FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 1, January, 2026, pp 57 – 63
DOI: https://doi.org/10.33003/fjs-2026-1001-4385

EFFECT OF PROCESSING METHODS AND ORGANIC ACID (FYSAL®) SUPPLEMENTATION ON THE FEEDING VALUE OF *Balanites aegyptiaca* FRUIT MEAL BY BROILER CHICKENS

[1]Abdullahi, I., *[2]Idachaba, C. U., [3]Zungum, A. G.,[2]Kudor, P. N., [2]Idris, H., [2]Silas, S. and [2]Yilwatda, B. M.

[1]National Animal Production Research Institute, Shika Zaria, Nigeria.
[2]Department of Animal Production, Faculty of Agriculture, University of Jos, Nigeria.
[3]Department of Animal Production, Federal College of Animal Health and Production Technology, Vom, Nigeria.

*Corresponding authors' email: udagbenei@unijos.edu.ng

ABSTRACT

The high cost and competition for conventional feed ingredients necessitate the exploration of alternative plant resources in poultry nutrition. The study evaluated the effects of processed *Balanites aegyptiaca* fruit meal (BAFM) supplemented with an organic acid blend (FYSAL®) on proximate composition, anti-nutritional factors, growth performance, and economic efficiency of broiler chickens. Raw *B. aegyptiaca* fruits were processed by soaking (24 hr), boiling (15 min), and roasting (15 min) and analyzed for proximate composition and anti-nutritional factors using standard procedures. One hundred and eighty (180) Cobb-500 broiler finisher chickens were randomly allotted to four dietary treatments (15 chickens per replicate) containing 0.0, 2.5, 5.0, and 7.5% soaked BAFM, with organic acid supplementation at 0.1% for the test diets, in a completely randomized design. Soaking significantly improved crude protein content (20.01%) and reduced tannin (68.13%), oxalate (74.58%), phytic acid (38.00%), and saponin (20.69%) levels compared with the raw fruit. Birds fed 5.0% BAFM recorded significantly higher ($P<0.05$) final body weight compared with the control, while weight gain, feed intake, and feed conversion ratio were not significantly affected ($P>0.05$). Feed cost per kilogram weight gain was lowest at 5.0% BAFM inclusion, indicating improved economic efficiency. The study concluded that soaked *Balanites aegyptiaca* fruit meal supplemented with organic acid can be included up to 7.5% in broiler finisher diets without adverse effects, with optimal biological and economic performance observed at 5.0% inclusion.

Keywords: *Balanites Aegyptiaca*, Broiler Chickens, Organic Acidifier, Growth Performance, Economic Benefit

INTRODUCTION

Poultry production remains one of the most efficient means of meeting the growing global demand for animal protein; however, the escalating cost of conventional feed ingredients such as maize, soybean meal and groundnut cake poses a major constraint to sustainable production, particularly in developing countries (FAO, 2013; Ravindran, 2013). Feed costs account for over 60–70% of total production expenses in intensive poultry systems, necessitating the exploration of cheaper, locally available and nutritionally viable alternative feed resources (Onyimonyi and Okeke, 2007). *Balanites aegyptiaca* (desert date) is a drought-tolerant multipurpose tree widely distributed across the Sahel and savannah regions of Africa. Its fruits are readily available, underutilized and have been reported to contain appreciable levels of carbohydrates, crude protein and energy, making them a potential feed resource for livestock (Abdullahi *et al*., 2016; Chothani and Vaghasiya, 2011). Despite its nutritional potential, the utilization of *B. aegyptiaca* fruits in monogastric nutrition is limited by the presence of anti-nutritional factors such as tannins, saponins, oxalates and phytic acid, which can impair nutrient digestibility, reduce feed intake and negatively affect animal performance (Makkar, 2003; Francis *et al*., 2002). Processing techniques including soaking, boiling and roasting have been shown to significantly reduce anti-nutritional factors in plant feedstuffs by leaching, thermal degradation and enzymatic activation, thereby improving their nutritive value and safety for poultry feeding (Adeola and Orban, 1995; Fasuyi, 2007). Soaking in particular has been reported to be effective in reducing soluble anti-nutrients such as tannins and oxalates while preserving protein quality (Onwuka, 2005).

