

Growth Performance and Cost Benefit of Producing Broiler Chickens fed Diets Containing Raw and Toasted Bambara nut Sievate Supplemented with or without Biozyme®.



Gege B. M.¹, Shaahu, D. T.¹, Tuleun, C. D.² and Kaankuka, F. G.²

¹Department of Animal Production, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria.

²Department of Animal Nutrition, Joseph Sarwuan Tarka University, Makurdi, Benue State, Nigeria.

Corresponding Author: mhungurgege@gmail.com; +2347040608033

Abstract

One major problem of farm animal production today is the difficulty in acquisition of low cost but nutritionally adequate feedstuff for feeding farm animals, thus the need to use other non-conventional ingredients like bambara nut sievate which could drastically reduce the cost of producing poultry and other livestock. A 49-day feeding trial to assess growth performance and cost-benefits of producing broiler chickens using diets containing raw and toasted bambara nut sievate supplemented with or without biozyme was conducted using 300 seven days old (Ross 308) broiler chicks. The birds were balanced for weight, randomly divided into 5 groups of 60 chicks. The 5 groups were replicated thrice with 20 chicks each in a completely randomized design. Birds in group 1, 2, 3, 4 and 5 were fed control diet, diet containing raw bambara nut sievate, raw bambara nut sievate with enzyme supplementation, toasted bambara nut sievate and toasted bambara nut sievate with enzyme supplementation, respectively. Biozyme was supplemented at the rate of 100 g/100 kg diet. Data were collected on growth performance, feed intake, feed conversion ratio, mortality and economics of production. The result showed that final weight, body weight gain and feed intake were significantly ($p < 0.05$) influenced. Birds on diet containing toasted bambara nut with enzyme supplementation and diet with toasted bambara nut without enzyme had highest (2180 g/bird) and least (1740 g/bird) values for final body weights, respectively. Body weight gained followed a similar trend of variation as final body weight. Inclusion of bambara nut sievate in the diets of broiler chickens reduced the cost of producing broiler chickens thereby raising the profit margin. It can be concluded that toasted bambara nut sievate with enzyme supplementation gave a better growth performance, it however increased cost of broiler chicken production compared to control diet.

Keywords: Sievate, Biozyme, Growth, Cost-benefit, Broiler.

Performances de croissance et rentabilité de la production de poulets de chair nourris avec des régimes contenant du siévat de noix de Bambara cru et grillé, supplémenté avec ou sans Biozyme®.



Résumé

L'un des principaux problèmes de l'élevage actuel est la difficulté d'acquérir des aliments à bas prix mais nutritionnellement adéquats. D'où la nécessité d'utiliser des ingrédients non conventionnels comme le siévat de noix de Bambara, qui pourraient réduire considérablement les coûts de production de la volaille et d'autres animaux d'élevage. Un essai d'alimentation de 49 jours visant à évaluer les performances de croissance et la rentabilité de la production de poulets de chair avec des régimes contenant du siévat de noix de Bambara cru et grillé, supplémenté avec ou sans Biozyme, a été mené auprès de 300 poussins de chair âgés de sept jours (Ross 308). Les oiseaux ont été équilibrés en poids et répartis aléatoirement en cinq groupes de 60 poussins. Ces cinq groupes ont été répliqués trois fois avec 20 poussins chacun, selon un schéma entièrement randomisé. Français Les oiseaux des groupes 1, 2, 3, 4 et 5 ont été nourris respectivement avec un régime témoin, un régime contenant du siévat de noix de bambara crue, du siévat de noix de bambara crue avec supplémentation enzymatique, du siévat de noix de bambara grillée et du siévat de noix de bambara grillée avec supplémentation enzymatique. Le Biozyme a été supplémenté à

