Nig. J. Anim. Prod. 2022, 49(4): 68-87. https://doi.org/10.51791/njap.v49i4.3705 *Nigerian Journal of Animal Production*

Performance, carcass features and economic indices of broilers fed diets supplemented with soaked and roasted *Jatropha curcas*

Ojo, R. J.,* Onowakpo, P. O., Olukahunsi, O. G., Shaba, O. A.
Department of Biochemistry, Faculty of Science and Technology, Bingham University Karu Nasarawa state, Nigeria
**Corresponding author's e-mail: saintlevites@yahoo.com ;*
Tel: +234- 8039217856
ORCID: 0000-0002-3246-7372

Abstract

Most African poultry farmers currently supplement the commercial feed with unconventional ingredients without recourse to their undesirable effects on the performance of the birds due to high cost of conventional poultry feed. This study therefore assessed the effect of commercial broiler finisher supplemented with soaked and roasted Jatropha curcas meal on performance, biochemical parameters, economic indices, carcass and organ features of broilers at the finisher phase. For the starter phase, the broilers were brooded for four weeks and fed with the standard commercial broiler starter diet before they were divided into their various experimental groups that received recomposed commercial broiler finisher containing 9.0% raw, soaked or roasted Jatropha curcas seed meal, respectively. After four weeks, blood samples were collected from each broiler for biochemical parameters. The performance, economic indices and carcass features were also assessed. The result revealed that inclusion of soaked and roasted Jatropha curcas in commercial diet resulted in significantly ($p<0.05$) decrease in the total cost of feed per kilogram body weight gain from ₦ 691.68 to ₦600.39. The cost of producing the roasted (₦993.67) and soaked (₦945.85) Jatropha curcas diet were also significantly lower than that of the control feed (commercial diet) (₦1,314.19). In terms of profit per kilogram weight gain per bird, the broilers fed soaked (₦1,199.61) and roasted (₦1,177.24) Jatropha curcas supplemented diets performed better than the control (₦1,108.32). Inclusion of detoxified Jatropha curcas reduced the feed conversion ratio from 2.67 to about 2.46.The carcass and organ characteristics of the broilers were not significantly affected ($p<0.05$) by soaked and roasted Jatropha curcas supplemented diet compare to the control, although the broilers fed with roasted and soaked Jatropha curcas presented 16.01% and 17.07% lower weight gain respectively. Similar packed cell volume (PCV) were observed in control (32.00 %) and the bird fed with the experimental diet (30.09% - 30.73%). Liver biomarkers (ALT, AST, ALP, bilirubin and serum total protein) and kidney biomarkers (uric acid, urea and creatinine) showed that soaking and roasting reduced the negative effect of Jatropha curcas inclusion in the diet. It did not also raise the lipid content of the broiler making it safe for consumers who are scare of cholesterol in chicken. This study therefore showed that locally processed Jatropha kernel meal in limited quantity can be added to commercial feed for broiler production at finisher's phase to increase the profit margin without deleterious effect on the performance of broilers.

Keywords: *Jatropha curcas*; broiler's feed; unconventional feed; economic indices; Poultry Performance

Performance, caractéristiques de carcasse et indices économiques des poulets de chair nourris avec des régimes alimentaires complétés par des *Jatropha curcas* trempée et rôti

Résumé

La plupart des aviculteurs africains complètent actuellement les aliments commerciaux avec des ingrédients non conventionnels sans recourir à leurs effets indésirables sur les performances des oiseaux en raison du coût élevé des aliments conventionnels pour volailles. Cette étude a donc évalué l'effet d'un finisseur de poulet commercial additionné de farine de Jatropha curcas trempée et torréfiée sur les performances, les paramètres biochimiques, les indices économiques, les caractéristiques de la carcasse et des organes des poulets de chair en phase de finition. Pour la phase de démarrage, les poulets de chair ont été couvés pendant quatre semaines et nourris avec un régime de démarrage de poulet de chair commercial standard avant d'être divisés en leurs différents groupes expérimentaux qui ont reçu un finisseur de poulet de chair commercial recomposé contenant 9,0 % de farine de graines de Jatropha curcas crues, trempées ou rôties, respectivement. Après quatre semaines, des échantillons de sang ont été prélevés sur chaque poulet de chair pour les paramètres biochimiques. Les performances, les indices économiques et les caractéristiques de la carcasse ont également été évalués. Le résultat a révélé que l'inclusion de Jatropha curcas trempé et rôti dans l'alimentation commerciale a entraîné une diminution significative ($p < 0,05$) du coût total de l'alimentation par kilogramme de gain de poids corporel de 691,68 ₦ à 600,39 ₦. Le coût de production du régime de Jatropha curcas torréfié (₦993,67) et trempé (₦945,85) était également significativement inférieur à celui de l'aliment témoin (régime commercial) (₦1 314,19). En termes de profit par kilogramme de gain de poids par oiseau, les poulets de chair nourris avec des régimes enrichis de Jatropha curcas trempés (₦1 199,61) et rôtis (₦1 177,24) ont obtenu de meilleurs résultats que le témoin (₦1 108,32). L'inclusion de Jatropha curcas détoxifié a réduit le taux de conversion alimentaire de 2,67 à environ 2,46. avec du Jatropha curcas torréfié et trempé ont présenté respectivement un gain de poids inférieur de 16,01 % et 17,07 %. Un hématocrite similaire a été observé chez le témoin (32,00 %) et chez l'oiseau nourri avec le régime expérimental (30,09 % - 30,73 %). Les biomarqueurs hépatiques (ALT, AST, ALP, bilirubine et protéines totales sériques) et les biomarqueurs rénaux (acide urique, urée et créatinine) ont montré que le trempage et la torréfaction réduisaient l'effet négatif de l'inclusion de Jatropha curcas dans l'alimentation. Il n'a pas non plus augmenté la teneur en lipides du poulet de chair, ce qui le rend sans danger pour les consommateurs qui ont peur du cholestérol dans le poulet. Cette étude a donc montré que la farine d'amandes de Jatropha transformée localement en quantité limitée peut être ajoutée à l'alimentation commerciale pour la production de poulets de chair en phase de finition afin d'augmenter la marge bénéficiaire sans effet délétère sur les performances des poulets de chair.

Mots-clés : *Jatropha curcas*; aliments pour poulets de chair; aliments non conventionnels ; indices économiques; Performances volailles

Introduction

Scarcity and exorbitant prices of conventional feed in developing countries has resulted in inadequate supply of poultry products and low intake of protein (Agboola, 2019; Esonu *et al*., 2020). The great impact of poultry on protein intake is due to the acceptance of poultry meat over beef due its higher protein, lower caloric content and its general acceptablities by almost every ethnic group or religion (Apata and Ojo, 2000;Cartoni *et al*., 2022; Jayaraman *et al*., 2013; Mir *et al*., 2017).Development of the poultry industry may therefore be the fastest means of bridging the protein-deficiency gap currently being experienced in the developing countries (Willems *et al*., 2013, Agboola, 2019, Esonu *et al*., 2020).

To solve the problem of inadequate feedstuff for poultry industry, livestock experts are currently focusing on cheap but suitable alternative feedstuff from less utilised crops, crop residues and industrial by–products to formulate a balanced ration that can replace the conventional feedstuff for poultry without compromising quality of the feed to sustain poultry industry (Esonu, 2008; Kenis *et al*., 2014). Use of unconventional feed ingredients would therefore possibly reduce the cost of poultry feed, guarantee feed security in the industry, increased profit for poultry producers and increased availability of cheaper poultry products in the developing countries.

Abundant sources of suitable unconventional feedstuff ingredients abound in Nigeria which include *Jatropha curcas which is* mainly cultivated for its inedible oil that is mainly converted into biodiesel (Ologhobo, 1992; Ojo *et al*., 2013; Ojediran *et al*., 2014). *Jatropha curcas is* resistant to a high degree of aridity, allowing it to be grown in deserts and barren lands that cannot support the growth of crops (Abd El-Hack *et al*., 2017; Fajingbesi *et al*., 2019). After extraction of the oil, the residue such as seed cake (seed meal) and shell which are regarded as waste products have been reported to contain high level of protein, substantial amount of energy and minerals with essential amino acids that are comparable with or higher than that of soybeans except lysine (Agboola, 2019; Kumar *et al*., 2008; Sumiati and Darmansyah, 2012).This makes Jatropha plant and its products a potential unconventional feedstuff for poultry (Kumar *et al*., 2008; Barros *et al*., 2015).

