



Impact of Soaked-toasted Tallow (*Detarium microcarpum*, Guill and Sperr) Seeds Meal on the Nutritional and Anti-nutritional and Growth Assay of Starter Broiler Chickens

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Authors' contributions

This work was carried out in collaboration between all authors. Authors COO and YTA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors PAS and ATJ managed the analyses of the study. Author BCL managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

This study was designed to evaluate the effects of raw and soaked-toasted Tallow seeds meals on proximate composition, mineral contents, amino acids profile, anti-nutrients and growth performance of starter broiler chickens fed dietary levels of 0, 10 and 20% soaked-toasted Tallow seed meal (STTSM). Proximate analysis, amino acids profile, minerals and anti nutrients contents of the raw and soaked-toasted tallow seeds were carried out. Three hundred and sixty (360) day-old broiler chicks of the Amo Strain were used to evaluate growth performance. The experimental layout was a completely randomized design with three treatments, each with three replicates (40 birds/ replicate). The inclusion levels of STTSM in the diets were 0, 10 and 20% (w/w). The results of the proximate analysis of the raw tallow seeds were high in crude protein (26.20%), moisture (10.58%), fat

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(16.21%), crude fibre (11.86%), ash (3.72), neutral detergent fibre (49.72%), acid detergent fibre (37.31%), hemi-cellulose (12.41%). with decrease in nitrogen free extracts (42.01%). The results of the element concentrations in raw and STTSM samples were (%): Ca (0.92-0.75), Mg (0.30-0.27), Na (0.41-32), S (0.17-14), P (0.22-14), K (1.00-0.66) and Fe (123-118 ppm). The results of the anti nutrients (mg/100 g) of the raw sample revealed the presence of tannin (9.56), phytic acid (25.49), hydrogen cyanide (5.08), alkaloids (8.39), oxalate (16.36) and flavonoids (4.32) compared with the STTSM showing complete elimination of tannin, saponin, hydrogen cyanide and insignificant presence of alkaloids (0.05 mg/100 g), phytic acid 0.02 mg/100 g), oxalate (0.02 mg/100 g) and flavonoids (0.01 mg/100 g). The analyzed amino acids results showed that glutamic acid (8.03-7.50 g/100 g) and arginine 4.25-4.62 g/100 g protein had the highest proportion. The soaked-toasted seeds showed reduction in amino acid profile compared with the raw sample. ANOVA showed that final body weight, body weight gain, total feed intake, daily weight gain, daily feed intake and feed conversion ratio of birds fed 0% STTSM diet were comparable ($p > 0.05$) with those fed STTSM based diets. Soaked-toasted Tallow seed reduced the anti nutritional factors and improved the nutritional quality of the seed and enhanced growth of starter broiler chicks without adverse effect on growth performance and feed intake. This seed can therefore be incorporated in animal feeding with proper processing methods.

Keywords: *Anti-nutrients; broiler chickens; Detarium microcarpum seed; growth performance; soaked-toasted method; tallow seeds.*

1. INTRODUCTION

The importance of fruits as a source of nutrient has attracted attention of various researchers throughout the world, especially in Nigeria [1-4]. Fruits and leafy vegetables are believed to occupy a modest place as a source of trace elements due to their high water content. In addition to meeting nutrient intake levels, greater consumption of fruits and vegetables is associated with reduced risk of cardiovascular disease, stroke, and cancers of the mouth, pharynx, esophagus, lungs, stomach, and colon [5,6]. Many plant components have potential to precipitate adverse effects on the productivity of farm livestock. These compounds are present in the foliage and seeds of virtually every plant that is used in practical feeding [7].

In Nigeria, *Detarium microcarpum* seeds (DMS) are unused feed resource and are readily available for livestock feeding. The detarium seed can be widely produced in Nigeria, because detarium trees thrive very well in a variety of soils including loam, marl, and sandy soils [8]. It is a highly yielding tree with large quantities of its fruits wasting every year in the field. Currently, the fruits/seeds are of less value as human food but rather the tree is cut down as fuel wood and for charcoal production. The seeds are a potential protein source, because they are rich in protein [9].