In addition to processing, dietary supplementation with organic acidifiers has gained considerable attention in poultry nutrition due to their beneficial effects on gut health, nutrient digestibility and growth performance. Organic acids such as citric, lactic, propionic and sorbic acids lower gastrointestinal pH, inhibit pathogenic microorganisms and enhance mineral absorption, thereby improving feed efficiency and overall performance (Dibner and Buttin, 2002; Adil *et al.,* 2010). The use of organic acidifiers is particularly valuable when feeding alternative plant ingredients that may otherwise compromise gut integrity and nutrient utilization.

Although several studies have evaluated unconventional plant feed resources in poultry diets, information on the combined use of processed *Balanites aegyptiaca* fruit meal and organic acid supplementation in broiler nutrition is scarce. Therefore, this study was designed to evaluate the effects of graded levels of soaked *Balanites aegyptiaca* fruit meal supplemented with an organic acidifier (Fysal®) on growth performance, feed utilization and economic efficiency of broiler chickens. The findings are expected to contribute to sustainable poultry feeding strategies through the utilization of locally available, non-conventional feed resources.

MATERIALS AND METHODS

Experimental Site

The experiment was carried out at the Teaching and Research Farm, in the Poultry Unit, of the Department of Animal Technology, Federal College of Forestry, Jos-Plateau state. The farm is located on latitude 9^0 56'49.0" N and longitude 8^0 53'34.1" E, at an altitude of 1250m above sea level. The temperature of the area ranges between 21-25°C depending on the season. The wet period in Jos is between April and

November with annual rainfall between 1200 – 1500mm (FCF, 2019).

Source of *Balanites aegyptiaca* Fruits
Raw *Balanites aegyptiaca* fruits were bought from Yandoya market in Jos metropolis, Plateau State.

Source of Organic Acid (Fysal®)
Organic acid (Fysal®) was sourced from commercial feed milling outlets in Zaria, Kaduna state. Fysal® contains a blend of acidifiers viz; sorbic, lactic, propionic, ascorbic and citric acids.

Source of Broiler Chicks
One hundred and eighty (180) broiler finisher chickens of Cobb-500 strain were sourced from Zartech hatchery located in Ibadan, Oyo state, Southwestern Nigeria.

Processing of *Balanites aegyptiaca* Fruits
Raw *Balanites aegyptiaca* fruits were processed using the soaking, boiling, roasting and soaking methods before dietary incorporation.

Boiling method
Four litres of water was poured in an aluminum pot and allowed to boil using gas cooker as source of heat. A batch of 300g of raw *Balanites aegyptiaca* fruits was poured into the boiling water and covered with a lid for 15 minutes. The water was drained and the fruits allowed to dry in a shade after which they were taken to the Biochemistry Laboratory of the Department of Animal Science, ABU Zaria to determine their proximate compositions according to procedures of A.O A.C (2005). Anti-nutritional factors in *Balanites aegyptiaca* fruits were also determined.

Roasting method
A batch of raw *Balanites aegyptiaca* fruits weighing 300g was put in an aluminum pot and heated using gas cooker as heat source. The duration of roasting was fifteen (15) minutes and the sample was routinely stirred to prevent charring. At the end of the roasting duration, the fruits were allowed to cool; they were then taken to the Biochemistry Laboratory of the Department of Animal Science, ABU Zaria to determine their proximate compositions according to procedures of A.O A.C (2005). Anti-nutritional factors in *Balanites aegyptiaca* fruits were also determined.

Soaking method
Four litres of water was poured in a plastic bowl and a batch of 300g of *Balanites aegyptiaca* fruit was poured and allowed to stand for 24 hours. The water was drained and fresh water of the same quantity replaced at regular intervals of 8 hours for the soaking duration (24 hours). At the end of the soaking durations the water was drained, dried in a shade and taken to the Biochemistry Laboratory of the Department of Animal Science, ABU Zaria to determine their proximate compositions according to procedures of A.O A.C (2005).

Determination of Anti-Nutritional Factors in Raw and Processed *Balanites aegyptiaca* Fruits
Samples of raw and differently processed *Balanites aegyptiaca* fruit were analysed for anti-nutritional factors at the Biochemistry Laboratory, Department of Animal Science, A.B.U. Zaria. The investigations carried out were the saponins, oxalate, phytic acid and tannic acid following well established analytical procedures.

Experimental Design and Management of Chickens
One hundred and eighty (180) finisher broiler chicks of Cobb-500 strain were used for the experiment. The chicks were weighed to obtain their initial weights and randomly allotted to four dietary treatments each replicated thrice with fifteen (15) chickens per replicate in a completely randomized design (CRD). The chickens were raised on deep litter with feed and water provided *ad libitum*. Management practices ideal for broiler chickens were strictly practiced. Parameters measured were: initial weight, final weight, weight gain and feed intake. Feed conversion ratio, and feed cost per kilogram gain were calculated, mortality was recorded as it occurred and the data was used to compute percentage mortality.