raison de 100 g/100 kg de régime. Des données ont été recueillies sur les performances de croissance, la consommation d'aliments, l'indice de conversion alimentaire, la mortalité et l'économie de la production. Les résultats ont montré que le poids final, le gain de poids corporel et la consommation d'aliments étaient significativement ($p < 0,05$) influencés. Les oiseaux nourris avec un régime contenant des noix de bambara grillées avec supplémentation enzymatique et un régime avec des noix de bambara grillées sans enzyme avaient respectivement les valeurs les plus élevées (2180 g oiseau) et les plus basses (1740 g/oiseau) pour les poids corporels finaux. Le poids corporel gagné a suivi une tendance de variation similaire à celle du poids corporel final. L'inclusion de siévat de noix de bambara dans l'alimentation des poulets de chair a réduit le coût de production, augmentant ainsi la marge bénéficiaire. On peut conclure que le siévat de noix de bambara grillé, supplémenté en enzymes, a permis d'obtenir de meilleures performances de croissance, mais a augmenté le coût de production des poulets de chair par rapport à l'alimentation témoin.

Mots clés: *Siévat, Biozyme, Croissance, Coût-bénéfice, Poulet de chair.*

Introduction

The increase in global demand for high quality meat and in the mist of escalating costs of production due to scarcity of feed resources which have necessitated the search for alternative poultry ration formulation ingredients (Mota de Carvalho *et al.*, 2021). Feed costs account for more than 65% of overall production cost (Moss *et al.*, 2021), and due to the high cost of poultry feeds, there is continuous pressure on farmers to be innovative in formulating 'least cost' diets that are not only affordable, but also able to meet the nutritional requirements of animals (Alhotan, 2021; Moss *et al.*, 2021). Drought, poor agricultural practices and plagues have also led to unviable farm harvests, especially in third world countries. Padilla *et al.* (2021) explored the decision-making process of commercial poultry enterprises facing rising input costs in Nigeria. They reported that while Nigeria has seen a rapid growth of commercial livestock enterprises, the sensitivity of the poultry industry to changes in feed prices is a major threat to the sector. These fluctuations in feed prices tend to be exacerbated by the existing competition for feedstuff between humans and livestock, thus increasing the cost of conventional animal feedstuff and consequently, the cost of poultry products (Truong *et al.*, 2021)

This has led to the sky rocketing of prices of these conventional protein and energy sources and subsequently, the attendant increase in the cost of

animal protein. Hence, a wide gap is created between the demand and supply of animal protein in Nigeria and many under developed countries of the world. Serious malnutrition is therefore widespread because of the deficiency of protein particularly animal protein, in human diets. One of the ways of solving this problem is to substitute with non-conventional feedstuffs like Bambara nut sievate that can be used as total or partial replacement for the conventional ingredients as an alternative protein and energy sources that are cheaper and more readily available in poultry feeds. Bambara nut sievate (BNS) is a by-product from the processing of Bambara nut into its flour. This flour is widely consumed in the South Eastern states of Nigeria in a form of a pudding called 'Okpa'. At present these sievates have no direct food use by man. In most areas they are merely used as feed supplements for small ruminants. With the increasing demand and consumption of 'Okpa' more of these sievates are produced. They are carelessly disposed within the processing plants and thus constitute environmental pollutants. Its incorporation in diets of livestock reduced cost/kg of feed tremendously and improved growth. Also, enhanced growth was observed in pullets when Bambara sievate were incorporated in the diet at a 20 percent level (Onyimonyi and Onukwufor, 2003). Ekenyem and Onyeagoro, (2006) reported that increasing levels of Bambara nut sievate reduced the cost of producing broilers thus

making the product more affordable to consumers. The development of the offal as an alternative energy and protein source could contribute to solving the problem of high cost of poultry feed and could provide a better avenue for its disposal which may constitute an environmental nuisance. Therefore, this study was designed to determine the efficacy of feeding broiler chickens' diets containing raw and toasted bambara nut sievate with and without enzyme supplementation on growth performance and associated cost benefits.