Exploring wild/underutilized legumes could be of high significance for food security, meeting

nutritional requirements, and agricultural development, as well as be an efficient means for rotation of crops, and thus can effectively contribute to the overall improvement of a nation's economy. Many of the known wild and underutilized legumes (such as *Mucuna* spp [10], *Parkia biglobosa* [11] *Daniellia oliveri* [12], *Azelia africana* [13] possess adequate amounts of protein, essential amino acids, polyunsaturated fatty acids (PUFAs), dietary fiber, and essential minerals and vitamins comparable to other common legumes, along with the presence of beneficial bioactive compounds. Poor nutritive values might also be related to the presence of many anti-nutritional factors such as tannins, phytates, saponin, oxalate and alkaloids. The deficiency of the elements or excess of anti-nutrients might disturb normal biochemical functions of the body.

Processing of wild legume seeds using integrated methods such as soaked-cooked, soaked fermented and cooked-fermented have been reported to eliminate anti nutrients and enhanced growth performance in broiler chickens [14-17] compared with single treatments of legumes grains [3,18-21]. However, Detarium seeds have an advantage of being less costly and less competed for than soybean. If the treated detarium seed meals would replace a larger proportion of soybean and groundnut meal, not only feed costs could reduce, but also competition between humans and livestock for ground nut cake. This study therefore investigates the level of nutrients, mineral

elements and anti-nutrient in raw and soaked-toasted detarium seeds and evaluates growth performance of broiler chicks.

2. MATERIALS AND METHODS

2.1 Site of the Experiment

The study was carried out at Aga Livestock Farm Ltd, a commercial farm with standard building for Teaching and Research in Wukari Metropolis, Taraba State, Nigeria. Wukari is located between Latitude 7°51'N, 9°47'E and Longitude 7°85'N, 90°78'E [22].

2.2 Collection and Processing of Seed Meal

Dry Tallow fruits were collected from Wukari area in Taraba State. The fruits were mechanically opened to remove the seeds. The raw seeds were cleaned of dirt soaked in water at room temperature for one day (1d), drained and rinsed once with fresh water and air-dried for three days. The dried seeds were poured into a frying pan mixed with sand in ratio 2:1 under control open fire. Turning was constantly done (to avoid the seeds burning off) until the white endosperm seed turns crispy brown in colour after 30-35 min [23]. The roasted seeds were decorticated and then ground to form soaked-toasted Tallow seed meal (STTSM).

2.3 Birds, Diets and Experimental Design

A total of 360 day-old unsexed broiler chicks (Amo) were purchased from a reputable Hatchery in Ibadan, Oyo State for this study. Birds were weighed and randomly assigned to three treatments. Each treatment had three replicates of 40 birds under a completely randomized design. Three diets were formulated with tallow seed meal to replace soybean meal at 0, 10 and 20% inclusion levels (starter (Table 1). The diets were formulated according to standard requirements recommended by Olomu [20]. The brooder house was thoroughly cleaned, washed, disinfected, allowed to rest for a week before the arrival of chicks and light provided using electricity and rechargeable lanterns to encourage the birds to eat in the night. Birds were fed starter diet for 28 day. Feed and water were provided *ad libitum*. All management procedures were according to that described by Olomu [23]. The birds were weighed weekly and feed intake daily recorded for the estimation of

the average daily weight gain and cumulative feed intake.

2.4 Proximate Analysis

Proximate composition of experimental diets was determined for moisture, crude protein, ash, fat and crude fibre according to AOAC [24] while fibre fractions were determined according to Van Soest et al. [25].

2.5 Mineral Analysis

The mineral elements of sodium and potassium were determined using a flame photometer (Elico, India) while phosphorus was determined by the Vanado-molybdate method using a spectrophotometer (Model Spectronic 20D, Milton Roy, USA). The other mineral elements (calcium, iron, magnesium and sulphur) were determined after wet digestion with a mixture of nitric, sulphuric and hydrochloric acid using Atomic Absorption Spectrophotometer (AAS model SP9) according to AOAC (24) method.