Experimental Diets
The processing method (soaking) which gave the best results in proximate composition (CP) and reduction of anti-nutritional factors was used to formulate the experimental diets for the feeding trial. Four broiler finisher diets were formulated to contain 0.0, 2.5, 5.0 and 7.5% inclusion levels of soaked *Balanites aegyptiaca* fruit meal (BAFM) in the control treatment (T_1), T_2, T_3 and T_4 respectively. Organic acid (Fysal®) was supplemented at the manufacture's recommendation of 100g/100kg diet in diets for treatments two to four (T_2, T_3, T_4). The ingredients composition of experimental broiler finisher diets are presented in Table 1.

Computation of Economic Benefit of Utilizing Soaked *Balanites aegyptiaca* Fruit Meal in Broiler Diets
At the end of the feeding trial, growth performance indices were pooled (0-8 weeks) and used for the computation of the economic benefit.

Data Analyses
Data obtained from the experiment was subjected to analysis of variance using the general linear model procedure of SAS (2001). Significant differences among treatment means was also separated using Duncan's Multiple Range Test, Duncan (1955).

Table 1: Composition of Broiler Finisher Diets Containing Graded Levels of Soaked *Balanites aegyptiaca* Fruit Meal Supplemented with Organic Acid (Fysal®)

Ingredients	Control	Levels of BAFM (%)		
		2.5	5.0	7.5
Maize	68.70	67.00	64.70	61.35
Soya cake	17.50	17.50	17.50	17.50
GNC	5.30	4.20	3.80	1.00
Blood meal	3.50	3.60	3.40	4.40
Bone meal	2.90	2.95	2.95	2.95
Limestone	1.10	1.10	1.10	1.10
BAFM	0.00	2.50	5.00	7.50
Salt	0.30	0.30	0.30	0.30

*Vitamin Premix	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20
Maize offal	0.05	0.20	0.60	3.25
*Fysal®	0.00	0.10	0.10	0.10
Total	100.00	100	100	100
Calculated analysis				
ME (Kcal/Kg)	3015.00	3018.00	3016.00	3012.00
Crude Protein (%)	19.25	19.21	19.21	19.25
Ether Extract (%)	4.10	4.19	4.30	4.31
Crude Fibre (%)	3.29	3.35	3.46	3.65
Calcium (%)	1.21	1.22	1.22	1.22
Available Phosphorus (%)	0.50	0.50	0.50	0.50
Lysine (%)	1.18	1.17	1.14	1..17
Methionine (%)	0.77	0.76	0.74	0.73
Feed cost/kg diet (₦/kg)	112.43	111.61	110.99	108.86

*Biomix chick premix provide per kg of diet vit A, 10,000 I.U; vit D, 2000 I. U; vit E; 23mg; vit K, 2mg; calcium pantothenate, 7.5mg; B12, 0.015mg; folic acid, 0.75mg, choline chloride, 300mg; vit B1, 1.8mg; vit B2, 5mg; vit B6, 3mg; manganese, 40mg; iron, 20mg; zinc, 53.34mg; copper, 3mg; iodine, 1mg; cobalt, 0.2mg; selenium, 0.2mg; zinc, 30mg. ** FYSAL® contains a blend of acidifiers viz; sorbic, lactic, propionic, ascorbic and citric acids; it is supplemented at 0.1%. BAFM= *Balanites aegyptiaca* fruit meal.

RESULTS AND DISCUSSION

Proximate Composition of Raw and Processed *Balanites aegyptiaca* Fruits

The proximate composition of raw and differently processed *Balanites aegyptiaca* fruits is presented in Table 2. Processing methods markedly influenced the nutrient composition of the fruits. Dry matter content ranged from 90.26% in boiled fruits to 93.29% in roasted fruits, with soaked fruits recording 91.93%, comparable to the raw sample (91.35%). Crude protein content increased with processing, with soaked fruits having the highest crude protein value (20.01%), followed by roasted (19.51%) and boiled samples (19.37%), compared to the raw fruits (18.98%). Ether extract content was highest in the raw fruits (10.98%) and reduced substantially by processing, particularly boiling (7.96%) and roasting (7.70%), while soaked fruits recorded an intermediate value (8.26%).