To substitute *Jatropha* meal for the conventional poultry diets, the anti-nutritional factors which are detrimental to the broilers' performance needed to be removed by physical, biological or chemical treatments (Aderibigbe *et al*., 1997; Belewu *et al*., 2013; Makkar and Becker, 1998; Makkar and Becker 1999; Ojo *et al*., 2013). These treatments are however, expensive and complex for most African poultry farmers in the rural areas making their use unrealistic. Therefore local processing methods such as soaking, roasting and fermentation are now being examine (Ojediran *et al*., 2018). Most of the experiment with *Jatropha* seed meal started the incorporation at the starter phase which usually result in high mortality. This study therefore departed from the tradition and assessed the effect of commercial broiler finisher supplemented with locally detoxified *Jatropha curcas* on performance, biochemical and economic indices of broilers at the finisher phase.

Materials and methods

Sample collection and preparation

Mature seeds of *Jatropha curcas* were collected from Agwada farm, asarawa state. The seed sample was divided equally into three parts then processed:

Raw: The seeds were oven-dried at 40^{o}C until constant weight was obtained

Roasted: The seeds were placed in roasting pan with dry sand and roasted at 160°C for 30 minutes with continuous stirring and the cooling.

Soaked: The seeds were soaked in a bowl of water at ratio 1:10 (w/v) for five days at room temperature (25°C) and then dried in oven at 40°C until constant weight was obtained. After each treatment, the seeds were hand-cracked. The kernels obtained were milled using a mechanical grinder, air dried at room temperature and passed through a sieve to separate and break up any crumps in the dry *Jatropha curcas* flour. They were stored in air tight containers to prevent contamination and spoilage.

Birds' management, experimental diet, duration of the study and experimental design

A total of 50 1-day old male Arbor acres broiler chicks were purchased from a reputable commercial hatchery. The broilers were raised for four weeks for starter phase then 5th-8th week on formulated finisher diet. For the starter phase, the chicks were randomly assigned into three groups and kept in a 4 m x 6 m well-ventilated broiler chicken barn for four weeks. During the test (day and night), the animals were heated by electric light (100 watts) ensuring luminosity and thermal comfort. The average temperature inside the experimental room was 31.6°C while the relative humidity was 37.7%. Commercial broiler starter obtained from a reputable feed manufacturing company and water were available *ad libitum*. Feed remnants were collected and weighed the day after the distribution. All routine vaccinations and necessary medication were administered to the birds as at when due. After four weeks, the chicks were randomly assigned into four treatment groups of 12 birds each with 3 replicates per treatment and kept in a 3m x 3m well-ventilated broiler chicken barn. Recomposed commercial broiler finisher from a reputable feed manufacturing company (same from starter) containing 9.0% raw, soaked or roasted *Jatropha curcas* seed meal, respectively and drinking water were made available *ad libitum* for the period of the study. The same managerial and experimental conditions were maintained for the finishers phase.

The four different dietary groups are:

Group 1(Control): Fed with normal commercial diet without *Jatropha curcas* .

Group 2 (Raw): Fed with experimental diet containing 9% raw *Jatropha curcas* seed meal by composition. Group 3(Roasted): Fed with experimental diet containing 9% roasted *Jatropha curcas* seed meal by composition.

Group 4 (Soaked): Fed with experimental diet containing 9% soaked *Jatropha curcas* seed meal by composition. Weight of the broilers were obtained at the beginning of the study (initial weight) and at the end of the study (final weight) using electronic balance.

Physical and clinical observations

The broilers were observed for any discharge, behavioural changes, change in weight, mortality and any appearance of pathological condition

Blood chemistry analysis

For PCV examination, blood samples were collected into ethylene diamine tetra-acetic acid (EDTA) bottles. Packed cell volume (PCV) was determined using Sysmex haematologic analyzer (Sysmex, KX-21, Japan). For other studies, blood samples were collected into plain tubes, the blood samples in the plain bottles were allowed to stand and clot about two hour. The blood samples were centrifuged at 3,500 rpm for 30 min to obtain the serum and stored at -10°C until when needed. Alanine Aminotransferase (ALT), Alkaline Phosphatase (ALP), Aspartate Aminotransferase (AST) Bilirubin, Urea, creatinine, uric acid, High density lipoprotein, Triglycerides, Total cholesterol

Table 1: Compositions of the experimental diet

Composition	CONTROL	RAW	ROASTED	SOAKED
Commercial diet (%)	100	91	91	91
Jatropha curcas (%)	0	9	9	9
Total (%)	100	100	100	100
Crude protein (%)	20	20.70	20.81	20.73
Crude fat (%)	10	13.23	12.92	12.27
Crude fibre (%)	9	8.74	8.83	8.64
Calcium (%)	1	1.05	1.03	1.02
Available phosphorous (%)	0.45	0.48	0.50	0.52
*Premix (%)	0.25	0.25	0.25	0.25
ME Kcal/Kg	2800.00	2851.09	2900.74	2904.84

Metabolizable energy (ME) calculation, ME= 37 × % CP + 81× % EE + 35.5 × % NFE was adapted from Augustine et al., 2020

*Premix per kilogram weight of diet provides *Composition of Premix per Kg of diet: vitamin A, 10,000 I.U; vitamin D3, 2,000 I.U; vitamin E, 40mg; vitamin K3, 2mg; vitamin B1, 3mg; vitamin B2, 5.5mg; niacin, 55mg; calcium pantothenate, 11.5mg; vitamin B6, 5mg; vitamin B12, 0.025mg; choline chloride, 500mg; folic acid, 1mg; biotin, 0 .08mg; manganese, 120mg; iron, 100mg; zinc, 80mg; copper, 8.5mg; iodine, 1.5mg; cobalt, 0.3mg; selenium, 0.12mg; Anti-oxidant, 120mg.

and Low density lipoprotein were determined using Randox kits. All the analytical kits were obtained from Randox agent in Abuja, Nigeria. The assays were performed according to the manufacturer's direction. Blood glucose was determine using glucometer. The protein concentration was determined according to Bradford method (1976).

Growth parameters, carcass analysis and economic Indices

Growth parameters and economic indices were estimated thus

Average daily feed intake (ADFI) (g/bird/day) = cumulative feed intake/ (number of birds x number of days); Average daily gain (ADG) (g/bird/day) = final weight gain-initial weight/number of days; Feed-gain ratio (FGR) = cumulative feed intake (kg)/total weight gain (kg); Feed cost per kg weight gain (₦) = Feed cost x total feed intake (kg)/total weight gain;

Income per kg weight gain bird (₦) = Selling price per bird/total weight gain (kg);

Profit per kg weight gain (₦) = Income per kg weight – feed cost/kg weight gain;

Economic efficiency of growth (EEG) = Profit per kg weight gain x 100/feed cost per kg weight gain.

After eight weeks, two broilers of similar weight per replicate from each treatment were taken and starved overnight and then slaughtered, the carcass were scalded in water bath at 80°C for 1 minute, de-feathered and eviscerated. The relative weight of the organs and cut parts were taken. Dressed weight, cut parts and organ weights were calculated as percentages of live weight.

Statistical analysis

The data are expressed as mean ± Standard deviation. Statistical analysis of the data was done using Graph Pad prism version 6 for Windows (GraphPad Software: San Diego California USA). The differences in various parameters within the groups and across the groups were investigated using one-way ANOVA. The p values $p < 0.05$ were considered significant.

