of six (6) birds per replicate. Adequate housing and brooding conditions were maintained to ensure proper ventilation, temperature and warmth. Feeds were served *ad libitum* with clean, cool water served throughout the 56 days experimental period.

**Data collection**

**Performance characteristics**

Data were collected on daily feed intake and weekly weight gain while feed conversion ratio (FCR) was calculated as the ratio of feed intake to weight gain.

**Economic analysis**

The under-listed economic tools were employed to determine the profitability and efficiency of the broiler chicken production

$$\text{Cost of feed \$/kg weight gain} = \frac{Cost\ of\ feed\ \$/kg\ weight\ gain\ xTFC}{Total\ weight\ gain}$$

$$Cost\ differential = Cost\ of\ feed\ \$/kg\ of controldiet - Cost\ of\ feed\ \$/kg\ oftest\ diet$$

$$Cost\ of\ weight\ gain = TWG\ x\ Cost\ of\ feed\ \$/kg\ weight\ gain$$

$$Return\ on\ sale\ OR\ Total\ revenue\ (TR) = Live\ weight\ x\ \text{Price/kg live weight}$$

$$Gross\ margin\ (GM) = TR - TVC$$

$$Net\ revenue\ (NR) = TR - \text{TC}$$

$$\text{Profit per animal over control group} = Net\ revenue\ of\ animal\ on\ test\ diet - Net\ revenue\ of\ animal\ on\ control\ group$$

$$\%Profit\ over\ the\ control\ group = Net\ revenue\ of\ animal\ on\ test\ group - Net\ revenue\ of\ animal\ on\ control\ group$$

$$\text{Relative cost} - \text{benefit (RCB)} = \frac{Cost\ differential}{Cost\ of\ feed\ \$/kg\ weight\ gain\ of\ control\ diet}\ x\ 100$$



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$$\text{Economic efficiency (EE)} = \frac{NR}{TC}$$

$$Relative\ economic\ efficiency\ (REE) = \frac{EE\ of\ treatment\ other\ than\ the\ controlx}{EE\ of\ the\ control\ group}x100$$

$$\text{Marginal relative economic efficiency (MREE)} = \frac{REE\ of\ the\ test\ group}{REE\ of\ the\ control\ group}$$

$$\text{Benefit} - \text{cost ratio (BCR)} = \frac{TR}{TC}$$

$$\text{Expense structure ratio (ESR)} = \frac{TFC}{TVC}$$

$$\text{Rate of return (ROR)} = \frac{NR}{TC}$$

$$\text{Return per \$ invested} = \frac{GM}{TVC}$$

$$\text{Gross ratio (GR)} = \frac{TC}{TR}$$

$$\%Profit\ margin = \frac{NR}{Cost\ of\ production}x100$$

The production cost of the processed cassava fibre meals was determined for the sum of expenditures incurred in the processing method employed.

**Statistical analysis**

Data collected were subjected to one way analysis of variance using General Linear Model of the Statistical Package for Social Sciences (SPSS) version 15.0 [18]. Duncan Multiple Range Text was used to separate the means.

## RESULTS AND DISCUSSION

**Chemical composition**

The proximate composition ($g100g^{-1}$) of cassava fibre meal (Table 2) used in this study shows a crude protein (CP) content of 3.95, crude fibre (CF) 20.02, crude fat 3.35 and ash 4.31. The crude protein recorded in this study was higher than the 1.30% by Ogunbode *et al.* [19], 1.55% by Suksombat *et al.* [20] and 1.12% by Aro *et al.* [21]. The differences in these protein contents might be attributed to the soil composition, geographical locations and possibly low level of foreign materials in the waste. Appreciable protein content in diet is essential to enhance growth and maintain tissue integrity. The fibre content of cassava fibre in the present study was similar to the 19.3% reported by Aro *et al.* [21] but far higher than the 3.15% reported by Ogunbode *et al.* [19], and lower than the 27.75% reported by Suksombat *et al.* [20]. Fibre is a significant factor in the diet as it functions to increase stool bulk and decrease the time waste spend in the gut. Ether extract, also referred to as crude fat reported in this study