Crude fibre content was highest in the raw fruits (9.41%) and was markedly reduced by all processing methods, with boiled fruits recording the lowest value (5.10%). Ash content also decreased with processing, ranging from 8.00–8.15% in roasted and boiled fruits, compared to 9.56% in raw fruits. Nitrogen free extract increased following processing, with roasted fruits having the highest value (52.16%), while soaked and boiled fruits recorded similar values (49.66 and 49.68%, respectively), compared to 42.42% in raw fruits. Overall, soaking for 24 hours produced the most favourable balance of increased crude protein and reduced fibre content, justifying its selection for diet formulation in the feeding trial.

Table 2: Proximate Composition of Raw and Differently Processed *Balanites aegyptiaca* Fruits

Parameters	Composition of Raw and Processed BAFM (%)			
	Raw	Boiled15mins	Roasted15mins	Soaked24hrs
Dry Matter	91.35	90.26	93.29	91.93
Crude Protein	18.98	19.37	19.51	20.01
Ether Extract	10.98	7.96	7.70	8.26
Crude Fibre	9.41	5.10	5.92	5.90
Ash	9.56	8.15	8.00	8.10
Nitrogen Free Extract	42.42	49.68	52.16	49.66

%= Percentage

Anti-Nutritional Factors in Raw and Differently Processed *Balanites aegyptiaca* Fruits

The concentrations of tannin, phytic acid, saponins and oxalate in raw and processed *Balanites aegyptiaca* fruits are presented in Table 3. All processing methods reduced the levels of the anti-nutritional factors compared to the raw fruits, although the magnitude of reduction varied with the method. Tannin content was highest in the raw fruits (0.91%) and was most effectively reduced by soaking for 24 hours (0.29%), representing a 68.13% reduction. Roasting and boiling resulted in moderate reductions of 20.88 and 9.89%, respectively. Phytic acid content was reduced from 7.00% in raw fruits to 4.34% in soaked fruits (38.00% reduction), 3.43% in roasted fruits (51.00% reduction) and 4.34% in boiled fruits (38.00% reduction). Roasting was therefore the most effective method for reducing phytic acid content.

Saponin concentration decreased from 8.70% in the raw fruits to 6.90% in soaked and boiled fruits, representing a 20.69% reduction, while roasting resulted in a reduction to 7.20% (17.24% reduction). Oxalate content was markedly reduced by soaking, from 129.8 mg/100 g in raw fruits to 33.00 mg/100 g, corresponding to a 74.58% reduction. Boiling also reduced oxalate content to 107.8 mg/100 g (16.95% reduction), while roasting had minimal effect, reducing oxalate to 121.0 mg/100 g (6.78% reduction). Among the processing methods, soaking for 24 hours consistently produced the greatest overall reduction in anti-nutritional factors, particularly tannin and oxalate, while maintaining improved proximate composition.

Table 3: Anti-nutritional Factors in Raw and Differently Processed *Balanites aegyptiaca* Fruits

Parameters	Raw	Soaked 24 hours	% Red	Roasted 15 mins	% Red	Boiled 15 mins	% Red
Tannin	0.91	0.29	68.13	0.72	20.88	0.82	9.89
Phytic acid	7.00	4.34	38.00	3.43	51.00	4.34	38.00
Saponins	8.70	6.90	20.69	7.20	17.24	6.90	20.69
Oxalate (mg/100)	129.8	33.00	74.58	121.00	6.78	107.8	16.95

%Red= Percentage reduction

Performance of Broiler Finisher Chickens Fed Diets Containing Soaked *Balanites aegyptiaca* Fruit Meal with Organic Acid Supplementation (5-8weeks)

The growth performance of broiler finisher chickens fed diets containing graded levels of soaked *Balanites aegyptiaca* fruit meal supplemented with organic acid is presented in Table 4. Final body weight was significantly (P<0.05) influenced by dietary treatments. Broiler chickens fed 5.0% BAFM attained the highest final weight, which was significantly higher than those fed the control and 2.5% BAFM diets but comparable (P>0.05) to birds fed 7.5% BAFM. Weight gain did not differ significantly (P>0.05) among the treatments, although birds fed 5.0% BAFM recorded numerically higher weight gain compared with the other dietary groups. Feed intake showed no significant (P>0.05) difference across all dietary treatments. Similarly, feed conversion ratio was not significantly (P>0.05) affected by the inclusion levels of soaked BAFM, although birds fed 5.0% BAFM exhibited a numerically better feed conversion ratio than those in the other treatments. Feed cost per kilogram weight gain was numerically lowest in birds fed 5.0% BAFM and highest in the control group; however, this parameter was not statistically analysed. Mortality was not recorded in any of the treatments throughout the finisher phase of the experiment. Overall, inclusion of soaked *Balanites aegyptiaca* fruit meal up to 7.5% with organic acid supplementation had no adverse effect on growth performance of broiler finisher chickens, with 5.0% inclusion showing the most favourable numerical performance indices.