RESULTS

Effect of commercial broiler finisher supplemented with soaked and roasted Jatropha curcas meal on the performance, carcass and organ characteristics of the broiler at the finisher's phase

The effect of inclusion of the *Jatropha curcas* in the commercial feed on broiler growth and performance at the finishers

phase is presented in Table 2.The average feed intake and daily feed intake per bird were affected by the inclusion of *Jatropha curcas* in the feed. Significant ($p<0.05$) decrease in feed intake was observed among the broilers fed with raw *Jatropha curcas* supplemented commercial diet. Inclusion of the raw *Jatropha curcas* in the commercial feed resulted in 39.77% decreased in feed intake while inclusion of roasted and soaked *Jatropha curcas* resulted in 19.76% and 23.27% decreased in feed intake respectively. The broilers fed with diets containing roasted and soaked *Jatropha curcas* presented 16.01% and 17.07% lower weight gain respectively compare with the control group fed with commercial diet without *Jatropha curcas*. The Inclusion of raw *Jatropha curcas* kernel meal in the commercial feed however had a significant negative effect on the body weight of the broilers ($p<0.005$), the birds fed with raw *Jatropha curcas* containing diet resulted in 55.45% reduction in body weight, making the weight loss significantly higher than the broilers fed with diets containing roasted and soaked *Jatropha curcas.*

The dietary treatments significantly affected ($p<0.05$) the feed conversion ratio. The highest value of 3.60 was observed in broiler chickens fed raw *Jatropha curcas* diet while the least value of 2.46 was recorded for broiler chickens fed with soaked *Jatropha curcas* diet. The total cost of feed per kilogram body weight gain decrease significantly ($p<0.05$) with the inclusion of soaked and roasted *Jatropha curcas*. The birds fed with raw *Jatropha curcas* diet however, had significantly higher ($p<0.05$) feed cost (₦868.92) per kg weight gain compare with the control (₦691.68). The cost of producing a kilogram of the roasted *Jatropha curcas* diet (₦622.75) and soaked *Jatropha curcas* diet (₦600.39) are however lower than that of the control fed with the commercial diet.

The profit per kilogram weight gain per bird was highest ($p<0.05$) for birds fed on soaked *Jatropha curcas* containing commercial diets (₦1,199.61) followed by those fed on the roasted *Jatropha curcas* containing commercial diet (₦1,177.24) while the least was from birds fed on raw *Jatropha curcas* diets diet (₦931.08). In terms of the profit per kilogram weight gain per bird, the broilers fed soaked or roasted *Jatropha curcas* containing commercial diets perform better than the control (Table 2). The effects of commercial broiler finisher supplemented with processed *Jatropha curcas* meal on carcass and organ characteristics of the broiler chickens are shown in Table 3. The carcass and organ characteristics of the broilers were not significantly affected ($p<0.05$) by soaked and roasted *Jatropha curcas* supplemented commercial diet compare to the control. However, the inclusion of the raw *Jatropha curcas* negatively affects all these characteristics (Table 3).

Effect of commercial broiler finisher supplemented with soaked and roasted Jatropha curcas meal on packed cell volume (PCV) and biochemical parameters of the broilers at the finisher's phase

The packed cell volume (PCV) of broiler fed on control diet was significantly ($P<0.05$) higher compared to the broilers fed with *Jatropha curcas* meal supplemented commercial diet Table 4. However, the PCV for the broilers fed with commercial broiler finisher supplemented with soaked and roasted *Jatropha curcas* meal were significantly ($P<0.05$) higher than the broilers fed with commercial broiler finisher supplemented with raw *Jatropha curcas* meal. They were also close to the control. There was no significant ($P<0.05$) difference between the two groups of broilers fed with commercial broiler finisher supplemented with soaked and roasted *Jatropha curcas* meal (Table 4). Parameters on liver biomarkers (ALT, AST, ALP, bilirubin and serum total protein)

***TABLE 2**: Effect of commercial broiler finisher supplemented with soaked and roasted Jatropha curcas meal on the performance of the broiler at the finisher phase*

	CONTROL	RAW	ROASTED	SOAKED
Initial Weight(g)	856.00±22.98	851.50± 7.69	857.4 ±35.08	867.60± 28.07
Final Weight(g)	2756 ±89.62^{a}	1698.00±107.5^{c}	2453±49.86^{b}	2443±56.96^{b}
Change in body weight(g)	1900^{a}	846.50^{c}	1595.60^{b}	1575.40^{b}
Daily weight gain (g)	67.85^{a}	30.23^{c}	56.99^{b}	56.27^{b}
Daily feed intake (g/day)	180.52^{a}	108.73^{b}	144.85^{c}	138.52^{c}
Feed conversion ratio	2.67^{b}	3.60^{a}	2.54^{b}	2.46^{b}
Cost of feed ((₦)/kg)	260^{a}	241.60^{b}	245.00^{b}	243.90^{b}
Total Cost of feed Consumed for 28 days (₦)	1,314.19^{a}	735.54^{c}	993.67^{b}	945.85^{b}
Cost of Feed per kg weight gain (₦)	691.68^{b}	868.92^{a}	622.75^{c}	600.39^{c}
**Income from the increase in body weight(₦)	3,420.00^{a}	1,523.70^{c}	2,872.08^{b}	2,835.72^{b}
PROFIT from the weight gain(₦)	2,105.81	788.16	1,878.41	1,889.87
Profit per kg weight gain (₦)	1108.32	931.08	1177.24	1199.61
Economic efficiency of growth (EEG) (%)	160.24	107.15	118.47	126.83

NOTE: COMMERCIAL FEED= ₦6, 500/25kg of broiler finisher ** 2.5kg live broiler cost ₦4,500. $1= ₦485

***TABLE 3**: Effect of commercial broiler finisher supplemented with soaked and roasted Jatropha curcas meal on Carcass and organ characteristics of the broiler at the finisher's phase*

	CONTROL	RAW	ROASTED	SOAKED
Live Weight(g)	2756 ±89.62^{a}	1698±107.50^{b}	2453±49.86^{a}	2443±56.96^{a}
Dressed weight (g)	2654 ± 67.34^{a}	1448± 90.44^{c}	2343± 54.33^{b}	2318 ± 62.00^{b}
Eviscerated wt. (g)	2254 ± 12.73^{a}	1128 ± 10.80^{b}	2003 ± 15.52^{b}	2000± 18.81^{b}
Dressing percentage (%)	81.78 ± 2.97^{a}	66.43 ± 3.07^{b}	81.66 ± 4.58^{a}	81.87± 2.60^{a}
Head (%)	3.24± 0.13 ^{a}	2.73 ± 0.10^{b}	3.00± 0.15 ^{a}	3.16 ± 0.18 ^{a}
Breast (%)	21.62 ± 0.30^{a}	16.00± 1.20^{b}	20.90 ± 0.5 ^{a}	22.09 ± 0.75 ^{a}
Thigh (%)	10.81 ±0.78^{a}	8.00 ±1.08^{b}	11.00±0.92^{a}	10.53±0.85^{a}
Drumstick (%)	10.81 ±0.15^{a}	8.00 ±0.25^{b}	11.00 ±0.20^{a}	10.53 ±0.17^{a}
Wing (%)	8.65 ±0.78^{b}	7.00 ±1.52^{c}	9.00 ±0.80^{a}	8.42 ±0.96^{b}
Back (%)	16.22 ±0.32^{a}	15.00 ±0.65^{b}	16.00 ±0.28^{a}	16.79 ±0.40^{a}
Neck (%)	3.24± 0.18 ^{b}	3.00 ± 0.23 ^{b}	4.00 ± 0.22^{a}	3.96 ± 0.16^{a}
Shank (%)	5.41± 0.39 ^{a}	4.00± 0.61 ^{c}	5.00 ± 0.46 ^{b}	5.21 ± 0.57 ^{a}
Heart (%)	0.51 ± 0.01 ^{b}	1.20± 0.02 ^{a}	0.62 ± 0.03 ^{b}	0.60 ± 0.01 ^{b}
Spleen (%)	0.13± 0.02 ^{b}	0.21 ± 0.03^{a}	0.11± 0.01 ^{b}	0.14 ± 0.02 ^{b}
Lungs (%)	0.82 ±0.03^{b}	1.05±0.06 ^{a}	0.76 ±0.03 ^{b}	0.81 ±0.02 ^{b}
Liver (%)	3.64± 0.41 ^{b}	4.00 ± 0.20 ^{a}	3.53 ± 0.24 ^{b}	3.73± 0.20 ^{b}
Kidneys (%)	0.73 ±0.04^{b}	0.90 ±0.06^{a}	0.69 ±0.08^{b}	0.74±0.09 ^{b}
Proventriculus (%)	0.91 ± 0.03^{b}	1.00 ± 0.04^{b}	1.18 ± 0.06^{a}	1.25 ± 0.08^{a}
Gizzard (%)	2.73 ± 0.28^{b}	3.00 ± 0.31^{b}	3.53 ± 0.32^{a}	3.75 ± 0.38^{a}

The values are expressed as mean ± standard deviation of observation from six birds
Means with the same superscripts in the same column are not significantly different (P<0.05). Values in percentage are calculated from percentage of live weight

presented in Table 4 indicated that feeding the broilers with *Jatropha curcas* diet led to significant increase (P < 0.05) in ALT, AST, ALP, bilirubin and blood glucose but significant decrease in serum total protein compared with broilers fed with the control diet. However, all the biomarkers examined were significantly lower (p<0.05) than the broilers fed on the raw *J. curcas* supplemented commercial diet except for serum protein concentration which was significantly higher (p<0.05).The serum uric acid, urea and creatinine levels of the broiler fed commercial broiler finisher

supplemented with soaked and roasted *Jatropha curcas* meal were significantly (P<0.05) lower than the broilers fed commercial broiler finisher supplemented with raw *Jatropha curcas* meal. However, they were higher than the control. This showed that soaking and roasting reduced the anti-nutritional content in the raw samples that resulted in the negative effect of *Jatropha curcas* meal (Table 4).

