International Journal of Animal Science and Technology
2026, Vol. 10, No. 3, pp. 65–71
https://doi.org/10.11648/j.ijast.20261003.11

SciencePG
Science Publishing Group

Research Article

Reproductive Performance of Laying Hens Fed Processed Cocoyam (*Xanthosoma sagittifolium*) Diets: Influence of Processing Method and Inclusion Level During Early Lay

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Abstract

This study evaluated the processing methods and inclusion levels of cocoyam (*Xanthosoma sagittifolium*) on the reproductive performance of laying hens during early laying phase (19–52 weeks). A total of 160 Shika Brown layers were assigned to seven dietary treatments in a 2×3+1 factorial arrangement consisting two processing methods (raw sundried and boiled sundried), three inclusion levels (25%, 50% and 75%) and a control (0%) in a completely randomized design. Parameters measured included age at first egg, body weight at first lay, first egg weight, egg mass, egg production rate, mortality and survivability. Data were analyzed using two-way ANOVA and means separated at $P<0.05$. Result revealed significant interaction effects were observed for most reproductive parameters. Birds fed 50% boiled cocoyam had the highest body weight at first lay (1.65 kg), egg mass (285.65 g) and egg production (5.45 eggs/day), with lowest mortality (0.005%). In contrast, higher raw inclusion delayed sexual maturity and reduced egg production performance. The improved performance observed in boiled cocoyam diets is attributed to the reduction of antinutritional factors and enhanced nutrient utilization, which supports optimal endocrine function and ovarian activity. It can be concluded that inclusion of boiled cocoyam at 50% optimized reproductive performance of laying hens during early lay and can serve as viable alternative energy source in poultry diets.

Keywords

Cocoyam, Reproductive Performance, Sexual Maturity, Ovarian Activity, Laying Hens

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Received: 17 April 2026; **Accepted:** 7 May 2026; **Published:** 8 July 2026

1. Introduction

Reproductive activity in laying hens is controlled by a coordinated interaction of hormonal and physiological mechanisms controlled by the hypothalamic–pituitary–gonadal (HPG) axis. The release of gonadotropin-releasing hormone (GnRH) from the hypothalamus stimulates the anterior pituitary gland to secrete follicle-stimulating hormone (FSH) and luteinizing hormone (LH), which are directly involved in follicular development, maturation, and ovulation [4, 8]. Efficient functioning of this endocrine system is essential for maintaining a consistent oviposition cycle and optimal reproductive performance.

Adequate nutrition plays a fundamental role in supporting these physiological processes. Insufficient energy intake or nutrient imbalance can disrupt hormonal regulation, delay sexual maturity, and reduce egg production efficiency [3, 4]. In addition, the presence of anti-nutritional factors in feed ingredients may limit nutrient availability and interfere with metabolic processes necessary for egg formation and reproductive stability [6, 9].

Energy deficiency or metabolic stress can suppress GnRH-pulsatility and reduce FSH secretion, thereby delaying sexual maturity and impairing egg production [5]. Cocoyam (*Xanthosoma sagittifolium*) is a locally available carbohydrate-rich feed resource that has gained attention as a potential alternative to maize in poultry diets. However, its utilization is constrained by the presence of anti-nutritional compounds such as oxalates, tannins, and cyanogenic glycosides, which may impair nutrient digestibility and adversely affect animal performance if not adequately processed [3].Anti-nutritional factors in feed ingredients may further compromise nutrient availability, affecting ovarian responsiveness and egg formation.

The early laying phase (19–52 weeks of age) represents a critical production period characterized by peak egg output and high metabolic demand. During this stage, optimal dietary composition is required to sustain endocrine activity, support follicular recruitment, and maintain reproductive efficiency. Therefore, this study was designed to evaluate the effects of different processing methods and graded inclusion levels of cocoyam on reproductive performance indices of laying hens during early lay.

2. Materials and Methods

Study Area: The study was carried out at the Poultry Research Programme Section of the National Animal Production Research Institute (NAPRI), Shika, Zaria, Nigeria.