Materials and methods

Experimental site

The study was conducted at Farm Craft' Farms, Judges Quarters Makurdi, Benue State, Nigeria. Makurdi lies within latitude 7.45°N and longitude 8.32°N within the Southern Guinea Savanna agro-ecological zone of Nigeria. It is characterized by tropical, dry and wet climate. The dry season lasts for a minimum of five months, beginning from November to March, while the wet season spans from April to October. Mean annual rainfall is about 1,290 mm (Weather station, 2020).

Source and preparation of feed ingredients

The bambara nut sievate (BNS) was purchased from Makurdi Local Government Area of Benue State. Five (5 kg) kilograme of raw BNS was thoroughly mixed with 1 litre of clean, fresh water and toasted using a big aluminum frying pan. The toasting material was turned frequently and cautiously to avoid charring until the material turned light-brown with a sweet aroma. Thereafter, the toasted material was allowed to cool before being incorporated into the various diets.

Experimental diets

Five diets were formulated for starter and finisher broiler chickens as presented in Tables 1 and 2, respectively. A maize – soya bean-based control diet, diet containing raw bambara nut sievate, diet containing raw bambara nut sievate plus enzyme, diet containing toasted bambara nut sievate and diet containing toasted bambara nut sievate plus enzyme respectively were formulated for broiler starter and finisher at 10% and 15% inclusion, respectively. The diets were designated T1, T2, T3, T4 and T5, respectively.

Proximate nutrient analysis of raw and toasted bambara nut sievate and experimental diets

Proximate nutrient composition of raw bambara nut sievate (RBNS), toasted bambara nut sievate (TBNS) and experimental diets was determined using the methods described by AOAC (2002), and the metabolizable energy calculated using the method described by Pazungu (1985).

Management of experimental animal

Birds were allowed adjustment period of one week before feeding trial commenced. Feed and water were provided *ad-libitum* and routine management practices were kept within standard procedures. Experimental broiler chicks were administered Newcastle Disease Vaccine intra ocular, Newcastle disease vaccine Lasota, infectious bursal disease vaccine via drinking water at day old, 7 days old and 14 days old, respectively.

Experimental design

Three hundred (300) unsexed 7 days old broiler chicks (Ross 308) were used for the 49 days study. The chicks were allowed a week acclimatization period while on commercial feed, thereafter, balanced for weight and randomly divided into five groups of sixty chicks and replicated thrice with twenty (20) chicks per replicate in a Completely Randomised Design.

Table 1: Ingredients and analyzed proximate composition of broiler chick's starter diets

Ingredient (%)	Control (T1)	Raw (T2)	BNS Raw Enzyme (T3)	BNS Plus (T4)	Toasted BNS (T5)	Toasted BNS plus
Maize	39.06	32.55	32.55		30.53	30.53
Full fat Soybean	50.39	46.90	46.90		48.92	48.92
Rice Offal	4.00	4.00	4.00		4.00	4.00
BNS	-	10.00	10.00		10.00	10.00
Blood meal	2.00	2.00	2.00		2.00	2.00
Bone Ash	3.50	3.50	3.50		3.50	3.50
Common salt	0.30	0.30	0.30		0.30	0.30
Lysine	0.25	0.25	0.25		0.25	0.25
Methionine	0.25	0.25	0.25		0.25	0.25
Vitamin Premix	0.25	0.25	0.25		0.25	0.25
Biozyme® (g)	-	-	100		-	100
TOTAL	100	100	100		100	100
Analysed nutrients composition (%)						
Crude protein	26.5	21.75	21.75		22.31	21.75
Crude fibre	4.71	8.62	7.33		7.03	9.50
Nitrogen free extract	42.18	44.15	44.94		44.66	42.73
Ether Extract	6.82	8.29	8.26		8.29	7.02
Ash	11.89	9.11	9.41		9.88	11.19
Methionine	0.67	0.72	0.72		0.69	0.69
Lysine	1.83	1.72	1.72		1.77	1.77
Calcium	1.36	1.38	1.38		1.38	1.38
Phosphorus	0.87	0.86	0.86		0.87	0.87
ME (Kcal/kg)	3021.06	3043.57	3069.18		3081.39	2890.29