Table 4: Growth Performance of Broiler Finisher Chickens Fed Diets Containing Soaked *Balanites aegyptiaca* Fruit Meal with Organic Acid Supplementation (5-8 weeks)

Parameters	Control	Levels of BAFM (%)			SEM	LOS
		2.5	5.0	7.5		
Initial weight (g/bird)	605.09^{b}	639.29^{b}	842.86^{a}	762.92^{a}	61.55	*
Final weight (g/bird)	1341.27^{b}	1440.55^{b}	1703.33^{a}	1604.17^{ab}	110.68	*
Weight gain (g/bird)	736.18	801.27	860.48	841.25	62.36	N/S
Feed intake (g/bird)	2245.73	2349.86	2247.65	2364.13	59.43	N/S
Feed conversion ratio	3.10	2.94	2.64	2.86	0.23	N/S
Feed cost/kg gain(N/kg)	348.53	328.13	293.01	311.34	0.00	NA
Mortality (%)	0.00	0.00	0.00	0.00	0.00	-

a, b=Means with different superscript on the same row differ significantly (P<0.05), SEM= Standard error of mean g/bird= gram per bird, LOS= Level of significance, %= Percentage, NA= Not Analysed, ₦/kg= Naira per kilogram, BAFM= *Balanites aegyptiaca* fruit meal, N/S= No significant difference

Economic Benefit of Utilizing Soaked *Balanites aegyptiaca* Fruit Meal with Acidifier Supplementation in Broiler Diets

Economic benefit of utilizing soaked *Balanites aegyptiaca* fruit meal with acidifier supplementation in broiler diets is presented in Table 5. Total feed intake increased slightly with increasing levels of BAFM inclusion, ranging from 3.01 kg in the control group to 3.26 kg in birds fed 7.5% BAFM. Despite the increase in feed intake, feed cost per kilogram of diet decreased progressively as the level of BAFM increased, with the lowest feed cost (₦213.55) recorded in birds fed 7.5% BAFM and the highest (₦219.46) in the control group. Total feed cost followed a similar trend, with values ranging from ₦659.84 in the control group to ₦695.46 in birds fed 7.5% BAFM, reflecting the higher total feed intake at increased inclusion levels. Total weight gain was highest in birds fed 5.0% BAFM (1.66 kg), followed by those fed 7.5% BAFM (1.56 kg), while the control group recorded the lowest weight gain (1.30 kg).

Feed cost per kilogram gain decreased markedly with increasing inclusion of BAFM up to 5.0%, where the lowest value (₦419.78/kg) was obtained, indicating superior economic efficiency. Birds fed 7.5% BAFM recorded a slightly higher feed cost per kilogram gain (₦451.30/kg) but still showed improved cost efficiency compared with the control (₦515.00/kg) and 2.5% BAFM (₦497.49/kg) diets. Overall, inclusion of soaked *Balanites aegyptiaca* fruit meal in broiler diets, particularly at the 5.0% level with acidifier supplementation, enhanced economic returns by reducing feed cost per unit gain, thereby demonstrating its potential as a cost-effective alternative feed ingredient in broiler production.

Table 5: Economic Benefit of Utilizing Soaked *Balanites aegyptiaca* Fruit Meal with Acidifier Supplementation in Broiler Diets

Parameters	Control	Levels of BAFM (%)		
		2.5	5.0	7.5
Total Feed Intake (kg)	3.01	3.18	3.17	3.26
Feed Cost (₦)	219.46	217.88	216.38	213.55
Total Feed Cost (₦)	659.84	692.13	686.64	695.46
Total Weight gain (kg)	1.30	1.40	1.66	1.56
Feed cost/Gain (₦/kg)	515.00	497.49	419.78	451.30

SEM= Standard error of mean, BAFM= *Balanites aegyptiaca* fruit meal, kg= Kilogram, ₦= Naira, ₦/kg= Naira per kilogram