Table 1. Gross composition of experimental starter diets

Ingredients	% Dietary Starter Phase		
	0%	10%	20%
Maize	51.00	51.00	51.00
Maize bran	10.00	10.00	10.00
Soybean (Fullfat)	30.00	20.00	10.00
STTSM	0.00	10.00	20.00
Fish meal	3.00	3.00	3.00
Bone meal	3.00	3.00	3.00
Lime stone	2.00	2.00	2.00
Methionine	0.25	0.25	0.25
Lysine	0.25	0.25	0.25
*Premix	0.25	0.25	0.25
Salt	0.25	0.25	0.25
Total	100	100	100
Crude protein	22.89	22.76	22.60
Crude fibre	4.20	4.40	4.70
ME (kcal/kg)	2876.00	2840.60	2832.31
Crude protein	22.00	21.81	21.72
Crude fibre	4.58	4.00	4.20
Fat	4.70	4.56	4.30
Ash	3.41	3.30	3.50
Ca	1.76	1.70	1.68
p	0.60	0.62	0.60

* To provide the following per Kg of feed: vit-A 100000 IU; vit. D₃2000iu; vit. B₁:0.75 mg; nicotinic acid-25 mg; Ca, panthothenate- 12.50 mg; vit.B₁₂2.5 mg; vit. K-2.5 mg; vitE-25 mg; Cobalt 0.4 mg Biotin-0.50 mg; Folic acid- 1 mg; Cholin chloride-25 mg; Cu-8.00 mg; Mg-64 mg; Fe-32 mg; Zn 4 mg; Iodine-0.80 mg; Flavomyacin-100 mg; Sapiromycin-5 mg; DL-methionine-50 mg; Selenium- 0.16 mg; 1-lysine 120 mg. STTSM: Soaked-toasted Detarium microcarpum seed meal

2.6 Amino Acid Profile Determination

Quantitative analyses of individual amino acids were carried out using HPLC after hydrolysis with 6 M HCl for 18 hr at 110°C as described by Pearson [26]. Because Cystine and methionine are destroyed by acid hydrolysis, they were oxidized to cystic acid and methionine sulphone prior to hydrolysis. Tryptophan is destroyed by the presence of hydrochloric acid. Therefore NaOH was used to hydrolyze the protein for tryptophan analysis. Five-ten microlitres of the hydrolysate were loaded on the Technicon Sequential Multi-Sample (TSM) amino acid analyzer (DNA, 0209) made by Technicon (Ireland) Ltd.

2.7 Determination of Anti-nutritional Factors in *Detarium microcarpum* Seed

The anti-nutritional factors (phytic acid, oxalate, hydrogen cyanide, tannins, saponins, flavonoids and alkaloids) of detarium seeds were screened for qualitative and quantitative toxicity levels according to Anhwange et al. [1] and Umar et al. [4] methods.

2.8 Data Collection

The birds were weighed and feed intake recorded weekly from which average daily weight gain and feed intake were computed for 28 days.

2.9 Statistical Analysis

Data collected for all the parameters were subjected to analysis of variance (ANOVA) for completely randomized design (CRD) using the Statistical Package for Social Sciences (SPSS for windows), Version 20. Means were separated using Duncan Multiple Range Test [27].

3. RESULTS AND DISCUSSION

3.1 Proximate Composition of Raw and Soaked-toasted Tallow Seed Meals

The results of the proximate composition are presented in Table 2. The moisture content showed higher value of 10.58% in raw seed as against 9.17% for STTS. Crude protein content for raw tallow seeds (RTS) was higher than the soaked-toasted tallow seed (STTS). The level of crude fibre in raw samples was higher (11.80%)

than those of the STTS (8.12%) samples. The percentage of ether extract composition was high in all the samples; However, the level of ether extract in STTS sample was lower than the RTS sample. The level of carbohydrate in STTS was higher than the RTS sample. The fibre fractions of neutral detergent fibre, acid detergent fibre and cellulose were as high as 49.72, 37.31 and 12.41% in the raw samples but were reduced to 35.15, 33.50 and .40% in soaked-toasted seed meal.