2.1. Experimental Animals and Management

A total of 160 day-old Shika Brown layer chicks were used for the study. The birds were obtained from the hatchery unit of the National Animal Production Research Institute (NAPRI), Shika, Zaria. They were reared on deep litter using wood shavings as bedding material of good absorbent quality. Brooding was carried out for two weeks at an average temperature of approximately 35 ℃. Standard vaccination and management practices were strictly followed, including intraocular vaccination against Newcastle disease. The birds were fed according to their nutritional requirements at different growth stages (starter, grower, and layer phases). Feed and clean water were provided *ad libitum* throughout the experimental period.

2.2. Procurement and Processing of Cocoyam (*Xanthosoma sagittifolium*)

Fresh cocoyam (*Xanthosoma sagittifolium*) corms were purchased from a local market in Sumaila Local Government Area, Kano State, Nigeria. The corms were manually cleaned to remove dirt and fibrous materials, then chopped into smaller pieces. Two processing methods were applied: raw sundried (RS) and boiled sundried (BS). For the raw sundried method, chopped cocoyam was directly sun-dried until a constant weight was achieved [14]. For the boiled sundried method, the chopped cocoyam was first boiled and subsequently sun-dried [11]. The preparation procedures followed standard methods described in previous studies.

2.3. Experimental Diets and Design

A total of 160 birds were randomly allocated into seven dietary treatments in a 2 × 3 + 1 factorial arrangement. The factors included two processing methods (raw and boiled cocoyam) and three inclusion levels (25%, 50%, and 75%), in addition to a control diet (0% cocoyam inclusion). Each treatment consisted of 20 birds in a completely randomized design. Seven experimental diets were formulated, comprising three diets containing raw sundried cocoyam, three diets containing boiled sundried cocoyam, and one control diet without cocoyam. Cocoyam meal was used to replace maize at inclusion levels of 0%, 25%, 50%, and 75%, respectively, as presented in Table 1.

2.4. Performance Parameters Measured

The following reproductive performance parameters were evaluated: Age at first egg: recorded as the age at which the first egg was laid. Body weight at first lay: measured using a digital weighing scale. First egg weight: determined using a sensitive digital scale. Egg production: number of eggs laid per treatment per day. Egg mass: calculated as the total weight of eggs produced per replicate. Hen-day production (HDP): calculated as the number of eggs laid per day divided by the number of hens present, expressed as a percentage. Hen-house production (HHP): calculated as the number of eggs laid per day divided by the initial number of hens, expressed as a percentage. Mortality: recorded as the number of deaths per treatment during the experimental period.

2.5. Statistical Analysis and Model

Data obtained were subjected to analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of SAS software (Version 9.4) [13]. Significant differences among treatment means were separated using Tukey's test at a 5% level of significance.

The statistical model used was:

$$Y_{ijk} = \mu + T_i + L_j + (TL)_{ij} + e_{ijk}$$

Where:

Y_{ijk} = observed response variable

μ = overall mean

T_i = effect of processing method

L_j = effect of inclusion level (0%, 25%, 50%, 75%)

$(TL)_{ij}$ = interaction effect between processing method and inclusion level

e_{ijk} = random error term

Table 1. *Ingredients Composition of Experimental Diets (Layer Diet).*

	Inclusion levels (%)			
Ingredients	**0**	**25**	**50**	**75**
Cocoyam	0.00	12.50	25.00	37.50
Maize	50.00	37.50	25.00	12.50
Fish meal	5.00	5.00	5.00	5.00
Soybean meal	22.00	22.00	22.00	22.00
De-oiled rice bran	11.20	10.70	10.20	9.70
Bone meal	3.00	3.00	3.00	3.00
Limestone	7.00	7.00	7.00	7.00
Salt	0.30	0.30	0.30	0.30
Methionine	0.25	0.25	0.25	0.25
Vit. Min. premix	0.25	0.25	0.25	0.25
Palm oil	1.00	1.50	2.00	2.50
Total	100.00	100.00	100.00	100.00
Selenium addition at 0.5mgSe/kg diet				
Calculated Analysis				
Crude protein (%)	16.63	16.40	16.17	15.94
Energy (kcal/kg)	2608.27	2617.31	2626.35	2635.40
Lysine (%)	1.04	1.04	1.05	1.05
Methionine (%)	0.58	0.57	0.57	0.56
Calcium (%)	3.88	3.85	3.85	3.85
Phosphorus (%)	0.99	0.95	0.91	0.87
Selenium(mg/kg)	0.13	0.12	0.11	0.09