Discussion

The influence of processing techniques (soaking, boiling and roasting) on BAFM affirmed that traditional processing can enhance the nutritive value of underutilized feed resources for poultry diets. Improvements in protein content following processing have been reported for other plant materials such as Cassia *tora* seeds and bambara nut, where boiling and other treatments increased protein availability by reducing interfering compounds (anti-nutrients) according to reports by Assam *et al*. (2024) and Bala and Rano (2025). The reduction in ether extract following processing, particularly boiling and roasting, may reflect leaching and thermal degradation of lipids, as similarly observed in processed sorghum and other oilseed by-products where heat treatment reduced fat content (Zhou *et al*., 2024). Additionally, crude fibre was substantially lowered by processing, with boiled fruits having the lowest fibre content, likely improving digestibility for monogastric animals. This trend aligns with earlier reports that soaking or thermal treatments disrupt cell wall components, thereby reducing fibrous fractions of seeds and fruits (Abdullahi *et al*., 2018). Processing also reduced ash content when compared to raw fruits. This may be attributable to leaching of mineral constituents into soaking or processing water, a phenomenon documented in studies of other legumes and seeds where minerals are partially lost during wet processing (Abdullahi *et al*., 2018). Elevated nitrogen free extract (NFE) in processed samples suggests enhanced carbohydrate availability, possibly due to the breakdown of complex carbohydrates during thermal or soaking treatments, corroborating previous findings on the effects of processing on seed nutrients (Bala and Rano, 2025).

A major goal of processing is to reduce anti-nutritional factors (ANFs) that can impair feed utilization. Soaking for 24 hours was most effective in lowering tannin content which was consistent with the findings of Abdullahi *et al.* (2018). Tannins are known to bind dietary proteins and reduce digestibility, but their reduction through wet processing has been widely reported for plant meals used in animal feeds (Maidala *et al*., 2013). The lowering of phytic acid by soaking, boiling and roasting underscored the efficacy of processing for enhancing feed quality (Idris *et al*., 2019). The lowering of saponins and oxalates in response to the various processing methods was beneficial as the compounds could form insoluble complexes with divalent cations like calcium, impairing mineral bioavailability (Woyengo and Nyachoti, 2013). Overall, the results demonstrate that processing, particularly soaking, effectively improved the proximate nutrient profile and reduced anti-nutritional factors in *Balanites aegyptiaca* fruits. These changes are important for formulating nutritionally balanced and safe broiler diets. Reducing ANFs such as tannin, phytic acid and oxalate is crucial for enhancing nutrient digestibility and animal performance, as unprocessed plant meals can otherwise limit growth and feed efficiency according to (Abdullahi *et al*., 2025).

The best final weight by birds fed 5.0 and 7.5% BAFM indicated improved utilization of the diets. According to reports by Maneemagalai and Reena (2011) and Muhammad *et al*. (2018) BAFM contains a more balanced array of amino acids compared to groundnut cake. In this study, BAFM replaced groundnut cake in the diets at varied levels up to 7.5%, thus indicating the reason for improved final weight. Adil *et al*. (2011a) and Brzoska *et al*. (2013) reported that organic acid supplementation in broiler diets improved utilization of feedstuffs. It is possible that the acidifier supplementation worked in consonance with the improved nutritive value of BAFM over groundnut cake leading to increased final weight from 2.5 to 7.5% levels of BAFM inclusion. Although not significantly different, feed intake and feed conversion ratio improved in numerical values in chickens fed BAFM based diets with acidifier supplementation compared to the control group. Ogori *et al*. (2019) and Annongu *et al*. (2009) found significant effect of processed BAFM on weight gain, feed intake and FCR of rabbits and pigs respectively. Their reports showed that these parameters improved up to the highest inclusion levels in both pigs and rabbits. Feed cost per kilogram gain was highest in chickens fed the control diet (₦348.53) compared to the diets containing BAFM (₦293.01-328.13). Overall, inclusion of soaked BAFM in broiler diets with acidifier supplementation, enhanced economic returns by reducing feed cost per unit weight gain, thereby demonstrating its potential as a cost-effective alternative feed ingredient in broiler production. The absence of mortality across all treatments further indicated that soaked BAFM supplemented with organic acid is safe for broiler finisher chickens. Organic acids such as citric, lactic and propionic acids have been reported to enhance gut health, suppress pathogenic microorganisms and improve nutrient absorption, thereby supporting stable growth and survivability in poultry (Dibner and Buttin, 2002; Ricke, 2003).

