Evaluation of White Sorghum Soaked in Wood Ash Extract on Apparent Nutrient Digestibility of Pullets Growers and Egg Qualities (External and Internal) of Laying Birds

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Abstract
This study evaluated the feeding value of graded levels of white sorghum soaked in wood ash extract on apparent nutrient digestibility in growing pullets and egg quality traits of laying birds. The experiment was conducted at the Livestock Teaching and Research Farm, Poultry Unit, Faculty of Agriculture, Ambrose Alli University, Ekpoma, Edo State, Nigeria, over 38 weeks. A total of 144 day-old pullets from a reputable hatchery were brooded and reared on deep litter. At 36 birds per treatment, they were randomly assigned to four dietary treatments in a completely randomized design (CRD), with each treatment replicated three times of 12 birds. All apparent nutrient digestibility parameters were significantly affected by dietary treatments ($P < 0.05$). Birds fed T3 recorded the highest crude protein digestibility at 80.41% and crude fiber digestibility at 64.80%. Ether extract digestibility was highest in T1 at 87.83%, while ash digestibility peaked in T4 at 87.10%. Nitrogen-free extract digestibility was highest in T2 at 82.65%. For egg quality, dietary treatments significantly influenced most parameters except egg length, shell weight, yolk weight, albumen weight, and yolk colour ($P > 0.05$). Egg weight was highest in T2 at 56.32 g. Egg breadth was highest in T2 at 3.56 mm, while egg shape index was highest in T3 at 0.72. Shell thickness was greatest in T4 at 0.38 mm. Albumen height and Haugh unit, indicators of internal egg quality, were highest in T3 at 6.88 mm and 90.59 respectively. Yolk colour was lowest in T3 and highest in T1. Conclusively, soaking white sorghum in wood ash extract improved nutrient utilization and egg quality, with treatment effects varying by parameter. T3 gave superior protein and fiber digestibility, albumen height, and Haugh unit, while T2 optimized egg weight and breadth. Recommendations: Wood ash extract soaking is an effective, low-cost, traditional method for reducing anti-nutritional factors in white sorghum for poultry diets. Inclusion of the T3 level of treated sorghum is recommended to maximize nutrient digestibility and internal egg quality in layers. Farmers and feed millers in sorghum-producing areas should adopt wood ash treatment to reduce feed cost and

DOI: https://doi.org/10.5281/zenodo.21618300

dependence on maize while maintaining performance. Further studies should determine the optimal soaking duration/concentration and assess long-term effects on hen longevity and profitability.

Key words: Grower pullets, layers, white sorghum, soaked, wood ash extract and maize

1.0 Introduction

The poultry industry continues to expand globally, intensifying demand for energy and protein-rich feed ingredients (Hussain *et al.*, 2023). Sorghum is emerging as a viable alternative to maize due to its relatively stable energy content and favorable price (Robertson & Perez-Maldonado, 2006). However, the presence of anti-nutritional factors such as tannins and phytic acid in sorghum limits its utilization in poultry diets. These compounds form complexes with dietary protein and minerals in the gastrointestinal tract, thereby reducing apparent nutrient digestibility, depressing feed intake, impairing growth of pullets, and compromising egg production and egg quality in laying birds (Avila *et al.,* 2021; Selle *et al.,* 2010a).

Various processing methods have been explored to reduce tannin and phytate levels in sorghum. Alkaline treatment using wood ash extract, a traditional and low-cost method, has shown potential to hydrolyze tannins and phytates, thus improving nutrient availability without introducing synthetic chemicals (Moritz *et al.,* 2023). If effective, this treatment could enhance the apparent nutrient digestibility of white sorghum for growing pullets and subsequently improve egg quality traits in laying birds.

Egg consumption and production have continued to rise globally to meet increasing protein demand (Conrad *et al.*, 2017; OECD/FAO, 2021). As a result, layer farmers are under pressure to optimize feed resources that will sustain egg production, improve egg quality, and extend hen longevity while maintaining profitability. Evaluating locally processed feed ingredients such as wood ash extract-soaked white sorghum therefore becomes critical for sustainable poultry production. Consequently, this study was designed to evaluate the effect of white sorghum soaked in wood ash extract on apparent nutrient digestibility of pullet growers and on egg quality parameters of laying birds.