The dietary inclusion of roasted and soaked *Jatropha curcas* in the broilers' diet resulted in increases in total cholesterol, HDL cholesterol, LDL cholesterol and triglycerides when compared to the control group. However, the processing of the *Jatropha curcas* resulted in significant decrease (P < 0.05) in the lipid profile of the bird fed with roasted and soaked *Jatropha curcas* diet compare with those fed with raw *Jatropha curcas* containing diet (Table 4).

TABLE 4 Effect of commercial broiler finisher supplemented with soaked and roasted Jatropha curcas meal on packed cell volume (PCV) and biochemical indices

PARAMETERS	CONTROL	RAW	ROASTED	SOAKED
Packed Cell Volume (%)	32.00 ± 1.41^{a}	27.55 ± 1.04^{c}	30.73 ± 1.85^{b}	30.09 ± 0.94^{b}
ALT(U/L)	69.00 ± 3.44^{d}	182.40 ± 7.60^{a}	104.80 ± 2.64^{c}	115.80 ± 3.69^{b}
AST(U/L)	27.86 ± 0.57^{c}	52.68 ± 1.77^{a}	31.26 ± 0.89^{b}	30.85 ± 1.05^{b}
ALP(U/L)	33.01 ± 0.70^{d}	75.41 ± 2.36^{a}	47.73 ± 0.75^{c}	57.95 ± 0.83^{b}
Bilirubin(mg/dl)	0.68 ± 0.02^{c}	1.58 ± 0.15^{a}	1.24 ± 0.05^{b}	1.41 ± 0.04^{b}
Serum Protein (mg/dl)	3829 ± 147.80^{a}	2767 ± 156.8^{b}	3721 ± 160.90^{a}	3881 ± 9.29^{a}
Serum glucose (mg/dl)	157.8 ± 2.82^{c}	267.9 ± 4.51^{a}	180.4 ± 1.93^{b}	186.7 ± 1.47^{b}
Uric acid(mg/dl)	24.86 ± 1.40^{d}	49.41 ± 1.99^{a}	35.65 ± 1.99^{b}	31.96 ± 0.84^{c}
Creatinine (mg/dl)	0.48 ± 0.06^{c}	1.64 ± 0.17^{d}	0.37 ± 0.07^{b}	0.53 ± 0.10^{b}
Urea (mg/dl)	7.966 ± 1.04^{d}	24.91 ± 1.33^{a}	10.90 ± 1.25^{c}	13.46 ± 1.41^{b}
SerumCholesterol(mg/dl)	113.6 ± 2.49^{d}	127.7 ± 2.02^{a}	120.8 ± 1.99^{b}	118.7 ± 6.27^{b}
Triglycerides (mg/dl)	101.1 ± 5.01^{d}	191.1 ± 5.91^{a}	127.5 ± 3.01^{b}	121.3 ± 2.30^{b}
HDL-cholesterol (mg/dl)	39.63 ± 2.32^{a}	44.06 ± 4.37^{a}	37.75 ± 1.65^{b}	39.89 ± 1.90^{b}
LDL-cholesterol (mg/dl)	15.75 ± 1.56^{d}	42.90 ± 1.01^{a}	25.44 ± 1.40^{b}	21.65 ± 2.50^{c}

The values are expressed as mean ± standard deviation of observation from eleven birds
Values with different alphabets in a column are significantly different from each other (p<0.05

Mortality

There was no mortality recorded for birds on commercial broiler finisher, commercial broiler finisher supplemented with soaked and roasted *Jatropha curcas* kernel meals. However, four broilers died among the birds fed with raw *Jatropha curcas* supplemented diet in the first week of the finishers phase. One each died in the two of the replicate while two birds died in the third replicate.

Discussion

Effect of commercial broiler finisher supplemented with soaked and roasted Jatropha curcas meal on the performance, Carcass and organ characteristics of the broiler at the finisher's phase

The commercial broiler finisher supplemented with *Jatropha curcas* kernel meals influenced the weight, feed intake, feed conversion ratio, total cost of feed consumed/bird and cost of feed/kg weight gain of the broiler to some extent depending on whether the seed were detoxified (soaked or roasted) or not before their inclusion. It was observed that broilers fed with commercial broiler finisher supplemented with raw *Jatropha curcas* diet performed poorly in all the parameters measured than the control group. This decline could be attributed to the reduction in feed intake, poor utilization of nutrients and poor feed conversion due to the presence of anti-nutritional factors in the

meal (Goel *et al.,* 2007; Ani and Omeje, 2011). Anti-nutrients such as trypsin inhibitors in raw *Jatropha curcas* kernel meals is known to reduce protein digestibility in diet resulting in poor utilization of available nutrients, tannins negatively affects palatability and general acceptability of the diet which can result in decrease in feed intake and utilisation while phorbol esters in the diet even at very low concentrations is known to significant reduce feed intake and growth rate (Abdel-Shafy *et al.,* 2011; Goel *et al.,* 2007; ; Pasaribu et al., 2010). The same result has been reported by Agboola and Adenuga, (2015), who reported significant weight loss in growing Japanese quails fed *Jatropha curcas* kernel meals. On the other hand, the improved performance of the broiler fed with soaked and roasted *Jatropha curcas* supplemented commercial diet could probably be as a result of the decrease in antinutritional factors in the soaked and roasted seeds *which significantly* improve the feed intake and growth rate of the birds (Ani and Omeje, 2011; Goel *et al*., 2007; Makkar and Becker, 1997; Sumiati *et al*. 2011). This is in agreement with Ojediran *et al.* (2016), Antyev *et al*. (2017) and Ojediran and Emiola (2018) who observed that a combination of different local detoxification methods improved average daily feed intake, average daily weight gain, final weight and feed conversion ratio of broilers fed with locally detoxified *Jatropha curcas supplemented diet* as a result of reduction in antinutritional content of the feed and with Alatise *et al*. (2014), Abozaid *et al*. (2016) and Musa *et al*. (2018) when detoxified Jatropha kernel meal was substituted for soybean in fish meal. This study did not measured the levels of phorbol esters as well as curcin, but given the performance of the broiler on locally processed *Jatropha curcas supplemented diet*. It is possible to conclude that the remaining phorbol esters as well as curcin in the feed were not sufficient enough to cause poor consumption and poor weight gain as observed in the raw *Jatropha curcas* supplemented diet. Positive response of the broilers to detoxified *Jatropha curcas* supplemented diet indicates increase in acceptability and palatability of the detoxified *Jatropha curcas* supplemented diet probably due to significant reduction in anti-nutritional factors which makes it compare favourably with those fed the control diet (Aregheore 2003; Belewu and Sam, 2010;Kumar et al., 2011).The finding on feed conversion ratio (FCR) agreed with the findings of Adeyina et al.,(2010) who postulated that inclusion of detoxified *Jatropha curcas* kernel meals had no remarkable effect on feed conversion ratio (FCR) in albino rats and Pasaribu *et al*. (2010) who reported no significant effect of Jatropha seed meal on feed conversion ratio of broiler chickens .

There was no mortality recorded for birds on commercial broiler finisher supplemented with soaked and roasted *Jatropha curcas* kernel meals in this study. This was contrary to the observation of Agboola and Adenuga (2015) who reported high mortality in growing Japanese quails fed 10-15% *Jatropha curcas* based diets. The current result could be due to the well-developed gastrointestinal tract of the broiler at finisher phase which help in metabolizing the anti-nutrients in Jatropha seed cake-based diets compared to Japanese quails (Agboola, 2019). Also enzyme system of the broilers at this stage might have developed to handle the residual anti-nutritional factors in the diet which may be responsible for mortality observed when the inclusion started at starter phase (Esonu *et al*, 2008; Singh et al*.,* 2003).