The economic benefit revealed that increasing levels of soaked *Balanites aegyptiaca* fruit meal in broiler diets resulted in reduced feed cost per kilogram of diet, reflecting the economic advantage of substituting conventional feed ingredients with locally available and nutritive plant resources. Feed cost decreased progressively from the control to the 7.5% BAFM diet, highlighting the potential of *Balanites aegyptiaca* fruit meal as a cost-effective alternative energy and protein source. Total feed intake increased slightly with increasing BAFM inclusion, which may be attributed to improved palatability and gut stimulation associated with organic acid supplementation. Organic acids have been reported to enhance feed intake by improving digestive efficiency and gut environment (Upadhaya *et al*., 2016; Ricke, 2003). Despite the increase in feed intake, birds fed

5.0% BAFM recorded the highest total weight gain, indicating more efficient conversion of feed into body tissue.
Feed cost per kilogram gain was lowest in birds fed 5.0% BAFM, demonstrating superior economic efficiency at this inclusion level. This suggests that the improved growth performance observed at 5.0% inclusion translated directly into reduced production cost per unit of weight gain. Similar findings have been reported in broiler studies involving processed unconventional feed ingredients, where optimal inclusion levels reduced feed cost without compromising performance (Adeniji, 2007; Zahraddeen *et al*., 2019). Although birds fed 7.5% BAFM recorded a slightly higher feed cost per kilogram gain than those fed 5.0%, the value was still lower than that of the control diet. This indicated that higher inclusion levels remain economically beneficial, even if marginal reductions in efficiency occur. The overall trend supports the use of soaked *Balanites aegyptiaca* fruit meal as a viable strategy for reducing feed cost, which accounts for over 60–70% of total poultry production expenses (FAO, 2013).

CONCLUSION

Conclusively, as much as poultry production remains one of the most efficient means of meeting the growing global demand for animal protein, there exist a justification that the influence of processing techniques (soaking, boiling and roasting) on BAFM affirmed that traditional processing can enhance the nutritive value of underutilized feed resources for poultry diets. Improvements in protein content following processing have been reported for other plant materials such as Cassia *tora* seeds and bambara nut, where boiling and other treatments increased protein availability by reducing interfering compounds (anti-nutrients). The reduction in ether extract following processing, particularly boiling and roasting, may reflect leaching and thermal degradation of lipids, as similarly observed in processed sorghum and other oilseed by-products where heat treatment reduced fat content.

REFERENCES

Abdullahi, A. Y., Orijajogun, J. O. and Adeyemi, K. D. (2016). Nutritional evaluation of *Balanites aegyptiaca* fruit meal as a potential feed ingredient for livestock. *Nigerian Journal of Animal Science*, 18(2): 45–54.

Abdullahi, I., Omage, J. J., Abeke, F. O., Onimisi, P. A. and Idachaba, C. U. (2018). Performance of broiler chickens fed diets containing differently processed desert date (*Balanite aegyptiaca)* fruit meal. *Journal of Animal Production Research,* 30(2): 10-21.

Abdullahi, I., Idachaba, C. U., Joseph, I., Adeniyi, A. K. and Kurdor, P.N. (2025). Effect of processing of sweet potato peel on its compositional analysis, nutrient inhibitor components and growth metrics by broiler finisher chickens. *Dutse Journal of Pure and Applied Sciences*, 11(2c): 149-157.

Adeola, O. and Orban, J. I. (1995). Chemical composition and nutrient digestibility of processed jackbean (*Canavalia ensiformis*) meals in rats and pigs. *Journal of Animal Science*, 73: 353–360.

Adeniji, A. A. (2007). Effect of replacing groundnut cake with maggot meal in the diet of broilers. *Journal of Poultry Science*, 44(2): 154–158.

Adil, S., Banday, T., Bhat, G. A., Mir, M. S. and Rehman, M. (2010). Effect of dietary supplementation of organic acids on performance, intestinal histomorphology, and serum biochemistry of broiler chicken. *Veterinary Medicine International*, 20: 479-485.

Adil, S., Banday, M. T., Bhat, G. A., Qureshi, S. D. and Wani, S. A. (2011). Effect of supplemental organic acids on growth performance and gut microbial population of broiler chicken. *Livestock Research for Rural Development*, 23(1):23-41.

Annongu, A.A., Daramola, J. O., Joseph, J. K. and Adeyina, A. O. (2009). Influence of Dietary Processed Nigeria Fruits on Some Biochemical, Haematological and Physiological Indices in Swine. *Journal of Agricultural Science and Environment*, 9(2):34-44.

AOAC (2005). Official Methods of Analysis. 18th Ed., Association of Official Analytical Chemists, Washington, DC, Method 935.14 and 999.24.