2. Materials and methods

2.1 Experimental site

The feeding trial comprised of the growing and laying phases of birds was carried out in the Livestock Teaching and Research Farm's Poultry Unit, Faculty of Agriculture, Ambrose Alli University Ekpoma, Esan West Local Government Area of Edo State, Nigeria. Located in Nigeria's tropical derived savannah rain forest vegetation area between longitudes 6.440N and 6.080NE, with a mean ambient temperature ranging from 260°C in December to 340°C in February and an average relative humidity of 61 percent in January and 92 percent in August.

2.2 Experimental diets

Four experimental pullet growers and layers diets were formulated, diet one (1) contained 100 percent maize (control), while diets 2, 3, and 4 substituted the percentage proportion of maize with white sorghum soaked in wood ash extracts at levels of 25, 50, and 75 (%) respectively. Diets were iso-nitrogenous and iso-caloric as revealed in Tables 1 and 2.

Table 1. Composition of Experimental grower diets (9-18weeks) fed graded level of white
Sorghum soaked in wood ash extract

Inclusion Levels of Sorghum %				
	0	**25**	**50**	**75**
Diets				
Ingredients (%)	**1**	**2**	**3**	**4**
Maize	45.00	33.75	22.50	11.25
Sorghum	0.00	11.25	22.50	33.75
Soya bean meal	14.00	14.00	14.00	14.00
Groundnut cake	4.45	4.45	4.45	4.45

DOI: https://doi.org/10.5281/zenodo.21618300

Wheat offal	30.00	30.00	30.00	30.00
Limestone	3.00	3.00	3.00	3.00
Bone meal	3.00	3.00	3.00	3.00
Salt	0.30	0.30	0.30	0.30
Biomix (grower)	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Calculated analysis (%)				
Crude protein	14.50	14.50	14.50	14.50
Crude fiber	5.00	5.00	5.00	5.00
Ether extract	4.00	4.00	4.00	4.00
Calcium	1.20	1.20	1.20	1.20
ME (Kcal/kg)	2500.00	2500.00	2500.00	2500.00

Premix grower: Vitamin A, 12,000,000 IU; Vitamin D3 2,000, 000 IU; Vitamin E 7,00 IU; Vitamin B12 10 mg; Nicotinic acid 15,000 mg; Calcium d-pentothenate 8,000 mg; Biotin 40 mg; Vitamin B12 10 mg; Min 20,000 mg; Fe 50,000 mg; Zn 100,000 mg; Cu 10,000 mg; Iodine 750mg; Co 3000 mg

Table 2: Composition of Experimental layer diets (19-34weeks) fed graded level of white sorghum soaked in wood ash extract.

	Inclusion Levels of Sorghum (%)			
	0	**25**	**50**	**75**
	Diets			
Ingredients (%)	**1**	**2**	**3**	**4**
Maize	**56.00**	**42.00**	**28.00**	**14.00**
Sorghum	**0.00**	**14.00**	**28.00**	**42.00**
Soya bean meal	**22.00**	**22.00**	**22.00**	**22.00**
Fish meal	**2.00**	**2.00**	**2.00**	**2.00**
Wheat offal	**9.50**	**9.50**	**9.50**	**9.50**
Limestone	**6.95**	**6.95**	**6.95**	**6.95**
Bone meal	**3.00**	**3.00**	**3.00**	**3.00**
Salt	**0.30**	**0.30**	**0.30**	**0.30**
Biomix (layers)	**0.25**	**0.25**	**0.25**	**0.25**
Total	**100.00**	**100.00**	**100.00**	**100.00**
Calculated analysis (%)				
Crude protein	**17.00**	**17.00**	**17.00**	**17.00**
Crude fiber	**6.00**	**6.00**	**6.00**	**6.00**
Ether extract	**5.00**	**5.00**	**5.00**	**5.00**
Calcium	**3.50**	**3.50**	**3.50**	**3.50**
ME (Kcal/kg)	**2600.00**	**2600.00**	**2600.00**	**2600.00**

Bio Mix Layer premix supplied the following per 100kg of diet: Vitamin A, 850,000 I.U; Vitamin D3 150,000 I.U; Vitamin E, 1,000 I.U; Vitamin K, 1000 mg; Thiamin (B1), 150 mg; Riboflavin (B2), 450 mg; Pyridoxine (B6), 300 mg; Niacin, 1500mg; Vitamin B12 1.5mg; Pantothenic acid, 450mg; Folic acid, 60mg; Biotin, 50mg; Choline chloride, 17,500mg; Anti-oxidant, 125mg; Manganese, 4000mg;, metabolizable energy; Ca, calcium; P, phosphorus; C.F, crude fiber.