The merit or demerit of any diet are usually determined by the price of the feedstuffs at the time of use and the current prices of live

and dressed chickens in the area (Ojewola, 1993). The commercial broiler finisher supplemented with *Jatropha curcas* kernel meals influenced the cost of the feed per kg weight gain, income from the increase in body weight and profit per kg weight gain. There was reduction in the cost of the feed/kg in broilers fed with commercial broiler finisher supplemented with soaked and roasted *Jatropha curcas* kernel meals compare with the control. This observation agreed with the reports of *Duwa et al. (2014)* who reported reduction in the feed cost/kg with the inclusion of banana peel meal in broiler diets. The high cost of feed/kg body weight in the control group was due to the exorbitant price of commercial feed during the study but this was lowered by using *Jatropha curcas* kernel meals **(**Apata and Ojo, 2000**)**. The high cost of production per broiler in control group compare with the other dietary treatments except the group fed raw *Jatropha curcas* kernel meals containing diet may be due to the high feed consumption recorded in the control group. The inclusion of raw *Jatropha curcas* kernel meals resulted in lowest rate of return on investment and economic efficiency compared with the control group and other dietary treatments. The rate of return on investment and economic efficiency on commercial broiler finisher supplemented with soaked or roasted Jatropha *curcas* kernel meals was however higher than the control. This observation agrees with the findings of Zakaria *et al*. (2008). The disparity between broilers on treated diets compared to control diet was probably due to reductions in final body weight. This result showed that inclusion of 9% soaked or roasted *Jatropha curcas* kernel meals in the commercial feed will consequently lead to reduced cost of poultry production and increased profit for poultry producers.

The inclusion of raw *Jatropha curcas* in the commercial diet influenced the live weight, dressed weight, eviscerated weight and the dressing percentage but inclusion of soaked and roasted *Jatropha curcas* did not have significant negative effect on these parameters. The dressing percentage obtained are higher than that of Esonu *et al*. (2008) who reported 74.82 - 77.39% and Lamidi *et al*. (2008) who obtained 69.49 - 73.98%. The raw *Jatropha curcas* based diets also influenced the cut up parts (percentage of live weight) of the broiler chickens but detoxified *Jatropha curcas* did not have this effect. This agrees with the reports Fafiolu *et al*. (2015) who reported no differences in the weight of the cut up parts, dressed weight and harvested organs of Marshall broiler chickens fed palm kernel extraction residue and palm kernel sludge based diets. The enlargement of the organs, especially the liver and spleen of broilers fed with raw *Jatropha curcas* diet could be due to increased detoxification activities in an effort to eliminate the residual toxin in the diet **(**Diarra *et al*., 2017).

Effect of commercial broiler finisher supplemented with soaked and roasted Jatropha curcas meal on packed cell volume (PCV) and biochemical parameters of the broilers at the finisher's phase

The reduction in the packed cell volume (PCV) of broiler fed with commercial broiler finisher supplemented with raw *Jatropha curcas* kernel meals may be attributed to the negative effects of high concentration of anti-nutritional factors in the raw seeds. The better PCV values exhibited by the broiler fed commercial broiler finisher supplemented with soaked or roasted *Jatropha curcas* kernel meals compare to the broiler fed the raw *Jatropha curcas* seed meal-based diets is an indication that the processing methods resulted in reduction in the antinutritional factors in the processed seeds. Similar

observation was made by Igene *et al*. (2012) when they fed processed pigeon pea seed meal to broiler.

Broiler fed the control diet and commercial broiler finisher supplemented with soaked or roasted *Jatropha curcas* kernel meals showed significantly (P<0.05) lower lipid profile compared to the groups fed with raw *Jatropha curcas* seed meal-based diets. This may be due to the reduction in the anti-nutritional factors by the processing methods used (Isidahomen *et al*., 2011). These results agree with Ojo *et al.* (2013) and Ojediran *et al*. (2014) who discovered that inclusion of Jatropha curcas at different levels from 4 to 12% in broiler diets caused an increase in serum lipids but contradict the finding of Zunft, *et al*., (2003) who reported that the anti-nutritional factors in feed can reduce fats and cholesterol levels in tissues. This result also indicate that the broiler fed with commercial broiler finisher supplemented with soaked or roasted *Jatropha curcas* kernel meals will be safe for consumers who earlier had reduced or stopped the consumption of chicken due to cholesterol scare (Onyimonyi *et al*., 2012).

The ALT, AST and Alkaline phosphatase of the broiler were significant (P<0.05) affected by *Jatropha curcas* supplementation. The significant (P<0.05) increase in the levels of these enzymes in broiler fed with raw *Jatropha curcas* kernel meals supplemented commercial broiler finisher might be due to the adverse effects of the anti-nutritional factors in the diet on the liver of the broilers which indicates that the broiler fed on the raw seed meal might have suffered from certain liver problems. However, the significant lower level of the biomarkers in the broilers fed with the processed *Jatropha curcas* kernel meals supplemented commercial broiler finisher indicated that the processing methods used effectively reduced the levels of the anti-nutritional factors present in the seed meal (Akinmutimi and Onen, 2008; Bahman *et al*., 2014; Ojediran et al.,2015). This agreed with the findings of Ojo et al. (2013) who fed broilers with graded levels of raw *Jatropha curcas* based diets and concluded that increase in these biomarkers is an indication that the hepatic capacity of the liver was grossly affected by *Jatropha curcas* which is an indicator of the hepatotoxic effects of raw *Jatropha curcas* on the liver cells leading to leakage of these enzymes from damaged hepatocytes into the bloodstream (Nabi *et al*., 2011)

The total protein concentrations were significantly (P<0.05) affected by the dietary treatments. The total protein values were significantly (P<0.05) lower in the group of broiler chickens fed the raw *Jatropha curcas* kernel meals supplemented commercial broiler finisher compared to the control and the processed *Jatropha curcas* kernel meals supplemented commercial broiler finisher. The decreased in the values of total protein are indications of inadequate protein utilization and also liver impairment resulting to low synthesis and production of protein especially, albumin (Augustine *et al*., 2020; Thapa and Walia, 2007). The total bilirubin of the broiler chickens fed the experimental diets were significantly (P<0.05) affected by the diets. The broiler chickens fed the raw, soaked and roasted *Jatropha curcas* kernel meals supplemented commercial broiler finisher recorded higher (P<0.05) values indicating adverse effect of anti-nutritional factors on the liver. This is in line with the report of Ojo *et al.*, (2013) who reported that high levels of bilirubin in blood is a reflection of liver damage and progressive impairment. This is connected to the adverse effects of residual anti-nutritional factors present in the raw seed meal. The lower levels of bilirubin in broiler chickens fed the boiled and soaked *Jatropha curcas* kernel meals supplemented commercial broiler finisher showed that the different processing

methods used were able to reduce the levels of the anti-nutritional factors which resulted in better protein utilization in broiler fed the processed seed meal-based diets. This is reflected by the closeness of the values for the total protein to the normal range.

Creatinine is a breakdown product of creatine. It is mainly produced at a fairly constant rate by the body and filtered out of the blood by the kidneys. If the filtering capacity of the kidney is deficient, the blood creatinine level rises (Nwanjo *et al*., 2005). The significant elevation of creatinine and urea is an indicator of renal dysfunction or damage in the broiler given *Jatropha curcas* kernel meals supplemented commercial broiler finisher (Isidahomen *et al*., 2011; Ojediran *et al*., 2012; Ojo *et al*.,2013).*This has been linked to* anti-nutrients in *Jatropha curcas (*Ojo *et al.*, 2013; Ojediran *et al.*, 2015) but the low value recorded for the broilers fed with the processed diet is an indication of the reduction in these antinutritional factors in these diets (Daramola, 2019**).**The serum uric acid levels of the broiler chickens were significantly ($P<0.05$) higher in the broiler chickens fed the raw *Jatropha curcas* seed meal-based diets compared to the other groups.Increase in uric acid levels can be linked to poor protein quality, poor protein utilization and kidney abnormalities(Thapa and Walia (2007). The high concentration of anti-nutritional factors in the raw seed meal might be responsible for this observed effect **(**Reed *et al*., 1995;Abiola *et al*., 2001).