Vit. Min. premix= vitamins minerals premix contains vitamin A 14,000,000 I.U, vitamin D_3 3,500,000 I.U, vitamin E 20,000 I.U, vitamin K2,400 mg, vitamin B_1 1,800 mg, vitamin B_2 5,000 mg, vitamin B_6 1,800 mg, vitamin B_{12} 12 mg, niacin 18,400 mg, panth acid 6,000 mg, folic acid 700, biotin 50 mg, choline chloride 240,000 mg, manganese 96,000 mg, zinc 60,000 mg, iron 40,000 mg, copper 8,000 mg, iodine 1,400 mg, selenium 240 mg, cobalt 250 mg and antioxidant 125mg; mg/kg: milligram/kilogram.

3. Result

3.1. Effect of Processing Method and Inclusion Level on Reproductive Performance

The effects of cocoyam processing methods and inclusion levels on reproductive performance of laying hens are presented in Table 2. Processing method significantly ($P < 0.05$) influenced most of the reproductive parameters measured. Birds fed boiled cocoyam diets exhibited improved performance compared to those fed raw cocoyam diets, particularly in body weight at first lay, egg mass, egg production, and mortality. In terms of inclusion levels, significant differences ($P < 0.05$) were observed across treatments. Birds fed 50% cocoyam inclusion generally showed superior performance in body weight at first lay and egg mass compared to other inclusion levels, while higher inclusion levels (75%) resulted in reduced performance. Age at first egg was significantly affected by both processing method and inclusion level, with earlier maturity observed in birds fed lower inclusion levels. Body weight at first lay was highest in birds fed diets containing 50% cocoyam inclusion, particularly under the boiled processing method. First egg weight decreased with increasing levels of cocoyam inclusion, with the control diet producing the highest values. Similarly, egg mass and numbers of eggs laid per day were significantly reduced in birds fed raw cocoyam compared to those fed boiled cocoyam and the control diet. Mortality was significantly higher ($P < 0.05$) in birds fed raw cocoyam diets compared to those fed boiled cocoyam and control diets. The number of birds remaining at the end of the experiment followed a similar trend. Hen-day production (HDP) and hen-house production (HHP) were not significantly ($P > 0.05$) affected by either processing method or inclusion level.

3.2. Interaction Effect of Processing Method and Inclusion Level

The interaction effects of processing method and inclusion level on reproductive performance are presented in Table 3. Significant interaction effects (P < 0.05) were observed for most parameters measured. Birds fed 50% boiled cocoyam recorded the highest body weight at first lay, egg mass, and egg production rate. Conversely, birds fed higher levels of raw cocoyam exhibited poorer performance across most parameters. Age at first egg varied significantly among treatments, with earlier onset observed in birds fed lower levels of raw cocoyam, while delayed maturity was observed at higher inclusion levels. Mortality was highest in birds fed 75% raw cocoyam and lowest in those fed 50% boiled cocoyam. The number of birds at the end of the experiment reflected the observed mortality trends. Overall, the interaction between processing method and inclusion level had a significant influence on reproductive performance, with boiled cocoyam at moderate inclusion levels producing the most favorable results.

4. Discussion

The results of this study demonstrate that both processing method and inclusion level of cocoyam significantly influence reproductive performance of laying hens, primarily through their effects on nutrient availability and metabolic efficiency. The improved performance observed in birds fed boiled cocoyam diets compared to raw cocoyam diets can be attributed to the reduction of anti-nutritional factors during processing. Cocoyam contains compounds such as oxalates, tannins, and cyanogenic glycosides, which are known to interfere with nutrient digestion and absorption. Boiling has been shown to effectively reduce these compounds, thereby enhancing nutrient bioavailability and supporting better growth and reproductive outcomes [3, 12]. In contrast, the poorer performance observed in birds fed raw cocoyam diets suggests that residual anti-nutritional factors limited nutrient utilization and imposed metabolic stress [10].

Body weight at first lay was highest in birds fed 50% boiled cocoyam, indicating that this inclusion level provided an optimal balance between energy supply and nutrient utilization. Adequate body weight at the onset of lay is essential for initiating reproductive activity, as it reflects sufficient energy reserves to support hepatic synthesis of yolk precursors and hormonal regulation of ovarian function [9]. The reduced body weight observed at higher inclusion levels, particularly under raw processing, suggests that excessive inclusion of poorly processed cocoyam may compromise nutrient density and growth performance [2].