Assam, E. D., Ndelekwute, E. K., Demo, K. and Ukachukwu, S. N. (2024). Effect of boiling on proximate composition, mineral and antinutritional factors of Cassia tora seeds for poultry feed production. *Nigerian Journal of Animal Production*, 2(1):13-20.

Bala, K. S. and Rano, M. B. (2022). Influence of processing method on the proximate composition and anti-nutrient content of Bambara nut (*Vigna subterranea L.*). *Nigerian Journal of Animal Science and Technology*, 5(2): 92–98.

Chothani, D. L. and Vaghasiya, H. U. (2011). A review on *Balanites aegyptiaca* Del (desert date): Phytochemical constituents, traditional uses, and pharmacological activity. *Pharmacognosy Reviews*, 5(9): 55–62.

Dibner, J. J. and Buttin, P. (2002). Use of organic acids as a model to study the impact of gut microflora on nutrition and metabolism. *Journal of Applied Poultry Research*, 11: 453–463.

Duncan, D. B. (1955). Multiple Ranges and Multiple F. Test Biometrics. New York: McGraw Hill Higher Education.

FAO. (2013). *Poultry development review*. Food and Agriculture Organization of the United Nations, Rome.

Fasuyi, A. O. (2007). *Amaranthus cruentus* leaf meal as a protein supplement in broiler finisher diets: Performance and digestibility. *African Journal of Biotechnology*, 6(10): 1272–1276.

FCF. (2019). Federal College of Forestry, Jos, Plateau, Nigeria. Retrieved from: https://vymaps.com/NG/Federal-College-of-Forestry-Jos-863074820376415/

Francis, G., Makkar, H. P. S. and Becker, K. (2002). Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. *Aquaculture*, 199: 197–227.

Idris, S., Yisa, J. and Ndamitso, M. M. (2019). Chemical composition and anti-nutritional factors of *Balanites aegyptiaca* fruits and seeds. *Asian Journal of Biotechnology and Bioresource Technology*, 5(4): 1–8.

Maidala, A., Doma, U. D., Egwim, E. C. and Adeyemi, H. A. (2013). Effects of processing methods on the nutrient

composition and anti-nutritional factors of *Balanites aegyptiaca* seeds. *Pakistan Journal of Nutrition*, 12(7): 638–642.

Makkar, H. P. S. (2003). Anti-nutritional factors in foods for livestock. FAO Animal Production and Health Paper No. 174. FAO, Rome.

Maneemegalai, S. and Reena, P. (2011). Evaluation of amino acid composition and protein solubility profile of commercially available sesame and groundnut seed meat. *Asia Journal of Food Agro-Industry*, 4(3): 161-166.

Muhammad, I.U., Alhassan, A.J., Ramatu, Y., Mohammad, A., Nasir, A., Yaradua, A.I., Alexander, I., Umar, Y. and Ezema, M.D. (2018). Amino Acid Profile and Mineral Content of *Balanites aegyptiaca* Kernel. *Asian Journal of Applied Chemistry Research,* 1(4): 1-7

Onwuka, G. I. (2005). *Food analysis and instrumentation: Theory and practice*. Naphtali Prints, Lagos, Nigeria.

Onyimonyi, A. E. and Okeke, G. C. (2007). Assessment of the practical potential of *Moringa oleifera* leaf meal in broiler diets. *Journal of Poultry Science*, 44: 113–120.

Ravindran, V. (2013). Poultry feed availability and nutrition in developing countries. In: *Poultry development review*. FAO, Rome.

SAS (2001). SAS User's Guide. Version 6.11, SAS Institute, Inc. Cary, NC.

Ricke, S. C. (2003). Perspectives on the use of organic acids and short chain fatty acids as antimicrobials. *Poultry Science*, 82: 632–639.

Upadhaya, S. D., Kim, I. H. and Neupane, P. (2016). Effect of organic acids on growth performance, nutrient digestibility and gut health in broiler chickens. *Journal of Animal Science and Biotechnology*, 7: 1–9.

Woyengo, T. A. and Nyachoti, C. M. (2013). Anti-nutritional effects of phytic acid in diets for pigs and poultry. *Canadian Journal of Animal Science*, 93(1): 9–21.

Zahraddeen, D., Umar, A. and Ibrahim, H. (2019). Economic effects of replacing fish meal with maggot meal in broiler chicken diets. *Nigerian Journal of Animal Production*, 46(1): 123–131.