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was higher than the previous values reported by Ogunbode *et al.* [19], Khempaka *et al.* [22] but similar with the value of 3.37% reported by Aro *et al*. [21]. Ether extract represents the fat/lipid content of a feed, and the value in a feed is of significance to produce a good quality carcass. Ash content is a measure of the mineral deposit in a feed. The ash content observed in this study was similar to the 4.40% reported by Ogunbode *et al*. [19] but lower than the 2.84% reported by Aro *et al.* [21]. The cyanide content of 23.97 mg/kg recorded in the present study was lower than the 37.58 mg/kg reported by Ogunbode *et al*. [19] but higher than the 15.5 mg/kg reported by Aro *et al*. [21] and thus far lower than the 50ppm recommended being harmful to animal [23]. The values reported for the macro and micro minerals in cassava fibre used in this study were in some cases similar or dissimilar to the findings by previous works. For instance, potassium 114.75 g/100g, magnesium 199.95 g/100g, phosphorus 262.17 g/100g and sodium 104.83 g/100g were similar to those reported by Aro *et al.* [21]. In contrast, calcium of the 353.0 g/100g was far higher to the 60.0 mg/kg reported by Aro *et al*. [21]. For the phytochemical components, tannin was 0.08 $g100g^{-1}$, oxalate 269.04 $mgg^{-1}$, phytate-P 4.29 $mgg^{-1}$, and phytate 15.23 $mgg^{-1}$ (Table 2). The results of the phytochemical components of cassava fibre in this study gave credence to the previous study by Aro *et al*. [21]. Results on the phytochemical components of the experimental diets (Table 4) show that oxalate, phytate-P, phytate and cyanide concentrations were significantly higher (P<0.05) in broiler-starter diets containing 20, 40 and 60% CFM when compared with maize-based diet while in broiler-finisher diets all the phytochemical components determined were significant (P<0.05) in CFM-based diets when compared with maize-based diet

**Performance response of broiler chickens**

The results on broiler-starter showed that weight gain was significantly (P<0.05) lower in birds fed 60% CFM with or without enzyme supplementation compared with those on 0, 20 and 40% CFM with or without enzyme supplementation. Feed conversion ratio did not show any particular trend in birds fed maize meal and up to 40% cassava fibre meal diets. However, at 60% substitution of CFM for maize, feed utilization by the birds was significantly (P<0.05) lower irrespective of enzyme supplementation. In broiler finishers, weight gain and FCR decreased significantly (P<0.05) and successively in birds fed above 20% CFM substitution with or without enzyme supplementation (Table 5).

The lower weight gain recorded for birds on CFM-based diets could be attributed to the effect of high fibre [24] and the possible toxigenic effect of residual cyanide to inhibit the uptake of iodine resulting in an increase in the secretion of thyroid-stimulating hormone (TSH) causing a decrease in thyroxin level necessary for growth rate [25]. Cyanide had been reported to have a great affinity for iron, making it unavailable for haemoglobin synthesis and effective transportation of oxygen and carbohydrate [26]. Diets high in non-starch polysaccharides had been reported to compromise weight gain as a result of the viscosity of intestinal content, and the abrasive effect on the intestinal wall resulting in an increase in endogenous cell losses and nutrients to the lumen [27], thus limiting the availability, absorbability and utilization of nutrients in broiler chickens a with possible decrease in weight gain. In the present study, feeding CFM at 40 and 60% substitution levels for maize as a source of energy resulted in a significant decrease in weight gain. The decrease in weight gain and poor feed utilization by broiler chickens fed higher dietary fibre was the accumulation of dietary fibre in the intestinal lumen resulting in high intestinal viscosity with a decrease in nutrient absorption and utilization. The similar feed intake in birds fed maize meal and CFM supports previous studies that dietary fibre had no dire consequence on feed intake. Krás *et al.* [28] reported that dietary fibre had no effect on the average daily feed intake of broiler chickens.

**Cost-benefit analysis**
Table 6 reveals that while the total cost of broiler chicken production was lower in birds fed CFM with or without enzyme supplementation compared with those fed the maize-based diets, net revenue, economic efficiency and profitability ratio analysis showed better economic viability in birds fed CFM with or without enzyme supplementation compared with those fed maize-based diets.