Table 2. Proximate composition of raw and soaked-toasted detarium deeds

Parameters	Raw	Soaked-toasted
Moisture	10.58	9.17
Crude protein (Cp)	26.20	24.07
Crude fibre (Cf)	11.86	8.12
Ash	3.72	3.00
Ether extract (EE)	16.21	14.44
Nitrogen free extract (NFE)	42.01	50.37
Neutral detergent fibre (NDF)	49.72	35.15
Acid detergent fibre (ADF)	37.31	33.50
Hemi cellulose	12.41	8.42
Gross energy (Kcal/kg)	3733	3700

The moisture contents of processed seeds reduced with values of 9.17% compared with values of 10.58% for raw samples. These values fall within the recommended range of 0–13% as reported by James [28]. The lowest moisture content registered by soaked-toasted sample indicates that the seeds are better preserved by toasting compared to other treatments methods previously reported by Anhwange et al. [1] and Obun [3]. Soaked-toasted treatment increased the nitrogen free extracts content and reduced the crude protein, crude fibre, ash, ether extracts and gross energy. This observed result is in agreement with earlier report [7] who reported reduction in proximate composition of heat treated legume seeds. The STTS samples recorded higher carbohydrate content, which support an earlier report by Agiang et al. [29] that suggested that processing causes the granules to break down, softens the cellulose, and makes the starch more available. Changes were also observed in proximate composition in heated *Detarium* seed by Uhegbu et al. [7], mucuna seed [30,31]. The proximate composition of raw and processed tallow seeds obtained in this study is comparable to pigeon beans, lima beans and bambara nut reported by Borge [32].

3.2 Mineral content in tallow seed meals

The results of the mineral concentration in raw and processed tallow seeds are presented in Table 3. The RTS sample has high percentage levels of Ca, K, Mg, P, S, Na and Fe as follows: 0.92, 1.00, 0.30, 0.22, 0.17, 0.41 and 123 ppm while percentage levels of STTS decreased in Ca, K, Mg, P, S, Na and Fe as follows: 0.75, 0.66, 0.27, 0.19, 0.14, 0.32 and 118 ppm, respectively.

Table 3. Mineral composition of raw and soaked-toasted *Detarium microcarpum* seed (% dry matter basis)

Components	Raw seeds	Soaked-toasted seeds
Calcium (Ca)	0.92	0.75
Potassium (K)	1.00	0.66
Sodium (Na)	0.41	0.32
Phosphorus (P)	0.22	0.19
Magnesium (Mg)	0.30	0.27
Sulphur (S)	0.17	0.14
Iron (Fe, PPM)	123.00	118.00

The reduction in mineral contents in this study confirms earlier reports by Akpa and Miachi [33] and Fasoyiro et al. [34] who reported that soaking and heating caused losses due leaching and denaturation.

3.3 Anti Nutritional Factors in Raw and Processed Tallow Seed Meal

The anti nutrient contents (saponin, oxalate, tannins, phytic acid, alkaloids, flavonoids and hydrogen cyanide) were higher in RTS sample compared to the STTS sample (Table 4). In this work, soaked-toasting was found to have greater efficiency in the elimination or reduction of the levels of all the anti nutrients available in the tallow seeds.

Anti-nutritional factors (ANFs) are generally toxic and may negatively affect the nutrient value of seeds by impairing protein digestibility and mineral availability. However, they are heat labile and hence may be inactivated by processing methods involving heat generation [35]. The integration of processing treatments by soaked-toasted of detarium seeds in this study resulted to almost elimination or reduction of the ANFs in the seeds compared with single processing treatment (soaked, cooked and toasted) previously reported by Obun [3]. The reduction in all nutrients and anti nutrients trend in these

results may be attributed to effect of heat and loss of nutrients degraded by destruction or chemical changes like leaching of nutrients during soaking and mallard reactions during toasting [36,37]. Okorie SU. [38] reported reduced nutrients when detarium seeds were roasted and soaked in water. The elimination of ANFs in this result is in agreement with reports of other processed legume grains such as pigeon pea (*Cajanus cajan*) and cowpea (*Vigna unguiculata*) which decreased with processing [39]. Generally, processing reduced the level of all the anti-nutrients analyzed to their permissible levels.