BNS = Bambara nut Sievate, ME = Metabolisable Energy calculated using Puazenga 1985 (37x %cp + 81 x % EE + 35.5x% NFE), T₁ = Control diet T₂ = Diet containing raw BNS, T₃ = Diet containing raw BNS plus Biozyme®, T₄ = Diet containing Tosted BNS, T₅ = Diet containing toasted BNS plus Biozyme®, Vitamin-mineral premix (animal care^R) will supply the following additional nutrients per kg of feed. Vitamin (1,200,000 I.U), D₃ (300,000 I.U), E (3,000 mg), k₃ (250 mg), folic acid (10 mg), Niacin (4,000 mg), Calpan (1,000 mg), B₂ (500 mg), B₁₂ (2 mg), B₁ (9,200), B₆ (350 mg), Biotin (8 mg), Antioxidant (12,500mg), Minerals; Cobalt (25 mg), Iodine (120 mg), Iron (4,000 mg), Manganese (700 mg), Copper (800 mg), Zinc (6,000mg), Chlorine Chloride (20,000 mg). Biozyme® contains *Bacillus subtilis*, *Saccharomyces cerevisiae*, Amylase, protease, β-Gluconase, hemicellulase and lipase.*

Table 2: Ingredients and analyzed proximate composition of broiler chicken finisher diets

Ingredient (%)	Control (T1)	Raw BNS (T2)	Raw BNS Plus Enzyme (T3)	Toasted BNS (T4)	Toasted BNS plus Enzyme (T5)
Maize	40.34	43.45	43.45	40.56	40.56
Full fat Soybean	34.11	31.00	31.00	33.89	33.89
Rice Offal	4.00	4.00	4.00	4.00	4.00
BNS	15.00	15.00	15.00	15.00	15.00
Blood meal	2.00	2.00	2.00	2.00	2.00
Bone Ash	3.50	3.50	3.50	3.50	3.50
Common salt	0.30	0.30	0.30	0.30	0.30
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Vitamin Premix	0.25	0.25	0.25	0.25	0.25
Biozyme® (g)	-	-	100	-	100
TOTAL	100	100	100	100	100
Analysed nutrients composition (%)					
Crude protein	19.69	17.50	21.88	21.88	17.50
Crude fibre	5.56	7.03	9.03	8.80	8.40
NFE	51.64	53.35	42.78	46.34	49.11
Either Extract	6.66	5.80	5.23	5.87	6.13
Ash	8.76	8.90	14.00	10.23	11.73
Methionine	0.56	0.68	0.68	0.64	0.64
Lysine	1.37	1.30	1.30	1.37	1.37
Calcium	1.32	1.35	1.35	1.36	1.36
Phosphorus	0.78	0.78	0.78	0.80	0.80
ME (Kcal/kg)	3101.21	3011.23	2751.88	2930.05	2887.44

BNS = Bambara nut Sievate,, **ME** = Metabolisable Energy calculated using Puazenga 1985 ($37x \%cp + 81 x \% EE + 35.5x\% NFE$), **T₁** = Control diet **T₂** = Diet containing raw BNS, **T₃** = Diet containing raw BNS plus Biozyme®, **T₄** = Diet containing Tosted BNS, **T₅** = Diet containing toasted BNS plus Biozyme®, Vitamin-mineral premix* (animal care^R) will supply the following (additional nutrients per kg of feed. Vitamin (1,200,000 I.U), D₃ (300,000 I.U), E (3,000 mg), k₃ (250 mg), folic acid (10 mg), Niacin (4,000 mg), Calpan (1,000 mg), B₂ (500 mg), B₁₂ (2 mg), B₁ (9,200), B₆ (350 mg), Biotin (8 mg), Antioxidant (12,500mg), Minerals; Cobalt (25 mg), Iodine (120 mg), Iron (4,000 mg), Manganese (700 mg), Copper (800 mg), Zinc (6,000mg), Chlorine Chloride (20,000 mg). Biozyme® contains *Bacillus subtilis*, *Saccharomyces cerevisiae*, Amylase, protease, β-Gluconase, hemicellulase and lipase.