The decline in first egg weight and egg mass with increasing levels of cocoyam inclusion, especially under raw processing, further supports the negative impact of anti-nutritional factors on reproductive efficiency. Egg formation is a metabolically demanding process that depends on efficient nutrient partitioning, particularly proteins and energy. Impaired nutrient utilization may reduce albumen deposition and yolk formation, resulting in smaller eggs [6].

Table 2. *Effect of cocoyam (Xanthosoma sagittifolium) processing methods and levels in the diet on performance of laying chicken (19-52 weeks).*

	Processing method					Level of cocoyam (%)					
Parameters	**Control**	**Raw**	**Boiled**	**SEM**	**P value**	**0**	**25**	**50**	**75**	**SEM**	**P val**
Age at first (weeks)	20.05^b	19.98^a	19.97^a	0.006	0.0001	20.03^b	19.58^a	20.18^c	20.18^c	0.004	0.0001
Bird wt at L (kg)	1.55^a	1.47^b	1.55^a	0.002	0.0001	1.55^b	1.50^b	1.60^a	1.43^d	0.002	0.0001
Wt first egg (g)	49.25^a	41.17^c	43.33^b	0.077	0.0001	47.19^a	40.44^c	44.44^b	43.94^b	0.072	0.0001
Egg mass (g)	271.70^a	248.59^b	269.11^a	2.348	0.0001	294.78^a	245.18^c	262.64^b	245.65^c	2.346	0.0022
No. of E L/(eggs/d)	5.16^a	4.72^b	5.11^a	0.040	0.0001	5.60^a	4.67^b	4.99^b	4.64^c	0.040	0.0027
HDP (%)	65.55	64.55	65.55	0.376	0.602	65.55	65.55	65.55	65.55	0.377	1.0000
HHP (%)	59.08	58.08	59.08	0.331	1.0000	59.08	59.08	59.08	59.08	0.332	1.0000
Mortality (%)	0.70^b	1.83^a	0.69^b	0.051	0.0001	0.42^d	1.53^b	1.39^c	2.15^a	0.054	0.0001
Number of Birds	9.30^a	8.17^b	9.31^a	0.012	0.0001	9.58^a	8.47^c	8.61^b	7.85^d	0.011	0.0001

	Processing method					Level of cocoyam (%)					
Parameters	Control	Raw	Boiled	SEM	P value	0	25	50	75	SEM	P val

a,b,c,dMeans within the rows with different superscripts are significantly different (p<0.05)
Cntrol= control; Pval= probability value; SEM= standard error of mean; d= day; b= bird; HDP= hen day production; HHP= hen house production; No. of EL/d= number of egg laid/day; Bird wt at L = weight at first egg lay; Wt first egg (g)= weight of first egg; Age at first= age at first egg laying

The delayed onset of lay observed at higher inclusion levels of raw cocoyam may be associated with reduced energy intake and disruption of endocrine signaling. Nutritional stress has been reported to suppress GnRH secretion and reduce gonadotropin release, ultimately delaying sexual maturity [8]. This explains the observed variation in age at first egg across treatments.

Mortality trends further highlight the importance of proper processing, however [1, 2] reported that mortality, did not show any trend attributable to the type of diet in broiler chicken fed wild cocoyam and taro cocoyam. Higher mortality in birds fed raw cocoyam diets suggests increased physiological stress, possibly due to toxic effects of residual anti-nutritional compounds [7]. Conversely, the low mortality recorded in birds fed boiled cocoyam, particularly at 50% inclusion, indicates improved health status and physiological stability.

The significant interaction between processing method and inclusion level confirms that the response of laying hens to cocoyam-based diets depends not only on the level of inclusion but also on the effectiveness of processing. Moderate inclusion of properly processed cocoyam appears to create a favorable metabolic environment that supports endocrine function and reproductive efficiency.

Overall, the findings of this study emphasize the importance of processing techniques in improving the nutritional value of alternative feed resources and demonstrate that boiled cocoyam can serve as an effective partial substitute for maize in layer diets when used at appropriate inclusion levels.