2.3 Birds management and experimental design

A total of 144 day-old points of lay were carried over from points of cage, birds were fed growers marsh till five percent (5%) egg droppings were observed, thereafter, layers mash was introduced to the birds. Thirty six

DOI: https://doi.org/10.5281/zenodo.21618300

(36) birds each were randomly selected, weighed and allocated to each of the four treatment diets (1, 2, 3, and 4) in a completely randomized designed (CRD). Each treatment group was divided into three duplicates of 12 birds each. The birds were reared on deep litters system and fed experimental diets (1, 2, 3 and 4). All recommended health routine practices was strictly observed.

2.4 Data collections

2.4.1 Apparent nutrients digestibility

At sixteen (16) weeks of the study, one (1) per replicate was randomly picked and transferred to the digestibility cages for digestibility study. The birds were fed a known quantity feed per day; data was not collected for the first four days of the birds in the metabolic cages while data (feaces) was collected on the 5^{th}, 6^{th} and 7^{th} days of the finding, and transferred to the oven until uniform drying was obtained. Thereafter, samples were taken to the laboratory for assay. Parameters analyzed were crude protein, crude fibre, ether extract, and nitrogen free extract.

2.4.2 External egg qualities

Egg weight (Ew) was determined with a sensitive scale to the nearest 0.00g. Egg Length and width were measured with electronic digital vernier calliper. Shell weight: Shells were dried in the air for 3 days before weighing in a determine balance and expressed as percentage of shell weight.

$$shell\,\% = \frac{shell\ \ weight}{egg\ weight} \times \frac{100}{1}$$

The shell thickness was measured to the closest 0.01mm using a micrometre screw gauge.

2.4.3 Internal egg qualities:

Albumen Height: Measured of the chalaza at a part above midway between the inner and outer circumference of the thick white. Haugh Unit (Hu) = 100 $\log_{10}$ (h -$1.7^{w0.37}$ + 7.6)
Where HU = Haugh unit, h = observed height of the albumen in mm, W = weight of egg in g. The HU value normally ranges from 0-130 and can be ranked as follows:
AA: 72 or more; A: 71 – 60;
B: 59 – 31; C: 30 or less
Albumen weight $_{(g)}$ = Egg weight – (yolk weight + Egg shell weight). Yolk weight was measured on a sensitive scale, and expressed as percentage of the egg weight

i.e. $$yolk\,\% = \frac{yolk\ \ weight}{egg\ weight} \times \frac{100}{1}$$

Yolk index = Ratio of yolk height/thickness
In the process of estimating egg shell thickness and weight, the following factors were investigated: egg surface area, egg contents, egg volume, egg shell weight per unit area, and shell percentage.
These variables were calculated using the following formulas:
Egg surface area (ESA) =3.9782W0.7056 (Carter, 1974) W=egg weight
(b) Egg contents (EC) = egg weight (W)-shell weight (SW) (Narushin, 1977; Arad and Marder,1982.).
(c)Egg volume = aWb where a= 0.7608 (constant), b = 1.0474 (constant),
w = egg weight(Carter, 1974). (d) Shell percentage =SW/EG * 100/1 (e) shell weight per unit surface area (SWUSA) = SW/ESA (e) Egg mass output =% egg production * egg weight (Phiriyane, 2011).

2.5 Statistical analysis

The results obtained were subjected to a one-way analysis of variance (ANOVA). All statistical procedures were according to SAS, 2003. Differences between mean were separated using Duncan’s Multiple Range Test (DMRT) at 5% level of probability.

3.0 Results and discussion

3.1Results of apparent nutrient digestibility of pullets (9-18weeks) fed graded levels of sorghum soaked in wood ash extract

Table 3 shows the apparent nutrient digestibility of pullets growers fed diets containing graded levels of sorghum soaked in wood ash extract (SWA). Except for dry matter, all apparent nutrient digestibility parameters were significantly influenced by dietary treatments ($P < 0.05$).
Crude protein (CP) digestibility was significantly ($P<0.05$) highest (80.41%) in birds fed T3 and was comparable to that of birds fed T2 (79.45%). Birds fed T4 (78.89%) and T1 (78.76%) had lower values, with T4 being statistically similar to T2. Crude fiber digestibility was also significantly ($P<0.05$) highest (64.80%) in birds fed T3 and was comparable to T4 (63.49%). Birds fed T1 had an intermediate value (62.30%), while the

DOI: https://doi.org/10.5281/zenodo.21618300

lowest digestibility was recorded in T2 (59.37%). Ether extract (EE) digestibility was highest in birds fed T1 (87.83%; P < 0.05), followed by T4 (79.51%). T2 (79.43%) and T3 (78.40%) had comparable values. Ash digestibility was P<0.05 highest (87.10%) in birds fed T4, followed by T3 (79.77%), which was comparable to T2 (79.27%). The lowest value was obtained in birds fed T1 (77.67%). Nitrogen-free extract (NFE) digestibility was significantly higher in birds fed T2 (82.65%; P < 0.05) and was comparable to T4 (80.78%) and T1 (80.14%). The lowest value was recorded in birds fed T3 (78.52%).