Table 4. Anti-nutritional factors of raw and soaked-toasted *Detarium microcarpum* seeds (mg/100 g)

Components	Raw seeds	Soaked-toasted seeds
Tannins	9.56	0.00
Saponin	13.14	0.00
Phytic acid	25.49	0.02
Hydrogen cyanide	5.08	0.00
Alkaloids	8.39	0.05
Oxalate	16.36	0.02
Flavonoids	4.32	0.01

3.4 Amino Acid Profile in Tallow Seed Meals

The results of the amino acid concentrations are presented in Table 5. The raw samples showed high proportion of amino acid compared to the processed samples. The analyzed amino acids results showed that glutamic acid (8.03-7.50 g/100 g) and arginine 4.25-4.62 g/100 g protein had the highest proportion. The soaked-toasted seeds showed reduction in all amino acid profile compared.

The amino acids content [(g/100 g protein, arginine (4.95), leucine (1.90), glutamine (8.03) and cystine (0.52)] in this are lower than values of 5.66, 2.35, 9.78 and 1.07 g/100 g protein reported by Umar et al. [3], while the other amino acids were higher in the present study compared with those reported by Umar et al. [3]. The variations in the present results from those reported by Umar et al. [3] may probably be due to differences in environment, soil type, processing techniques and analysis procedures of the seeds. The processing of seeds resulted to a drastic reduction of amino acids probably due to leaching during soaking and degradation caused by heat. Similar trend was observed in wild melon seeds [40] and *Sclerocarya birrea*

seeds [41]. The reduction in nutrients in soaked-toasted seeds treatment in this study is in agreement with previous reports by [3,7,42,43] that heat treatments reduced proximate composition, mineral elements, amino acids contents and ANFs. The decreased in amino acid profile in this study contradicts reports by Khalil and Mansour [41], who found that heat increase amino acids contents of legume grains.

Table 5. Composition of amino acids profile of raw and soaked-toasted seeds (g/100 g protein)

Amino acid profile	Raw seeds	Soaked-toasted seeds
Arginine	4.95	4.62
Lysine	2.48	1.96
Isoleucine	2.60	2.07
Leusine	1.90	1.70
Phenylalanine	2.97	2.40
Tyrosine	2.86	1.00
Valine	2.50	2.03
Tryptophan	1.10	0.70
Threonine	2.54	2.06
Methionine	1.18	0.80
Alanine	2.28	2.0
Glycine	2.57	2.38
Proline	2.51	2.02
Glutamic acid	8.03	7.50
Cystine	0.52	0.30
Histidine	1.74	1.07
Serine	3.58	3.03

3.5 Performance Assay of Starter Broiler Chicks Fed Soaked-toasted Tallow Seed Meals

The results of the final body weight (FBW), average body weight gain (BWG), total feed intake (TFI), average daily feed intake (ADFI), average daily weight gain (ADWG) and feed conversion ratio (FCR) are presented in Table 6. There was no significant difference ($P>0.05$) in

all the parameters measured in this study across the treatment groups. Birds fed 0% diet had high FBW, BWG and TFI values of 454.84, 415.64 and 854.17 g/bird as against birds fed 20% STTSM diet having the lowest values of 445.40, 406.07 and 844.65 g/bird, respectively. Result of average daily weight gain and daily feed intake were not significantly ($P>0.05$) affected by partial replacement of levels of soaked-toasted dietary treatments. Similarly, FCR was not significantly ($P>0.05$) influenced by the processing method.

