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EFFECTS OF PROCESSING METHODS AND LEVELS OF INCLUSION OF *JATROPHA CURCAS* KERNEL MEAL ON PERFORMANCE, ORGAN CHARACTERISTICS, HAEMATOLOGY AND SERUM CHEMISTRY OF FINISHER BROILER CHICKENS

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Abstract: Three hundred 21-day-old broiler chicks were reared using a 3 x 3 factorial model in a completely randomized design with 10 treatment groups having 3 replicates of 10 birds each. The birds were raised on a commercial starter diet at the starter phase before being allotted into dietary groups in a 21-d feeding trial at the finisher phase. The interaction between treatment and varying inclusion levels of processed-fermented *Jatropha curcas* (L) kernel meals (JKM) on the performance of broiler chicks was investigated. *Jatropha curcas* kernels were subjected to three different processing methods, namely: raw defatted fermented meal (RDFM), cooked defatted fermented meal (CDFM) and lye treated defatted fermented meal (LDFM). Each meal was included at varying inclusion levels of 2.5%, 5.0% and 7.5% such that diet 1 (control) contained 0% JKM while diets 2, 3, 4 contained 2.5%, 5.0% and 7.5% RDFM, diets 5, 6, and 7 contained 2.5%, 5.0% and 7.5% CDFM and diets 8, 9, 10 contained 2.5%, 5.0% and 7.5% LDFM. Feeding differently processed-fermented JKM to these broilers did not ($p>0.05$) compromise the feed conversion ratio. The results indicated an improvement ($p<0.05$) in the weight gain of broiler chicks fed CDFM and LDFM at 2.5 and 5.0% inclusion levels respectively. There were significantly ($P<0.05$) elevated levels of alkaline phosphatase and creatinine in their blood serum. The kidney, lungs and proventriculus of birds fed CDFM showed significant differences ($p<0.05$) among the treatments. Therefore, finisher broilers could tolerate up to 5.0% inclusion level of LDFM.

Key words: *Aspergillus niger,* blood, broilers, growth, *Jatropha curcas* kernel meal, organ weight.

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Introduction

Jatropha curcas is an underutilized, oil bearing crop. The oil content of its seed compares well with groundnut kernel, rape seed and soybean seed. The oil is almost all stored in the kernel which has an oil content of around 50–55% (Jongschaap et al., 2007; Ojediran and Emiola, 2012). This oil content has attracted interest in the biofuel industry, while the protein content of the cake is of interest to livestock nutritionists. The seed has been reported to have about 35–50% crude protein (Aslaniet al., 2007) although Ojediran and Emiola (2012) reported a crude protein content of 23.57% in the untreated kernel meal. Nonetheless, the myriad of antinutrients (lectin, saponin, tannin, phytate, trypsin inhibitors and phorbol esters) inherent in the unprocessed *Jatropha curcas* seed or kernel meals pose a risk to humans and livestocks.

Sumiati et al. (2007) reported that feeding *Jatropha curcas* meal at the level of 5% in the diet to the broilers reduced feed consumption and caused 100% mortality at the age of 22 days while Ojediran et al. (2014) reported that feeding raw and locally treated (cooked, toasted, lye-treated and sand-roasted) *Jatropha curcas* kernel meals to broiler chicks resulted in depressed feed intake, weight gain and high mortality ranging from 43.33% to 83.33% within 21 days of the feeding trial.

In previous studies, Belewu and Sam (2010) used *Aspergillus niger* to detoxify *Jatropha curcas* kernel meals with a significant reduction of the anti-nutritional compounds such as phorbolesters, lectins, saponins and phytate. Akande et al. (2012) reported that lye treatment, followed by fermentation produced better results in terms of feed consumption. Ojediran et al. (2016) used a combination of different local methods coupled with fermentation and fed the resultant meals to broiler chicks. This improved average daily feed intake, average daily gain and mortality in birds. The result was attributed to the reduction in phorbol esters during fermentation, but concluded that the birds cannot tolerate the 10.33% inclusion level.

Ojediran and Emiola (2018) were able to establish the tolerable level of inclusion and suggested that broiler chicks could tolerate cooked defatted fermented meal and lye treated defatted fermented meal (up to 2.5% and 5.0% inclusion respectively). Therefore, additional research will be required to investigate the response of broilers to processed-fermented *Jatropha curcas* kernel meal at the finisher phase.