Table 3. Apparent nutrient digestibility of pullets (9-18 weeks) fed graded levels of white sorghum soaked in wood ash extract

	Inclusion level (%)				
	0	**25**	**50**	**75**	
	DIET				
Parameters(%)	1	2	3	4	SEM±
Dry matter	76.00	78.00	80.00	79.00	0.84
Crude protein	78.76^{b}	79.45^{ab}	80.41^{a}	78.87^{b}	0.20
Crude fiber	62.30^{bc}	59.37^{d}	64.80^{a}	63.49^{ab}	0.15
Ether extract	87.83^{a}	79.43^{b}	78.40^{b}	79.51^{b}	0.17
Ash	77.67^{c}	79.27^{b}	79.77^{b}	87.10^{a}	0.02
Nitrogen free extract	80.14^{a}	82.65^{a}	78.52^{b}	80.78^{a}	0.61

[abc]: Means in the same row with varying superscripts differ significantly (P<0.05); SEM= Standard error of mean

3.2.Discussion for apparent nutrient digestibility of pullets growers (9-18 weeks) fed graded levels of white sorghum soaked in wood ash extract

Apparent nutrient digestibility reflects the net outcome of all digestive and absorptive processes along the gastrointestinal tract (Grener, 2013). The increase in crude protein (CP) digestibility observed with increasing dietary levels of sorghum relative to the control could be attributed to enhanced feed intake and improved nutrient utilization. This improvement may be due to the superior protein content and amino acid profile of sorghum, particularly its lysine content, as reported by Shamme et al. (2016). These authors reported higher protein digestibility in sorghum compared with maize (99% vs. 81%). However, birds fed 75% sorghum replacement exhibited reduced nutrient digestibility. This decline may be attributed to residual anti-nutritional factors in white sorghum. Although the differences were not statistically significant, possibly due to the high overall quality of the diets, the trend agrees with Abeke (2008), who reported that monogastric animals lack the enzymes necessary for cellulose degradation. Crude protein digestibility was similar between T1 and T3, while the reduced digestibility in T4 agrees with Kyarisiima et al. (2004), who reported that tannin-containing sorghum adversely affects protein digestibility. Similarly, Ravindran et al. (2006) reported that an increase of 0.1% dietary tannin can reduce the digestibility of most amino acids by 10%. The improved digestibility of ether extract (EE) and nitrogen-free extract (NFE) may also be attributed to the high fat and carbohydrate content of the diets.

3.3 Results of external and internal eggs quality of layers fed graded levels of sorghum soaked in wood ash extract

The results for external and internal egg quality traits of layers fed graded levels of sorghum soaked in wood ash extract are shown in Table 4. Except for egg length, shell weight, yolk weight, albumen weight, and yolk colour, dietary treatments had a significant (P < 0.05) effect on all parameters tested. Egg weight was highest (P < 0.05) in birds fed T2 (56.32 g), followed by 54.90, 53.66, and 53.18 g recorded for T4, T1, and T3, respectively. Egg weights of layers fed T2, T4, T1, and T3 did not differ significantly (P > 0.05) from one another. Egg length values of 4.75, 4.71, 4.70, and 4.56 mm were recorded for layers fed T3, T2, T4, and T1, respectively. Egg breadth was highest (P < 0.05) in birds on T2 (3.56 mm)