Conclusion

This study showed better biochemical values, superior weight gain *and feed conversion ratio* in broiler fed with the commercial broiler finisher supplemented with soaked and roasted *Jatropha curcas* compare with the broilers fed with raw *Jatropha curcas. The inclusion of* soaked and roasted *Jatropha curcas* also reduced feed cost and cost of meat produced per kilogram body weight. *N*o mortality was recorded for birds fed with commercial broiler finisher supplemented with soaked or roasted *Jatropha curcas*, though there was little alteration in the biomarkers examined. In addition the performance and economic indices of the broilers were similar to the control. This study therefore showed that soaked and roasted *Jatropha curcas* kernel meal in limited quantity can be added to commercial feed for broiler production at finisher's phase to increase the profit margin without significant deleterious effect on the performance of the birds.

Competing interests

The authors declare that they have no competing interests

Compliance with Ethical Standard

Animals were humanely cared for in compliance with the principles of laboratory Animal care as stated by Bingham University Karu Nasarawa State, Nigeria.

Acknowledgement

The authors thank all the staff in the animal house, Bingham University Karu for their technical suggestion and assistance in handling the animals.

References

Abd El-Hack, M. E., Alagawany, M, El-Sayed, S. A. A *and* Fowler, *J.* 2017. Influence of dietary inclusion of untreated or heat-treated *Jatropha meal* on productive and reproductive performances and performance and biochemical blood parameters of laying Japanese quail. *Poultry science*, 96:761 2767.

Abdel-Shafy, S., Nasr, S. M., Abdel-

Rahman, H. H. and Habeeb S. M. 2011. Effect of Various Levels of Dietary Jatropha curcas seed Meal on Rabbits Infested by the Adult Ticks of Hyalomma Marginatum Marginatun in Animal Performance, Anti-tick feeding and Haemogram. *Tropical Animal Health Production.* 43 (2): 347-357 **https:// doi.org/ 10.1007 /s11250-010-9696-x**

Abiola, S. S. 2001. Haematological indices and serum metabolites of cockerel fed hatchery waste meal diets. *Tropica. Veterinian*, 18:79-84.

Achten, W. M. J., Mathijs, E., Verchot, L., V. P., Singh, Aerts, R. and Muys. B. 2007. *Jatropha* biodiesel fueling sustainability? Biofuels, Bioproducts and Biorefining. *The Jatropha Archives,* 1 (4): 283-291. https://doi.org/10.1002/bbb.39.

Achten, W. M. J., Verchot, L., Franken, Y. J. Mathijs, E., Singh, V. P., Aerts, R and Muys B . 2008. *Jatropha* bio-diesel production and use (a literature review). *Biomass and Bioenergy.The Jatropha Archives,* 32(12): 1063-1084.https://doi.org/ 10.1016/ j.biombioe.2008.03.003

Adebayo O. T., Fagbenro, O. A. and Jegede, T. 2004. Evaluation of *Cassia fistula* meal as a replacement for soybean meal in practical diets of *Oreochromis niloticus* fingerlings. *Aquaculture Nutrition*, 10(2): 99-104. https://doi.org/10.1111/j.1365-2095.2003.00286.x

Aderibigbe, A. O., Johanson, C. O. L. E., Makkar, H. P. S., Becker, K. and Foid, N. 1997. Chemical composition and effect of heat on organic matter and nitrogen degradability and some antinutritional components of Jatropha meal. *Animal Feed Science and Technology*, 67:223–243. https://doi.org/10.1016/s0377-8401(96)01136-4

Adeyina, A. O., Yousuf, M. B and Ogunjimi, K. B. 2010. Detoxification of *jatropha curcas* seeds for use in nutrition of monogastric livestock as alternative feedstuff. *Pakistan Journal of Nutrition,* 9(9):902–904. https://doi.org/10.3923/pjn.2010.902.904

Agboola, A. F. 2019. Effects of Heat Treated Jatropha Seed Cake-Based Diets on Performance and Blood Meta-bolites in Broiler Chickens. *Journal of Experimental Agriculture International 29 (3): 1-6* . ***https://doi.org/10.9734/jeai/2019/45597***

Agboola, A. F. and Adenuga A. A. 2015. Performance and organ histopathology of growing Japanese quails (Coturnix coturnix japonica) fed heat treated Jatropha seed cake substituted for soyabean meal. *Tropical Animal Production Investigation*, 18: 1-8.

Akinmutimi, A. H. and Onen, G. E. 2008. The response of broiler finisher birds fed graded levels of yam peel meal in place of maize-based diets. *International Journal of Poultry Science*, 7(5), 474–479.**https://doi.org/10.3923/ijps. 2008.474.479**

Alatise S. P., Adedokun, M. A., Adelodun, O. B. and Ajiboye, G. E. 2014. Effects of Boiled Jatropha Kernel Meal as a Substitue for Soybeas Meal in Diet of African Mud

Catfish (*Clarias gariepinus*) Fingerlings. *Journal of Fisheries and Aquatic Science. 9: 446-454. https://doi.org/10.3923/jfas.2014.446.454*

Ani, A. O. and Omeje, O. D. 2011. Effect of Enzymes Supplementation of raw Bambara nut (*Vigna Subterranea* (L) Verde) waste diet on nutrient utilization and Haematological parameters of broiler finisher.Anim.Prod Res; Adv., 7 (1):74-80.

Antyev, M., Yakubu, B., Aliyara Y. H. and Wafar, R. J. 2017. Effects of Processing Methods of *Jatropha curcas* seed Meal on Growth Performance and Blood profile of broiler finisher chickens.*Asian Research Journal of Agriculture*, **4**(4): 1-9. https://doi.org/10.97 34/arja /2017/33690

Apata, D. F. and Ojo, Y. 2000. Efficacy of the *Trichoderma viride* enzyme complex in broiler starter fed cowpea Testa Based Diets. *Proceedings of 25th Annual Conference of Nigerian Society for Animal Production*. March 19-23, 2000: 132-134.

Aregheore, E. M., Becker, K and Makkar, H. P. S. 2003. Detoxification of a toxic variety of *Jatropha curcas* using heat and chemical treatments, and preliminary nutritional evaluation with rats. South Pacific Journal of Natural Science. 21:50-56. https://doi.org /10.1071 /sp03010

Association of Official and Analytical Chemists. 2015. Official Methods of Analysis. Arlington, USA.

Augustine, C., Igwebuike, J. U., Kwari, I. D., Adamu, S. B., John, T., Ardo, M. U., Katsala, J. G. Obidah, L. U., Maspalma, A. J., Shall, M. P. and Ahmed, S. 2020. Haematological and Biochemical Parameters of Broiler Chickens Fed Processed or Raw Tropical Sickle Pod (*Senna obtusifolia*) Seed Meal-Based Diets. *Life Sci J.;* 17(1):80-89

Barros, C. R., M. A. M. Rodrigues, F. M. Nunes, M. C. M. Kasuya, J. M. R. Da Luz, A. Alves, L. M. M . Ferreira, V. Pinheiro, and J. L. Mour˜ao, 2015. The effect of Jatropha curcas seed meal on growth performance and internal organs development and lesions in broiler chickens. *British Journal of Poultry. Sci*ence, 17,(1) 6.https://doi.org/10.1590/1516 635xspecialissuenutrition-poultryfeedingadditives001-006

Belewu, M.A., Belewu, K.Y., Lawal. I.A., 2013. Cocktail of Fungi Blend on Jatropha curcas Kernel Cake: Effect on Feed Intake and Blood Parameters of Goat. *American- Eurasian J. Agric. & Environ. Sci.,* 13 (3), 315-320. doi: 10.5829/idosi.aejaes .2013.13 .03.1502

Belewu, M.A. and Sam, R. 2010. Solid state fermentation of Jatropha curcas kernel cake: Proximate composition and anti-nutritional components. *Journal of Yeast and Fungal Research*, 1 (3): 44-46.