Data collection

Growth performance

Initial weight was recorded prior to commencement of the study, average feed intake was calculated by subtracting leftover feed from feed offered on weekly basis and divided by 7 days and by number of birds per replicate, weight gain was calculated on weekly basis by subtracting previous weight from the present weight and dividing by 7 days and by number of

birds per replicate. Feed to gain ratio was calculated by dividing feed intake by weight gain.

Cost-benefit analysis

Cost-benefit analysis was determined at the end of the study by difference of all the expenses and the income earned at completion of the experiment. The following indices were considered; cost of broiler chicks, cost of feed, cost of vaccines/drugs and other operational cost.

Statistical analysis

Data obtained were subjected to one-way Analysis of Variance (ANOVA) and the means that differed significantly ($P < 0.05$) were separated using Duncan's Multiple Range Test (DMRT) using the same package (SPSS, 2016).

Results and discussion

Result of proximate nutrient composition of raw and toasted bambara nut sievate (BNS) is presented in Table 3. The result showed significant variation ($P < 0.05$) in Dry Matter (DM) and Crude Protein (CP). Crude fibre (CF), Ether Extract (EE), Ash, Nitrogen-Free Extract (NFE) and Metabolisable Energy (ME) were not significantly ($P > 0.05$) affected by toasting of BNS. Result of this study revealed an increase in DM from 91.30 to 92.44 % when BNS was toasted, while a decrease from 18.54 to 14.11 % in CP content of BNS was observed with toasting. Values of EE, Ash and ME though not statistically significant were observed to decrease while CF and NFE increased when BNS was toasted. The dry matter (DM) and crude fibre (CF) values of toasted bambara nut sievate obtained in this study were higher than 86.10 % and 5.4 % recorded by Amaefule *et al.* (2011) with toasted bambara nut offal. They however

recorded higher values of CP, EE, and nitrogen-free extract. The difference in result may be attributed to difference in the degree of processing BNS. Processing of bambara nut offal has been shown to improve its nutritional value and reduce the level of anti-nutritional factors, however the degree of processing and the processing conditions can affect the quality of the final product (Ayo-Ajasa *et al.*, 2013). The reduction in CP, EE and ME of BNS toasted agreed with the findings of Uche *et al.* (2014) and Uza *et al.* (2021) in their analysis of toasted bambara nut seeds and bambara nut sievate respectively. The numerical increase in digestible carbohydrate level when subjected to heat treatment confirmed the reports of Ayoola *et al.* (2012) that digestible carbohydrate content of raw groundnut seeds increased when roasted. The observed decrease in ether extract of raw BNS though not significant was consistent with the report of Ayoola and Adeyeye (2010) on groundnut seeds, they observed further decrease in fat levels as the intensity of heat increased. The result also suggests that ash content was higher in raw BNS compared to the toasted. This result also agreed with Ayoola and Adeyeye (2010) who observed higher ash content with raw groundnut seeds compared to the toasted.

Table 3: Proximate Composition of Raw and Toasted Bambara nut Sievate

Parameters	Raw BNS	Toasted BNS	SEM
Dry matter (%)	91.30 ^b	92.44 ^a	0.19*
Crude Protein (%)	18.54 ^a	14.11 ^b	0.79*
Crude Fibre (%)	20.58	21.83	0.35
Ether Extract (%)	2.40	1.93	0.08
Ash (%)	2.76	2.67	0.02
Nitrogen-free Extract (%)	47.02	51.90	0.81
Metabolizable energy(kcal/kg)	2549.59	2520.85	13.88

^{ab} = Means within each row with different superscript are significantly different ($P < 0.05$),

BNS – Bambaranut sievate, SEM- Standard Error of Mean.