From the result of this study, feed constituted about 66% on maize meal diet compared with the range 63-65% on CFM-based diets of the variable cost of broiler production. This agrees with the findings of Ogunsipe [1] that feeding poultry birds accounted for over 50% of the cost of production. The feed cost per kilogram body weight gain obtained in this study conformed to the findings by Bello *et al.* [29] on broiler birds fed dietary levels of palm kennel cake. The findings showed that a single broiler bird nurtured to maturity had a total cost of $5.75 on maize meal diet (control) compared with $5.28-5.70 on CFM with or without enzyme supplementation. The gross revenue per bird was $1.05 on maize meal diet compared with $1.13-1.33 on CFM with or without enzyme supplementation. Net profit of $0.83-1.03 per bird on CFM-based diets compared with $0.75 per bird on maize meal diet was estimated giving a net margin-to-cost ratio of 0.16-0.18 per bird on CFM-based diet compared with 0.13 on maize meal diet. This thus implied that $1.00 invested in broiler production, all things being equal, would yield $0.16-0.18 on broilers fed CFM-based diets compared with $0.13 on broilers fed on maize meal diet. The higher production cost and lower net returns arising from birds on maize meal-based diets compared with those on CFM-with or without enzyme supplementation might result from the competitive demand for maize, causing its higher market price. On the other hand, lower production cost and higher net returns with better economic efficiency and profitability ratio in broiler birds fed CFM-based diets could be due to lower feed cost arising from the non-competitive use of cassava fibre meal as an energy substitute for maize. The result of this study conformed to the result by Omolayo [30] that raising broilers on alternative management system would reduce cost and improve net returns with better economic efficiency of broiler production.

## CONCLUSION

The study revealed that CFM at 20% optimum substitution for maize would economically replace maize as an energy source in the broiler chicken diet without compromising weight gain of the birds. However, cassava fibre meal substitution levels at 40 and 60% for maize as energy source led to decrease in weight gain and feed utilization. On economics of broiler chicken production, results showed that a broiler chicken nurtured to maturity recorded a lesser cost of production with attendant increase in net returns when compared with birds on maize meal diet. Thus, farmers in this part of the world where cassava waste abound can take advantage of this non-competitive feed resource to improve broiler chicken production at least cost for maximum profit.

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**Table 1: World Leading Cassava Producers**

| Country | Production (000,000 metric tons) |
|---|---|
| Nigeria | 60.0 |
| Congo, DR | 41.0 |
| Thailand | 29.0 |
| Ghana | 21.8 |
| Indonesia | 18.3 |
| Brazil | 18.2 |
| Vietnam | 10.5 |
| Angola | 8.8 |
| Cambodia | 7.7 |
| Tanzania | 7.5 |

Source: Authors' compilation using FAOSTAT 2020 data

**Table 2: Chemical composition of cassava fibre meal (n=3)**

| Proximate composition ($g100g^{-1}$) | Mean | SEM |
|---|---|---|
| Dry matter | 88.63 | 0.07 |
| Crude protein | 3.95 | 0.02 |
| Crude fibre | 20.02 | 0.37 |
| Crude fat | 3.35 | 0.02 |
| Ash | 4.12 | 0.03 |
| **Mineral content ($mgkg^{-1}$)** | | |
| Calcium (Ca) | 353.02 | 2.65 |
| Phosphorous (P) | 262.17 | 2.09 |
| Magnesium (Mg) | 199.95 | 0.63 |
| Sodium (Na) | 104.83 | 1.08 |
| Potassium (K) | 114.75 | 1.97 |
| Copper (Cu) | 0.96 | 0.02 |
| Manganese (Mn) | 1.12 | 0.01 |
| **Phytochemical components** | | |
| Cyanide $CN^-$ ($mgkg^{-1}$) | 23.97 | 0.53 |
| Tannin ($g100g^{-1}$) | 0.08 | 0.03 |
| Oxalate ($mgg^{-1}$) | 269.04 | 0.62 |
| Phytate-P ($mgg^{-1}$) | 4.29 | 0.06 |
| Phytate ($mgg^{-1}$) | 15.23 | 0.11 |
| Flavonoid ($mg100g^{-1}$) | 5.69 | 0.04 |
| Alkaloids ($mgg^{-1}$) | 6.18 | 0.02 |