Berenchtein, B., Abdalla, A.L. Do Prado, T..P., Sbardella, M., Louvandini, H., Filho, A. L. A., Dhanasekaran, D., Dos Santos, P. P. 2014. Effects of detoxified *Jatropha curcas* kernel meal in finishing pig diets on their performance, carcass traits, meat quality and intoxication. *Livestock Science*, 165,100-

103.https://doi.org/10.1016/j.livsci. 2014.04.005

Cartoni Mancinelli, A.; Mattioli, S.; Twining, C.; Dal Bosco, A.;Donoghue, A.M.; Arsi, K.Angelucci, E.; Chiattelli, D.; Castellini, CB.2022. Poultry Meat and Eggs as an Alternative Source of n-3 Long-Chain Polyunsaturated Fatty Acids for Human Nutrition. Nutrients, 14, 1969. https://doi.org/10.3390/nu14091969

Daramola, O. T., Oloruntola, O. D. and Ayodele, S. O. 2017. Effect of varying levels of Vernonia amygdalina leaf meal on lipid profile and serum metabolites of broiler chickens. Pages 623-626. In: Adeloye, A. A., Oyawoye, E. O., Toye, A. A. And Adesina, B. T. (Eds.). Proceeding of the 42nd Annual Conference, Nigerian Society for Animal Production (NSAP). Held at Landmark University, Omu- Aran, Kwara State, Nigeria, 26 – 30th March, 2017.

Diarra S. S., Sandakabatu, Perera, D., Tabuaciri, P. and Mohammed U. 2014. Growth performance, carcass measurements and organ weight of broiler chickens fed cassava copra meal-based or commercial finisher diets in Samoa. *Asian Journal of Poultry Science*.8(1):16-22. https://doi.org/10.3923/ajpsaj.2014.16.22

Duwa, H., Saleh, B., Lamido, M. and Saidu, A. 2014. Growth, Haematological and serum biochemical indices of Broiler chickens fed Banana peel meal as replacement for maize in the semi-Arid zone of Nigeria. *Online Journal of Animal and Feed Research* 4(50), 121 - 126.

Esonu, B. O., Azubuike, J. C., Emelalom, O. O., Etuk, E. B., Okoli, I. C., Ukwu, H. O. and Nneji, C. S. 2004. Effect of Enzyme supplementation on the performance of broiler finisher fed Microdesmis puberula leaf meal. International Journal of Poultry Science. 3,112-114. **https://doi.org/10.3923/ijps.2004.112.114**

Esonu, B. O., Ogbonna, U. D., Anyanwu, G. A., Ukpabi, U. H., Azubuike, F. C. And Odoemelam, V.2020. Chemical and nutritive evaluation of Jatropha curcas leaf meal in broiler chicken diets. Nigerian Journal of Animal Production. 47(4):176–183. **https://doi.org/10.51791/njap.v47i4.80**

Esonu, B. O., Udedibie, A. B. I., Emenalom, O. O. Madumere, C. C. and Ucheghu, O. A. 2008. Evaluation of oil palm (Elaeis guinensis) leaf meal as feed ingredient in broiler diets. *Nigeria Journal of Animal Production* 35(1), 32 - 39.

Fafiolu, A. O., Jegede, A. V., Teniola, A. A., Olarotimi, I. D., Odukoya, S. O., Alabi, J. O. and Oduguwa, O. O. 2015. Performance, Carcass characteristics and apparent nutrient digestibility of broiler chickens fed palm-kernel extraction by-products. *Nigerian Society for Animal Production*. 42(1), 110 - 117. https://doi.org/10.51791/njap.v42i1.842

Fajimi, A. O., Babatunde, G. M., Ogunlana, F. F. and Oyejide, A. 1993. Comparative Utilization of Rubber Seed Oil and palm oil by

broilers in a humid tropical environment. *Animal Feed Science and Technology,* 43:177-188.

Fajingbesi, A. O., Whong, C. M. Z., Ameh J. B., Anzaku A. A., Balogun,O., Oche,O.D. Yusuf I. and Ibrahim, B. 2019. Detoxification And Anti-Nutrient Reduction of J. *Curcas* Seed Cake by Fermentation Using *Bacillus Coagulans*. *World Journal of Pharmaceutical and Medical Research*, 5(1), 01-08.

Goel, G., Makkar, H. P. S., Francis, G. and Becker, K. 2007. Phorbol esters: structure, biological activity, andtoxicity in animals. *International Journal of Toxicology*, 26 (4), 279-288. **https://doi.org/10.1080/10915810701464641**

Igene, F. U., Isika, M. A., Oboh, S. O. and Ekundayo, D. A. 2012. Replacement value of boiled pigeon pea (Cajanus cajan) on growth performance, carcass and haematological response of broiler chickens.Asian Journal of Poultry Science, 6:1-9. **https://doi.org/10.3923/ajpsaj.2012.1.9**

Isidahomen, C. E., Ozoje, M. O. and Njidda, A. A. 2011. Haematological and serum biochemical indices of local and exotic chickens in a subtropical and tropical environment. European Journal of Biological Sciences. 3(1): 16 – 21.

Jayaraman, K., Munira, H., Dababrata Chowdhury and Iranmanesh, M (2013).The preference and consumption of chicken lovers with race as a moderator –An empirical study in Malaysia. International Food Research Journal 20(1): 165-174.

Jimoh, W. A., Aderolu, Z. A., Oladele-Bukola, M. O., Abdulasalami, S. A. and Okermakin F. Y., 2016. Growth performance of *Clarias gariepinus* fingerlings fed graded levels of dietary cooked *Jatropha curcas* seed meal-based diets. *The Egyptian Journal of Experimental Biology (Zoology).* **12**(1): 87-91

Kenis M., Kone N., Chrysostome C. A. A. M., Devis, E., Koko G. K. D., Clottey V. A., Nacambo S. and Mensah G. A. 2014. Insects used for animal feed in West *Africa.Entomologia*,**2**(218), 107-114.https://doi.org/10.4081/entomologia.2014.218

Kumar, V., Makkar, H. P. S. and Becker, K. 2011. Detoxified *Jatropha curcas* kernel meal as a dietary protein source: Growth performance, nutrient utilization and digestive enzymes in common carp (*Cyprinus carpio* L.) fingerlings. *Aquacult. Nutr.* 17(3):313-326. https://doi.org/10.1111/j.1365-2095.2010.00777.x

Kumar, V., Makkar, H. P. S. and Becker, K. 2008. Detoxification of Jatropha curcas seed meal and its utilization as a protein source in fish diet. *Comp. Biochem. Phys. A.* 151:13–19.https://doi.org/10.1016/j.cbpa. 2008.05.025

Lamidi, A. W., Fanimo, A. O., Eruvbetine, D. and Biobaku, W. O. 2008. Effect of Graded levels of Pineapple (*Ananas comosus* L. Meer) crush waste on the performance, carcass yield and blood parameters of broiler chickens. *Nigeria Journal of Animal Production* 35(1):40-

47.https://doi.org/10.51791/njap.v35i1.1108

Li, C-Y., Devappa, R.K., Liu, J-X., Li J-M., Makkar, H. P. S. and Becker, K. 2010. Toxicity of Jatropha curcas phorbol esters in mice. *Food and Chemical Toxicology*; 48(2):620- 625. https://doi.org/10.1016/j.fct.2009.11.042

Makkar, H. P. S., Aderibigbe, A. O. and Becker, K. 1998. Comparative evaluation of nontoxic and toxic varieties of Jatropha curcas for chemical composition, digestibility, protein degradability and toxic factors, Food chem., 62(2),207-215.

Makkar, H. P. S. and Becker, K. 1998. Jatropha curcas toxicity: Identification of toxic principle(s). In: Garland T, Barr AC, J. M. Betz, J. C. Reagor, and E. M. Bailey, Jr. (Eds). Toxic plants and other natural toxicants. New York: CAB International; 1998. P.554-558.

Makkar, H. P., Becker, K., Sporer, F. and Wink, M. 1997. Studies on nutritive potential and toxic constituents of different provenances of *J. curcas. Journal of Agriculture and Food Chemistry*, 45, 3152–3157.https://doi.org/10.1021/jf970036j

Makkar, H. P. S., and Becker, K. 1999. Plant Toxins and detoxification methods to improve feed quality of tropical seeds. Review. *Asian-Aust. J. Anim. Sci.* 12:467–480. https://doi.org/10.5713/ajas.1999.467

Makkar, H. P. S. and Becker, K. 1997. Potential of *J. curcas* seed meal as a protein supplement to livestock feed, constraints to it utilization and possible strategies to overcome constraints. *In: Biofuels and industrial products from J. curcas, "Jatropha 97", Managua Nicaragua,* 1997.