Effect of Dietary BNS with or without and Biozyme® Supplementation on Growth Performance of Broiler Chickens

Results on effects of inclusion of raw and toasted bambara nut sievate with or without enzyme

supplementation on growth performance of broiler chicken are presented in Table 4. The results showed significant differences ($p < 0.05$) in final body weight gain, daily body weight gain, daily feed intake and mortality. The efficiency

with which birds converted feed to body weight (FCR) was not significantly ($p > 0.05$) affected by dietary treatment across the groups. Final and daily body weights of birds fed diet containing toasted bambara nut sievate with enzyme supplementation were higher (2180 and 40.49 g/bird) than those fed dietary toasted bambara nut sievate without enzyme. These values were however, comparable to the control and other diets. Feed intake of birds fed diet containing raw bambara nut sievate with enzyme supplementation (106.53 g) was higher than those fed control diet and diet containing raw bambara nut sievate without enzyme and toasted bambara nut sievate without enzyme. Percentage mortality was lower in birds fed diet containing raw bambara nut sievate with enzyme supplementation compared to those fed other diets.

The obtained result showed that, feed intake increased with inclusion of bambara nut sievate and enzyme supplementation in the diets. This agreed with the findings of Oyeagu *et al.* (2016) who reported increased feed intake of chicks fed diets containing graded levels of toasted bambara nut offal. The increased feed intake of birds fed diet containing raw bambara nut sievate with enzyme supplementation disagreed with the findings of Ani *et al.* (2012) who observed that, enzyme supplementation of poultry diets results in decrease in feed intake.

The result also contradicted the findings of Ghazala *et al.* (2011) who reported no significant effect of enzyme supplementation on feed intake in laying hens.

The increase in feed intake recorded may be attributed to fibrous and bulky nature of the raw bambara nut contained diet. This could also be as a result of the addition of enzyme since enzymes are also known to improve the intake of feeds (Zeng *et al.* 2015). The depression in feed intake and body weight gain at the 15% toasted BNS inclusion in diet without enzyme supplementation (T₄) may be attributed to the

activities of residual anti-nutritional factors present in the toasted bambara nut sievate. These residual anti-nutrients may have been removed by addition of enzyme as evidenced in the improved performance observed in birds fed diet containing toasted bambara nut sievate with enzyme supplementation (T₅). According to Shirmohammed and Mehri (2011), exogenous enzymes are known to reduce anti-nutrients content and improve the nutritional value of feeds. This increased body weight corroborated the report of Sheriff (2009) on increase in body weight of broiler chicks fed enzyme supplemented diets compared to un-supplemented diets. Also, the findings aligned with the reports of Tuleun *et al.* (2020) on significant weight increase in broiler chickens fed graded levels of raw bambara nut offal. However, this contradicted reports from Slominski (2011) and Rabie and Abo EL-Maaty, 2015) on depressed final body weights and body weight gains in growing Japanese quails fed diets with exogenous enzymes. Ahmed *et al.* (2017) also opined that enzyme supplementation in some cases do not increase body weight gain. The significantly ($p < 0.05$) higher body weights of birds fed toasted bambara nut- based diet with enzyme supplementation could be attributed to the reduction in anti-nutrients by toasting of bambara nut sievate and addition of enzyme to the diet. Exogenous enzymes are known to enhance the nutritive value of feeds (Shirmohammed and Mehri, 2011).