DOI: https://doi.org/10.5281/zenodo.21618300

but was comparable to T3 (3.51 mm) and T1 (3.47 mm), while T4 had the lowest value (3.40 mm). Egg breadth of layers on T3, T1, and T4 was statistically similar.
Egg shape index was highest ($P < 0.05$) in birds fed T3 (0.72), comparable to T4 (0.71), followed by T1 (0.65), and lowest in T2 (0.63). Percentage shell weight did not differ significantly ($P > 0.05$) among T1, T2, T3, and T4, with respective values of 5.25, 5.27, 4.72, and 5.05%. Birds fed T4 had the highest ($P < 0.05$) shell thickness (0.38 mm), followed by T3 (0.35 mm), T1 (0.34 mm), and the lowest in T2 (0.33 mm). Shell thickness of eggs from birds fed T4, T3, T1, and T2 did not differ significantly ($P > 0.05$). Percentage yolk and albumen weights were not significantly ($P > 0.05$) affected by dietary treatment, with respective values of 14.39 and 34.35%, 14.69 and 34.83%, 14.68 and 33.47%, and 14.86 and 33.45% for T1, T2, T3, and T4.
Percentage albumen height was significantly ($P < 0.05$) highest in birds on T3 (7.96%), followed by T2 (7.67%), T1 (7.31%), and lowest in T4 (7.03%). Albumen height was significantly ($P < 0.05$) highest in T3 (6.88 mm), comparable to T2 (7.29 mm), followed by T1 (6.61 mm), and lowest in T4 (6.66 mm). Laying birds on T3 and T2, and T2 and T1, had similar ($P > 0.05$) albumen height and percentage albumen height, respectively. Yolk colour ranged from 1 in T3 to 2 in T1. Haugh unit was significantly ($P < 0.05$) highest in T3 (90.59), comparable to T2 (87.84) and T1 (87.07), while T4 had the lowest value (84.58). Haugh unit values for T2 and T1 did not differ significantly ($P > 0.05$)
Table 4: External and Internal Egg Qualities of Laying Birds (19-34 Weeks) fed graded Levels of White Sorghum Soaked in Wood Ash Extract

	Inclusive level (%) SWA				
Parameters	**0**	**25**	**50**	**75**	
	Diet				
	1	**2**	**3**	**4**	**SEM±**
Egg weight (g)	**53.66^{b}**	**56.32^{a}**	**53.18^{b}**	**54.90^{ab}**	**0.59**
Egg length (mm)	**4.56**	**4.71**	**4.75**	**4.70**	**0.08**
Egg breadth (mm)	**3.47^{ab}**	**3.56^{a}**	**3.51^{ab}**	**3.40^{b}**	**0.03**
Egg shape index(%)	**0.65^{b}**	**0.13^{c}**	**0.72^{a}**	**0.71^{a}**	**0.04**
Shell weight (%)	**5.25**	**5.27**	**4.72**	**5.05**	**0.08**
Shell thickness(mm)	**0.34^{b}**	**0.33^{b}**	**0.35^{ab}**	**0.38^{a}**	**0.01**
Yolk weight (%)	**14.39**	**14.69**	**14.68**	**14.86**	**0.17**
Albumen weight (%)	**34.35**	**34.83**	**33.47**	**33.45**	**0.81**
Albumen height (mm)	**6.61^{b}**	**7.29^{a}**	**6.88^{a}**	**6.66^{b}**	**0.50**
Albumen height(%)	**7.31^{b}**	**7.67^{ab}**	**7.96^{a}**	**7.03^{c}**	**0.12**
Yolk colour	**2**	**2**	**1**	**2**	**0.02**
Haugh unit	**88.07^{ab}**	**87.84^{ab}**	**90.59^{a}**	**84.58^{c}**	**1.16**

^{abc}; Means in the same row with varying superscripts differ significantly (P<0.05); SEM= Standard error of mean

3.4 Discussion of external and internal eggs quality of layers fed graded levels of sorghum soaked in wood ash extract

Egg external and internal quality parameters value were significantly higher for egg weight in treatments T2 and T_4 but compare with T_1 and T_3, indicating a positive effect of sorghum soaked in wood ash extracts on performance. Egg length values were similar across treatments. This could be attributed to the age of the birds at the start of the trial and low or absence of anti-nutritional factors that would depress palatability in the diets. Egg breath followed a similar trend. Result for albumin weight, height and Haugh unit were consistent with the report of Ebadi (2005), who reported that albumin weight is positively correlated with egg weight. Haugh unit scores were within the recommended range of 70-100, indicating good internal egg quality. (Lewko and Gornowiez, 2009). The result of this study shows that soaked wood ash had no negative effect on yolk quality, suggesting that the

DOI: https://doi.org/10.5281/zenodo.21618300

dietary formulations were devoid of compounds responsible for normal yolk colouration. Shell weight did not differ among treatments, in agreement with Zebiba, (2012), while yolk colour attributes remained within normal limits.

4.0 Conclusion

Feeding white sorghum soaked in wood ash extract up to 75% inclusion level improve nutritive values of the pullet growers, internal and external qualities of the layers.

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DOI: https://doi.org/10.5281/zenodo.21618300