Mir, N. A, Rafiq, A., Kumar, F., Singh, V. and Shukla, V (2017). Determinants of broiler chicken meat quality and factors affecting them: a review. J Food Sci Technol. 54(10):2997-3009. doi: 10.1007/s13197-017-2789-z.

Musa S. O., Tiamiyu L. O., Solomon S. G., Ayuba V. O. and Okomoda V. T. 2018. Nutritional value of hydrothermally processed *Jatropha curcas* kernel and its effect on growth and hematological parameters of *Clarias gariepinus* fingerlings (Burchell, 1822).*Aquaculture Reports*, **10**, 32-38. https://doi.org/10.1016/j.aqrep.2018.04.001

Nabi, A. E. A., Neveen, A. E., Elsharkawy, E. E. and Elmotleb, E. A. 2011. Chemical and pathological evaluation of jatropha curcas seed meal toxicity with or without heat and chemical treatment. *Aust. J. Basic Appl. Sci.* 5:49–59.

Nwanjo, H. U., Okafor, M. C. and Oze, G. O. 2005. Changes in biochemical parameters of kidney function in rats co-administered with chloroquine and aspirin. *Journal of Clinical Sciences, 23,* 10-12.

Ojediran, T. K., Adisa, Y. A., Yusuf, S. A. and Emiola I. A., 2014: Nutritional evaluation of processed *Jatropha curcas* kernel meals: effects on growth performance of broiler chicks. *Journal of Animal Science Advances*, **1**(11), 1110-1121.https://doi.org/10.5455/jasa.20141115115449

Ojediran, T. K. and Emiola, I. A. 2018. Effect of processing and level of inclusion of processed fermented Jatropha curcas (L) kernel meals on the performance of starter broiler chicks. *Tropical Agriculture (Trinidad)*, 95 (1), 55-66.

Ojediran, T. K., Ogunmola, B. T., Ajayi, A. O, Adepoju, M. A., Odelade, K. and Emiola, I.A. 2016. Nutritive value of processed dietary fungi treated Jatropha curcas(L). kernel meals: voluntary intake, growth, organ weight and hepatic histology of broiler chicks. *Tropical Agriculture (Trinidad),* 93 (2), 101-110.

Ojediran, T. K., Olayeni, T. B., Shittu, M. D., Ogunwemimo, O. T. and Emiola, I. A. 2015. Residual anti-nutrients in differently processed *Jatropha curcas* kernel meals: Effect on blood parameters and gut microbes of broiler chicks. *International Journal of Applied Research and Technology, 4* (1), 29-38.

Ojediran, T. K.; Onaolapo, O. B; Obimakinde, B. S.; Akpan, E. U. and Emiola, I. A. 2016. Response and economic indices of broilers on low crude protein diets fortified with lysine. *Am J Exp Agricult,* 10: 1-7. *https://doi.org/10.9734/ajea/2016/22243*

Ojewola, G. S. 1993. Productive performance and body composition of broiler as influenced by dietary energy and protein in humid tropics. PhD Thesis. Department of Animal Science, University of Ibadan, Nigeria.

Ojo R. J., Oguche P. L., Kube G. D., and Udzer T. E., 2013. Effect of *Jatropha curcas* supplemented diet on broilers. *Scholars Academic Journal of Biosciences*, **1**(6), 329-336.

Ojo R. J., Obi N. P., Akintayo C. O., Adebayo-Gege G. I., 2013. Evaluation of Cyanogen Contents of Cassava and Cassava Based Food Products in Karu, Nasarawa State, North Central Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology, 6, 1: 47-50. https://doi.org/10.9790/2402-0614750

Ojo, R. J., Kajang, D. D., Adebayo-Gege, G. I. and Akintayo, C. O., 2013. Analysis of Potassium Bromate and Hydrocyanic Acid Contents of Commonly Consumed Loaves of Bread and WheatFlour Samples In Karu,Nasarawa State, Nigeria. IOSR Journal of Environmental Science, Toxicology and Food Technology 6(1), 2013, 42-46. https://doi.org/10.9790/2402-0614246

Ologhobo, A. D. 1992. The Dilemma of Animal feeds and Indigenous Poultry Production in Nigeria. Proceedings 14th World's Poultry Congress, Amsterdam.

Onyimonyi, A. E., Chukwuma, P. C and Igbokwe Chinenye 2012. Growth and hypocholesterolemic properties of dry garlic powder (*Allium sativura*) on broilers. *African Journal of Biotechnology* 11(11), 2666 - 2671.https://doi.org/10.5897/ajb11.2877

Pasaribu, T., Wina, E., Tangendjaja, B. and Iskandar, S., 2010.Performance of broiler chicken fed physically and chemically treated jatropha seed

meal. Indones. J. Agric. 3(2),121–126.

Reed, J. D. 1995. Nutritional toxicology of tannins and related polyphenols in forage legumes. Journal of Animal Science, 73:1516–1528. https://doi.org/10.2527/1995.7351516x

Runumi, G., Utpal, K. N. and Ajay, K. T., 2014. Reduction of phorbol ester content in *Jatropha* cake using high energy gamma radiation. *Journal of Radiation Research and Applied Sciences*, 7(3):305-309. https://doi.org/10.1016/j.jrras.2014.04.002

Singh, P. K., Khatta, V. K., Thakur, R. S., S. Dey S. and Sangwan M. L. 2003. Effects of Phytase Supplementation on the Performance of Broiler Chickens Fed Maize and Wheat Based Diets with Different Levels of Non-Phytate Phosphorous. Asian-Australasian Journal of Animal Sciences;16(11):1642--1649 .https: //doi.org /10.5713/ ajas. 2003. 1642

Solomon, S. G., Okomoda, V. T. and Onah, R. E., 2017. Nutritional profile of soaked *Cajanus cajan* (L.)Millsp. And its utilization as partial replacement for soybean meal in the diet of *Clarias gariepinus* (Burchell, 1822) fingerlings. *Journal of Applied Ichthyology*, 33(3), 450-457. https://doi.org/10.1111/jai.13280

Sumiati, F., Hermana, W., Sudarman, A., Istichomah, N. and Setiyono, A. 2012. Broiler performances fed diet contained Jatropha curcas L. meal fermented with Rhizopus oligosporus.*Journal Animal ScienceTechnology*,34(2),117-125.https://doi.org /10.5398 /medpet.2012.35.2.117

Sumiati, F., Hermana, W.., Sudarman, A., Istichomah, N. and Setiyono, A. 2011. Performa Ayam Broiler yang Diberi Ransum Mengandung Bungkil Biji Jarak Pagar (*Jatropha curcas L.*) Hasil Fermentasi Meng- gunakan *Rhizopus oligosporus.* Med. Pet. 34(2):117- 125 . https://doi.org/10.5398/medpet.2011.34.2.117

Sumiati, F., Mutia, R. and Darmansyah, A., 2012. Performance of layer hen fed fermented jatropha curcas l. meal supplemented with cellulase and phytase enzyme. J.Indonesian Trop.Anim.Agric.37(2),108-114.

Thapa, B. R. and Walia, A. 2007. Liver function test and their interpretation. Indian Journal of Pediatrics, 74:663-671. https://doi.org/10.1007/s12098-007-0118-7

Willems O. W., Miller S. P. and Wood B. J., 2013. Aspects of selection for feed efficiency in meat producing poultry. *World's Poultry Science journal*, **69**(1), 77-88. https://doi.org/10.1017/s00439339 1300007x

Zakaria, H. A. H., Jalal, M. A. R. and Jabarin, A. S. 2008. Effect of Exogenous Enzymes on the growing performance of broiler chickens fed regular corn/soya bean-based diets and the Economics of enzyme supplementation. *Pakistan Journal of Nutrition* 7(4): 534 -539. https://doi.org/10.3923/pjn.2008.534.539

Zunft, H. J. F, Luder, W., Harde, W., Haber, B., Graubaum, H. J., Koebnick, C. and Grunwald, J.

2003. Carob pulp preparation rich in insoluble fibre lowers total and LDL cholesterol in hypercholesterolemic patients. European Journal of Nutrition, 42:235-242. https://doi.org/10.1007/s00394-003-0438-y

Date received: 4th April, 2022.
Date accepted: 22nd July, 2022.