Improved performance in this study disagreed with the report of Ani *et al.* (2012) who opined that bambara nut offal can lower performance even at 10%. The observed average daily gain and daily weight gain showed that inclusion of 15% raw and toasted BNS in diets with enzyme supplementation was capable of supplying adequate nutrients for growth of broiler chickens. This may have resulted from the activities of cellulases and glycanase contained in the enzyme which might have caused a cleavage of non-

starch polysaccharides (NSP) in toasted bambara nut sievate into smaller polymers, thereby preventing the formation of viscous digesta and enhancing nutrient digestibility (Kalantar *et al.*, 2015). The insignificant effect of enzyme supplementation on feed conversion ratio (FCR) contradicted the findings of Zeng *et al.* (2015)

and Kalantar *et al.* (2015) on significant ($p < 0.05$) decrease in FCR with enzyme supplements in diets of broiler chickens. The result obtained in the present study suggested that, 15% raw and toasted bambara nut inclusion with or without enzyme supplementation enhanced efficient feed conversion by broiler chickens.

^{abc} = Mean within each row with different superscripts are significantly different ($P < 0.05$) FCR- Feed

Table 4: Effect of Dietary Bambara nut Sievate with or without Biozyme® Supplementation on Growth Performance of Broiler Chickens

Parameters	T1	T2	T3	T4	T5	SEM
Initial body weight(g/bird)	195.00	196.00	196.00	195.00	196.00	1.16
Final body weight (g/bird)	1870 ^{ab}	1860 ^{ab}	2140 ^{ab}	1740 ^b	2180 ^a	0.67
Daily body weight gain (g/bird)	34.18 ^{ab}	33.96 ^{ab}	39.67 ^{ab}	31.53 ^b	40.49 ^a	2.16
Daily feed intake (g/bird)	88.16 ^{bc}	90.41 ^{bc}	106.53 ^a	85.51 ^c	97.35 ^{ab}	3.44
Feed conversion ratio	2.57	2.67	2.70	2.72	2.40	0.11
Mortality (%)	6.67 ^{ab}	15.00 ^a	1.67 ^b	16.67 ^a	5.00 ^{ab}	2.08

Conversion Ratio T₁, - Control Diet Containing No Bamabara Nut Sievate, T₂, - Containing Raw Bamabara Nut Sievate, T₃, - Diet Containing Raw Bamabara Nut Sievate + Biozyme®, T₄, - Diet Containing Toasted Bamabara Nut Sievate and T₅ - Diet Containing Toasted Bamabara Nut Sievate + Biozyme®.

Cost-benefit analysis of Broiler Chickens Fed Diets Containing Raw and Toasted Bambara nut Sievate Supplemented with or without Biozyme®

The economics of production of broiler chickens fed diets containing BNS supplemented with or without Biozyme is presented in Table 5. One kg of raw bambara nut sievate cost ₦70.00 and was put at ₦90.00 post-processing. Cost of day-old chicks (₦ 555.00) was same for all treatment groups. Cost per kg diet reduced from ₦297.26 to ₦269.22 when bambara nut sievate was included in the diet. Feed cost (₦) to raise a broiler chick to table size reduced from ₦ 1,275.25 to ₦1,169.47 as a result of inclusion of bambara nut sievate in the diets, except in diets with enzyme supplementation where there was an increase in cost of feed consumed from ₦1,275.25 to ₦1,420.74 and ₦1,275.25 to ₦1,350.43 in the raw and toasted bambara nut sievate contained diets, respectively. The increase in cost of feed consumed in T₃ and T₅ may be as a result of the higher feed intake of birds on these diets and enzyme addition to the diets. Ajaja *et al.* (2003)