The performance characteristics of starter broiler chicks are shown in Table 6. The birds on 0% STTSM diet had the highest ($p<0.05$) average final weight of 454.84 g and weight gain of 415.64 g compared with 10 and 20% STTSM diets. The daily weight gain (ADWG) and daily feed intake (ADFI) were similar ($p>0.05$) across the dietary treatments. Although the variations obtained in the average daily feed intake (ADFI) of chicks fed 10 and 20% STTSM were lower than that of birds on 0% diets. The non-significant ($p>0.05$) decrease in the ADFI with increasing levels of partial replacement of STTSM for full fat soybean-based diet could be explained by elimination of residual anti-nutritional factors in detarium seed. The average daily weight gain (ADWG) followed the same trend with the ADFI. The highest ($p<0.05$) average daily weight gain (ADWG) of 14.84 g/bird/day was obtained in the birds fed the 0% STTSM diet. This was followed by those on 10 and 20% STTSM with respective values of 13.94 and 13.22 g/bird/day. The feed: gain ratio expressed as feed conversion ratio (FCR) of the birds fed 0% STTSM diet had the best value of 2.06 while the least value (2.28) was recorded by birds on the 20% STTSM. Depressed feed intake and growth have been reported with single treatment of toasted detarium seed at 10% inclusion level by Obun [3] due to residual tannins, oxalate, phytate, saponin and alkaloids

Table 6. Performance of starter broiler chickens fed soaked-toasted detarium seed meal

Parameters	% Dietary levels of STDSM			
	0	10	20	SEM
Initial body weight (g)	39.2	39.1	39.33	0.03
Average final body weight (g)	454.84	449.33	445.40	0.08
Average body weight gain/bird (g)	415.64	410.23	406.07	0.23
Average daily weight gain/bird (g)	14.84	14.65	14.50	0.23
Average total feed intake/bird (g)	854.17	848.29	844.65	0.30
Average daily feed consumed/bird (g)	30.51	30.30	30.17	0.07
Feed conversion ratio	2.06	2.07	2.08	0.05

ab Means with different superscripts are significantly different ($P<0.05$)

SEM: Source of error mean

in the toasted meal. The non significant FCR observed in birds fed soaked-toasted tallow based diets in this study agrees with reports of Uhegbu et al. [7] that integrated processing methods enhanced performance of animals compared with sole treatment.

The non significant differences in the performance of bird across the dietary treatments of this study are consistent with [44] who stated that process detarium seed meal can be included in the diets of monogastric animals as a protein source without any adverse effects. STTSM inclusion beyond 10% in the diet brought about a decline in body weight, feed consumption and conversion rate indicating the response of the birds due to decreased in crude protein of the diets and increase in dietary fiber content as the STTSM levels of inclusion increases. The absence of statistical significances ($p>0.05$) across the treatments is an indication of adequacy of the processing technique in reducing/eliminating the ANFs in the raw seeds. The similarity in feed intake across the treatments suggests that there was complete elimination of ANFs, especially tannin which interferes with digestive processes by binding to feed proteins, vitamins, minerals and digestive enzymes. Dietary hydrolysable tannins were also reported to retard growth eliminated. The slight variation in TFI values may had resulted from differences in body mass but not the effects ANFs which would have caused poor palatability of feed due to bitter tastes hence reduction in feed intake [45], bio degradability, poor protein digestibility and retarded growth [46].

4. CONCLUSION

It is concluded that processing of detarium seeds by soaking and toasting method enhanced the nutritional quality of this legume seeds. The processing method of soak-toasted reduced proximate composition, mineral elements, amino acid profile and ANFs to a tolerable level by starter broiler chickens. Soaked-toasted of tallow seed meal supported growth performance of starter chicks with no adverse effect. Detarium seed is therefore a good quality ingredient to partially replaced soybean meal in ration of broiler chickens. Further integrated processing methods are therefore recommended for study.

ETHICAL CONSIDERATION

The study was conducted with permission from the Nigeria Institute of Animal Science welfare

and ethics committee (Act No. 26 of 2007) in collaboration with the Department of Animal Production and Health, Federal University Wukari, Taraba State, Nigeria.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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