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**Table 3: Gross composition of experimental diets for broiler-chickens ($g100g^{-1}$) in which maize was replaced with cassava fibre meal**

| | Levels of cassava fibre meal substitution (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Broiler starters | | | | Broiler finishers | | | |
| **Ingredients** | **0** | **20** | **40** | **60** | **0** | **20** | **40** | **60** |
| Maize | 52.53 | 42.03 | 31.53 | 21.01 | 55.59 | 44.47 | 33.35 | 24.24 |
| CFM | - | 10.50 | 21.00 | 31.52 | - | 11.12 | 22.24 | 33.35 |
| SBM | 22.50 | 22.50 | 22.50 | 22.50 | 21.42 | 21.42 | 21.42 | 21.42 |
| GNC | 14.20 | 14.17 | 14.17 | 14.17 | 11.94 | 11.94 | 11.94 | 11.94 |
| Fish meal | 5.00 | 5.00 | 5.00 | 5.00 | 4.50 | 4.50 | 4.50 | 4.50 |
| Bone meal | 2.00 | 2.00 | 2.00 | 2.00 | 2.50 | 2.50 | 2.50 | 2.50 |
| Oyster shell | 0.50 | 0.50 | 0.50 | 0.50 | 0.60 | 0.60 | 0.60 | 0.60 |
| Premix* | 0.25 | 0.25 | 0.25 | 0.25 | 0.20 | 0.20 | 0.20 | 0.20 |
| Lysine | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 |
| DL-Methionine | 0.11 | 0.11 | 0.11 | 0.11 | 0.10 | 0.10 | 0.10 | 0.10 |
| Salt | 0.30 | 0.30 | 0.30 | 0.30 | 0.35 | 0.35 | 0.35 | 0.35 |
| Veg. Oil | 2.50 | 2.50 | 2.50 | 2.50 | 2.70 | 2.70 | 2.70 | 2.70 |
| **Calculated value ($g100g^{-1}$)** | | | | | | | | |
| Crude protein | 22.85 | 22.71 | 22.55 | 22.34 | 20.26 | 20.18 | 20.07 | 20.02 |
| Crude fibre | 4.53 | 4.71 | 5.26 | 6.09 | 5.02 | 5.87 | 6.30 | 6.85 |
| ME (kcal/kg) | 3112.07 | 3007.60 | 2998.38 | 2911.73 | 3129.13 | 3118.84 | 3082.61 | 3013.73 |
| Ca | 1.31 | 1.31 | 1.32 | 1.31 | 1.31 | 1.30 | 1.31 | 1.31 |
| Av. P | 0.54 | 0.54 | 0.53 | 0.53 | 0.56 | 0.57 | 0.56 | 0.56 |
| **Analysed value ($g100g^{-1}$)** | | | | | | | | |
| Crude protein | 22.81 | 22.76 | 22.57 | 22.41 | 20.29 | 20.24 | 20.19 | 20.07 |
| Crude fibre | 4.46 | 4.62 | 5.31 | 6.11 | 5.05 | 5.79 | 6.35 | 6.83 |
| ME ($kcalkg^{-1}$) | 3111.19 | 2999.03 | 2978.11 | 2917.84 | 3124.08 | 3109.26 | 3095.72 | 3030.35 |
| Ca | 1.32 | 1.32 | 1.33 | 1.33 | 1.32 | 1.31 | 1.32 | 1.32 |
| P | 0.56 | 0.55 | 0.56 | 0.55 | 0.57 | 0.56 | 0.56 | 0.57 |
| Mg | 0.33 | 0.32 | 0.32 | 0.33 | 0.32 | 0.33 | 0.32 | 0.33 |
| Na | 0.31 | 0.30 | 0.30 | 0.30 | 0.30 | 0.31 | 0.30 | 0.30 |
| K | 0.35 | 0.34 | 0.35 | 0.34 | 0.33 | 0.35 | 0.34 | 0.34 |
| Cu | 0.074 | 0.073 | 0.072 | 0.070 | 0.072 | 0.071 | 0.070 | 0.070 |
| Mn | 0.050 | 0.048 | 0.047 | 0.48 | 0.048 | 0.046 | 0.046 | 0.045 |