Table 3. *Interaction of cocoyam (Xanthosoma sagittifolium) processing methods and inclusion levels on performance of laying chicken (19-52 weeks).*

Processing	Control	Raw cocoyam			Boiled cocoyam				
Treatment	0	25	50	75	25	50	75	SEM	P val
Age at first (week)	20.05^c	19.35^a	20.30^d	20.30^d	19.80^b	20.05^c	20.05^c	0.004	0.0001
Bird wt at L (kg)	1.55^b	1.50^c	1.55^b	1.35^d	1.50^c	1.65^a	1.50^c	0.001	0.0001
Wt first egg (g)	49.25^a	41.00^e	39.00^f	45.00^b	42.50^d	43.50^c	44.50^{bc}	0.072	0.0001
Egg mass (g)	271.70^b	233.01^e	255.01^c	257.75^c	272.74^b	285.65^a	248.94^d	2.341	0.0005
No. of E L/(eggs/d)	5.17^b	4.52^d	4.82^c	4.81^c	5.10^b	5.45^a	4.77^c	0.040	0.0040
HDP (%)	65.55	65.55	65.55	65.55	65.55	65.55	65.55	0.377	1.0000
HHP (%)	59.08	59.08	59.08	59.08	59.08	59.08	59.08	0.332	1.0000
Mortality (%)	0.70^e	1.61^c	1.89^b	2.00^a	0.59^e	0.005^f	1.44^d	0.055	0.0001
No. of Birds	9.30^b	8.39^c	8.11^d	8.00^d	9.41^b	9.95^a	8.56^{bc}	0.010	0.0001

a,b,c,d,e,fMeans within the rows with different superscripts are significantly different (p<0.05)
Pval= probability value; SEM= standard error of mean; d= day; b= bird; HDP= hen day production; HHP= hen house production; No. of EL/d= number of egg laid/day; Bird wt at L= weight at first egg lay; Wt first egg (g)= weight of first egg; Age at first= age at first egg laying

5. Conclusion

The findings of this study demonstrate that both processing method and inclusion level of cocoyam significantly influence the reproductive performance of laying hens during the early laying phase. Boiled cocoyam diets consistently improved body weight at first lay, egg mass, egg production rate, and survivability compared to raw cocoyam diets. This improvement is primarily attributed to the reduction of anti-nutritional factors through boiling, which enhances nutrient availability and supports metabolic and endocrine functions necessary for efficient reproduction.

Among the inclusion levels evaluated, 50% replacement of maize with boiled cocoyam provided the most favorable results, indicating an optimal balance between energy supply and nutrient utilization. In contrast, higher inclusion levels of raw cocoyam negatively affected reproductive parameters, likely due to reduced nutrient digestibility and increased metabolic stress associated with residual anti-nutritional compounds.

Therefore, properly processed cocoyam can serve as a viable alternative energy source in layer diets without compromising reproductive efficiency when included at appropriate levels.

6. Recommendations

Based on the results of this study, the following recommendations are proposed:

Boiled cocoyam should be used as a partial replacement for maize in layer diets, particularly at an inclusion level of 50%, to optimize reproductive performance and reduce feed cost.

Raw cocoyam should be avoided or adequately processed before inclusion in poultry diets to minimize the negative effects of anti-nutritional factors on nutrient utilization and bird health.

Poultry producers in regions where cocoyam is readily available should consider its use as a cost-effective alternative energy source, provided proper processing methods are applied.

Further studies should be conducted to evaluate the long-term effects of cocoyam-based diets on egg quality, reproductive hormones, and overall flock productivity.

Additional research is recommended to explore other processing techniques that may further improve the nutritional value of cocoyam and enhance its utilization in poultry production systems.

Abbreviations

HPG	Hypothalamic–Pituitary–Gonadal axis
GnRH	Gonadotropin-Releasing Hormone
FSH	Follicle-Stimulating Hormone
LH	Luteinizing Hormone
HHD	Hen-Day Production
HHP	Hen-House Production
SEM	Standard Error of Mean
ANOVA	Analysis of Variance
GLM	General Linear Model
RS	Raw Sundried
BS	Boiled Sundried

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Conflicts of Interest

The authors declare no conflicts of interest.

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