and Ani *et al.* (2012) had earlier reported similar observation which was attributed to increase in average daily feed intake, improved feed efficiency and utilization, and improved average daily weight gain of the birds. Cost of producing a kilogram weight of chicken was reduced (₦ 759.08 to ₦ 678.61) with inclusion of bambara nut sievate and enzyme in the diets. The reduction in cost of producing a kilogram weight of chicken and production cost observed in this study is indicative of the economic viability of bambara nut sievate as an alternative feed ingredient for broiler production. Total production cost reduced from ₦2,002.23 to ₦ 1896.47 with the inclusion of 15% toasted bambara nut sievate in diet, while there was an increase in production cost from ₦2,002.25 to ₦2,161.07, and ₦2,090.76 when the raw and toasted bambara nut sievate based diets were supplemented with enzyme. Increase in production cost and reduction in revenue generated in groups fed raw and toasted bambara nut-based diets with enzyme supplementation can be attributed to additional cost from enzyme addition to the diets. This agreed with Togun *et*

al. (2020) that the cost of feed ingredients has a direct impact on the overall production cost and consequently, the gross profit. There was an increase in revenue generated from ₦1,497.75 to ₦1,603.53 with toasted bambara nut sievate inclusion in the diets. The revenue was however reduced to ₦1,409.24 when the diet was supplemented with enzyme due to additional cost from enzyme.

Diets containing bambara nut sievate gave optimum cost benefit compared to control. This is because bambara nut sievate has less commercial value compared to conventional feed ingredients like maize and soyabean within the study area. The result of this study is consistent

with earlier reports (Togun *et al.*, 2020; Olanrewaju *et al.*, 2017) that investigated cost-effectiveness of various feed ingredients in broiler diets. Despite the increased production cost and reduced revenue associated with enzyme supplementation of the diets, there was no loss of revenue recorded in this study and the least benefit and profit recorded from birds fed diet containing raw bambara nut sievate with enzyme (₦1338.93) is still recommendable to farmers.

Table 4: Cost-benefit analysis of Broiler Chickens Fed Diets Containing Raw and Toasted Bambara nut Sievate Supplemented with or without Biozyme®

Parameters	T1	T2	T3	T4	T5	Percent cost reduction by BNS inclusion			
						T2	T3	T4	T5
Cost of DOC (₦/Bird)	555.00	555.00	555.00	555.00	555.00				
Cost of Feed (₦/Kg)	297.26	269.22	273.22	279.11	283.11	28.04	24.04	18.15	14.15
Total Feed Consumed (Kg/Bird)	4.29	4.42	5.20	4.19	4.77				
Cost of Feed Consumed (₦/Bird)	1,275.25	1,189.95	1,420.74	1,169.47	1,350.43	85.3	145.49*	105.78	75.18*
Total Weight Gain (Kg/Bird)	1.68	1.66	1.94	1.54	1.99				
Cost/Kg Weight Gain (₦)	759.08	716.84	732.34	759.04	678.61	42.24	26.74	0.04	80.47
Vaccine/Drug /Bird)	(₦) 107.67	107.67	107.67	107.67	107.67				
Miscellaneous /Bird)	(₦) 64.33	64.33	64.33	64.33	64.33				
Total Cost of Production (₦/Bird)	2,002.25	1,916.95	2,161.07	1,896.47	2,090.76	85.3	158.82*	105.78	88.51*
Gross Profit (₦)	1,497.75	1,583.05	1,338.93	1,603.53	1,409.24	85.3	158.82-	105.78	88.51-

DOC = Day Old Chick

Sales = ₦ 3,500.00/Bird

* = Increased cost - = Less profit compared to control. T₁, - Control Diet Containing with no Bambara nut Sievate, T₂, - Diet Containing raw bamabara nut Sievate, T₃, - Diet containing raw bamabara nut sievate + enzyme, T₄, - Diet containing toasted bamabara nut sievate And T₅ -Diet containing toasted bamabara nut sievate + enzyme

Conclusion

Incorporation of toasted bambara nut sievate with enzyme supplementation in diets of broiler chicken enhanced better performance compared to diet containing toasted bambara nut without enzyme supplementation.

Generally, inclusion of bambara nut sievate in diets reduced cost of broiler chicken production.

Recommendation

Bambara nut sievate should be toasted and supplemented with enzyme before inclusion in broiler chicken diets to improve growth performance.

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