Note: Each level of cassava fibre substitution was supplemented with 0, 100 and 200mg/kg Roxazyme® G2

**vit A 8,000,000i.u, vit. $D_3$ 2,000,000i.u, vit. E 8,000mg, vit $K_3$ 2,000mg, vit. $B_1$ 1,500mg, vit. $B_2$ 4,000mg, vit. $B_6$ 1,500mg, vit. $B_{12}$ 10mcg, niacin 15,000mg, pantothenic acid 5,000mg, folic acid 500mg, biotin 20mcg, choline chloride 100,000mg, Mn 75,000mg, Zn 45,000mg, Fe 20,000mg, Cu 4,000mg, Iodine 1,000mg, Se 200mg, Co 500mg, antioxidant 125,000mg*

CFM: Cassava fibre meal, SBM: Soybean meal, GNC: Groundnut cake

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**Table 4: Phytochemical components of experimental diets for broiler-chickens**

| Diets | CFM (%) | Tannin ($g100g^{-1}$) | Oxalate ($mgg^{-1}$) | Phytate-P ($mgg^{-1}$) | Phytate ($mgg^{-1}$) | Cyanide $CN^-$ ($mgkg^{-1}$) |
|---|---|---|---|---|---|---|
| | | | **Broiler-starters** | | | |
| 1 | 0 | 0.05 | $0.17^{b}$ | $2.99^{b}$ | $10.61^{b}$ | $2.47^{b}$ |
| 2 | 20 | 0.06 | $0.28^{a}$ | $3.27^{a}$ | $11.61^{a}$ | $9.03^{a}$ |
| 3 | 40 | 0.06 | $0.30^{a}$ | $3.35^{a}$ | $11.89^{a}$ | $9.24^{a}$ |
| 4 | 60 | 0.06 | $0.30^{a}$ | $3.33^{a}$ | $11.82^{a}$ | $9.37^{a}$ |
| SEM | | 0.10 | 0.07 | 0.11 | 0.68 | 0.32 |
| P value | | 0.09 | 0.002 | 0.02 | 0.03 | 0.002 |
| | | | **Broiler-finishers** | | | |
| 1 | 0 | $0.05^{b}$ | $0.21^{b}$ | 3.09c | $10.97^{b}$ | $2.10^{c}$ |
| 2 | 20 | $0.08^{a}$ | 0.33a | $3.45^{b}$ | $12.25^{a}$ | $8.71^{b}$ |
| 3 | 40 | $0.08^{a}$ | $0.34^{a}$ | $3.56^{a}$ | $12.64^{a}$ | $9.18^{a}$ |
| 4 | 60 | $0.09^{a}$ | 0.34a | 3.59a | $12.74^{a}$ | $9.46^{a}$ |
| SEM | | 0.19 | 0.12 | 0.07 | 0.31 | 0.11 |
| P value | | 0.02 | 0.02 | 0.002 | 0.001 | 0.002 |

[a,b,c]Means with different superscripts along the same row are significant ($P<0.05$)

CFM: Cassava fibre meal, SEM: Standard error of the mean

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**Table 5: Performance of broilers fed Roxazyme® G2 supplemented cassava fibre meal diet**

| **CFM (%)** | | **0** | | | **20** | | | **40** | | | **60** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Enzyme mg/kg** | **0** | **100** | **200** | **0** | **100** | **200** | **0** | **100** | **200** | **0** | **100** | **200** | **SEM** | **Sig** |
| | | | | | | **Broiler starters** | | | | | | | | |
| **Parameters** | | | | | | | | | | | | | | |
| Initial wt g/b | 50.29 | 50.27 | 50.32 | 50.54 | 50.58 | 50.50 | 50.68 | 50.29 | 50.53 | 50.32 | 50.41 | 50.48 | 1.12 | 0.85 |
| AWG g/b/d | 23.94$^{a}$ | 23.73$^{a}$ | 24.23$^{a}$ | 24.35$^{a}$ | 24.57$^{a}$ | 23.52$^{ab}$ | 23.64$^{ab}$ | 23.93$^{a}$ | 23.08$^{b}$ | 22.71$^{c}$ | 22.83$^{c}$ | 22.41$^{c}$ | 0.85 | 0.82 |
| AFC g/b/d | 42.76 | 40.10 | 42.32 | 40.81 | 43.38 | 41.37 | 43.33 | 40.19 | 40.91 | 43.38 | 41.61 | 41.96 | 0.78 | 0.49 |
| FCR | 1.79$^{b}$ | 1.69$^{a}$ | 1.75$^{b}$ | 1.67$^{a}$ | 1.76$^{b}$ | 1.75$^{b}$ | 1.83$^{c}$ | 1.68$^{a}$ | 1.77$^{b}$ | 1.90$^{c}$ | 1.82$^{c}$ | 1.87$^{c}$ | 0.83 | 0.55 |
| | | | | | | **Broiler chickens** | | | | | | | | |
| AWG g/b/d | 40.88$^{ab}$ | 41.41$^{a}$ | 41.77$^{a}$ | 41.58$^{a}$ | 41.56$^{a}$ | 41.11$^{ab}$ | 40.19$^{b}$ | 40.14$^{b}$ | 40.49$^{b}$ | 39.59$^{c}$ | 39.66$^{c}$ | 39.62$^{c}$ | 0.46 | 0.02 |
| AFC g/b/d | 101.74 | 102.28 | 100.74 | 101.57 | 101.64 | 103.16 | 101.35 | 103.24 | 101.79 | 103.36 | 102.92 | 103.24 | 2.49 | 0.52 |
| FCR | 2.49$^{a}$ | 2.47$^{a}$ | 2.41$^{a}$ | 2.44$^{a}$ | 2.45$^{a}$ | 2.57$^{b}$ | 2.52$^{b}$ | 2.57$^{b}$ | 2.51$^{b}$ | 2.61$^{c}$ | 2.60$^{c}$ | 2.61$^{c}$ | 0.09 | 0.02 |

$^{a,b,c}$Means with different superscripts along the same row are significant ($P<0.05$)

CFM: Cassava fibre meal, AWG: Average weight gain, AFC Average feed consumption, FCR: Feed conversion ratio, SEM: Standard error of the mean

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**Table 6: Economics of production of broiler-chickens fed Roxazyme® G2 supplemented cassava fibre meal diet**

| CFM (%) | 0 | | | 20 | | | 40 | | | 60 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Enzyme (mg/kg)** | **0** | **100** | **200** | **0** | **100** | **200** | **0** | **100** | **200** | **0** | **100** | **200** | **SEM** |
| **Performance indices** | | | | | | | | | | | | | |
| Initial weight (g) | 50.29 | 50.27 | 50.32 | 50.54 | 50.58 | 50.50 | 50.68 | 50.29 | 50.53 | 50.32 | 50.41 | 50.48 | 1.12 |
| Final live weight (kg) | 2.36 | 2.37 | 2.39 | 2.38 | 2.38 | 2.35 | 2.30 | 2.30 | 2.32 | 2.27 | 2.27 | 2.27 | 0.07 |
| Total weight gain (kg) | 2.31 | 2.32 | 2.34 | 2.33 | 2.33 | 2.30 | 2.25 | 2.25 | 2.27 | 2.22 | 2.22 | 2.22 | 0.08 |
| Feed consumed (kg) | 5.70 | 5.73 | 5.64 | 5.69 | 5.69 | 5.78 | 5.68 | 5.78 | 5.70 | 5.79 | 5.76 | 5.78 | 0.13 |
| **Cost and returns analysis** | | | | | | | | | | | | | |
| Purchase price ($) | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | 0.33 | |
| Cost of maintenance of building and cage ($) | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | 0.51 | |
| Depreciation cost on building ($) | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | |
| Cost of feed ($/kg) | 0.64 | 0.64 | 0.65 | 0.61 | 0.62 | 0.62 | 0.58 | 0.59 | 0.59 | 0.55 | 0.56 | 0.56 | |
| Cost of feed ($/kg) weight gain | 1.59 | 1.58 | 1.57 | 1.49 | 1.51 | 1.56 | 1.46 | 1.52 | 1.48 | 1.43 | 1.45 | 1.46 | |
| Cost differential ($) | | 0.01 | 0.02 | 0.10 | 0.08 | 0.03 | 0.13 | 0.07 | 0.11 | 0.16 | 0.14 | 0.13 | |
| Cost of weight gain ($) | 3.64 | 3.67 | 3.67 | 3.47 | 3.52 | 3.59 | 3.29 | 3.42 | 3.36 | 3.17 | 3.22 | 3.24 | |
| Cost of power, transportation, drugs, medication and vaccination ($) | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | 0.19 | |
| Labour cost ($) | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | 0.14 | |
| Total variable cost ($) | 5.45 | 5.48 | 5.48 | 5.28 | 5.33 | 5.40 | 5.10 | 5.23 | 5.17 | 4.98 | 5.03 | 5.05 | |
| Total cost ($) | 5.75 | 5.78 | 5.78 | 5.58 | 5.63 | 5.70 | 5.40 | 5.53 | 5.47 | 5.28 | 5.33 | 5.35 | |
| Return on sale ($) | 6.50 | 6.58 | 6.64 | 6.61 | 6.61 | 6.53 | 6.39 | 6.39 | 6.44 | 6.31 | 6.31 | 6.31 | |
| Gross margin ($) | 1.05 | 1.10 | 1.16 | 1.33 | 1.28 | 1.13 | 1.29 | 1.16 | 1.27 | 1.32 | 1.28 | 1.25 | |
| Net revenue ($) | 0.75 | 0.80 | 0.86 | 1.03 | 0.98 | 0.83 | 0.99 | 0.86 | 0.97 | 1.03 | 0.98 | 0.96 | |
| Profit/bird over control group ($) | - | 0.05 | 0.11 | 0.28 | 0.23 | 0.08 | 0.24 | 0.11 | 0.22 | 0.28 | 0.23 | 0.21 | |
| %Profit over control group | - | 6.67 | 14.67 | 37.33 | 30.67 | 10.67 | 32.00 | 14.67 | 29.33 | 37.33 | 30.67 | 28.00 | |
| Relative cost benefit (%) | - | 0.63 | 1.26 | 6.29 | 5.03 | 1.89 | 8.18 | 4.40 | 6.92 | 10.06 | 8.81 | 8.18 | |
| Economic efficiency | 0.13 | 0.14 | 0.15 | 0.18 | 0.17 | 0.15 | 0.18 | 0.16 | 0.18 | 0.20 | 0.18 | 0.18 | |
| Relative economic efficiency (%) | 100 | 107.69 | 115.38 | 138.46 | 130.77 | 115.38 | 138.46 | 123.08 | 138.46 | 153.85 | 138.46 | 138.46 | |
| Marginal relative economic efficiency | 0 | 1.08 | 1.15 | 1.38 | 1.31 | 1.15 | 1.38 | 1.23 | 1.38 | 1.54 | 1.38 | 1.38 | |
| **Profitability ratio** | | | | | | | | | | | | | |
| Benefit cost ratio | 1.13 | 1.14 | 1.15 | 1.18 | 1.17 | 1.15 | 1.18 | 1.16 | 1.18 | 1.20 | 1.20 | 1.18 | |
| Expense structure ratio | 5.45 | 5.48 | 5.48 | 5.28 | 5.33 | 5.40 | 5.10 | 5.23 | 5.17 | 4.98 | 5.03 | 5.05 | |
| Rate of return | 0.13 | 0.14 | 0.15 | 0.18 | 0.17 | 0.15 | 0.18 | 0.16 | 0.18 | 0.20 | 0.18 | 0.18 | |
| Return per $ invested | 0.19 | 0.20 | 0.21 | 0.25 | 0.24 | 0.21 | 0.25 | 0.22 | 0.24 | 0.26 | 0.25 | 0.25 | |
| Gross ratio | 0.88 | 0.88 | 0.87 | 0.84 | 0.85 | 0.87 | 0.85 | 0.86 | 0.85 | 0.84 | 0.84 | 0.85 | |
| %Profit margin | 13.04 | 13.84 | 14.88 | 18.46 | 17.41 | 14.56 | 18.33 | 15.55 | 17.73 | 19.51 | 18.39 | 17.94 | |

1$ = ₦390 as at 2019
SEM: Standard error of the mean, CFM: Cassava fibre meal

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