Materials and Methods

Experimental site, birds and management

The feeding trial was conducted at the Poultry Unit of the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Three hundred (300) 21-day-old Marshal strain broiler chicks were used for this study. All the birds were initially fed on commercial broiler feed for the starter phase before being randomly allotted without sexing into ten dietary groups of thirty (30) birds each. Each group was further sub-divided into three replicates of ten (10) birds each. The birds were fed with their respective diets and water was served *ad libitum.* The experimental chicks were raised under intensive care management in a deep litter system for three weeks.

Feeds and feeding/Source of test material

Mature *J. curcas* seeds were sourced locally. The seeds were dehulled to remove the kernel. The kernel was later treated as follows (solid state fermentation was done using *Aspergillus niger*):

i. A portion of the kernel was milled and subjected to oil extraction using a hydraulic press after which it was fermented and was referred to as the raw defatted fermented meal (RDFM).

ii. Another portion of the raw kernel was cooked at $120^0C \pm 5^0C$ for 30 minutes in a cooking pot. The treated kernel was dried, milled, fermented and was referred to as the cooked defatted fermented meal (CDFM).

iii. The lye was prepared by putting wood ash in a muslin cloth, and hot water ($100^0C \pm 5^0C$) was poured on the ash. Then the filtrate (pH 9.5) was used to cook another portion of the kernel at $120^0C \pm 5^0C$ for 30 minutes. The treated kernel was dried, milled, fermented and was referred to as the lye defatted fermented meal (LDFM).

All meals were between 0.5 and 1.0mm mesh size. The preparation and sub-culturing of the fungi and innoculation of the substrates followed the procedure as described by Ojediran et al. (2016). However, the fungi growth was terminated by oven drying at 85°C.

Experimental diets

Ten (10) experimental diets were formulated. The test ingredients (RDFM, CDFM and LDFM) were included at varying levels of 2.5%, 5.0% and 7.5% for each fermented meal while the control (Diet 1) had 0% of JKM. Diets 2, 3, 4, contained 2.5%, 5.0% and 7.5% of RDFM, diets 5, 6, and 7 contained 2.5%, 5.0%

and 7.5% of CDFM and diets 8, 9, 10 contained 2.5%, 5.0% and 7.5% of LDFM respectively. The gross composition of the experimental diets is presented in Table 1.

Table 1. Gross composition of experimental diets for finisher broilers (4–6 weeks).

		RDFM			CDFM			LDFM		
Ingredients%	Control	2.5%	5.0%	7.5%	2.5%	5.0%	7.5%	2.5%	5.0%	7.5%
Maize	465.00	465.00	465.00	465.00	465.00	465.00	440.00	465.00	465.00	465.00
Wheat offal	205.00	205.00	195.00	195.00	205.00	205.00	230.00	205.00	205.00	205.00
SBM	270.00	245.00	220.00	195.00	245.00	220.00	195.00	245.00	220.00	195.00
JCKM	0.00	25.00	50.00	75.00	25.00	50.00	75.00	25.00	50.00	75.00
Fishmeal	20.00	20.00	30.00	30.00	20.00	20.00	20.00	20.00	20.00	20.00
#Fixed ingre	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Calculated analysis										
CP (%)	209.20	208.60	213.40	212.80	207.70	206.50	206.50	208.60	207.70	207.30
CF (%)	44.50	43.80	42.40	41.80	44.30	44.30	49.10	44.00	43.70	46.50
ME (kcal/kg)	2766.16	2807.73	2859.22	2900.79	2813.81	2861.46	2870.20	2891.86	2853.02	2896.15

#Fixed ingredients include 1.35% Limestone, 2.00% Dicalcium phosphate, 0.20% Salt, 0.25% *Vitamin premix, 0.15% Methionine, 0.05% Lysine; *Vitamin premix contained the following vitamins and minerals in 1kg of broiler diet: 12500 IU Vit. A; 2500 IU Vit. D_3; 40mg Vit.E; 2mg Vit.K_3; 30mg Vit B_1; 55mg Vit.B_2; 550mg Niacin; 115mg Calcium pantothenate; 50mg Vit B_6 ; 0.25mg Vit B_{12}; 500mg Choline chloride; 10mg Folic acid; 0.08mg Biotin; 120mg Manganese; 1000mg Fe; 80mg Zn; 8.5mg Cu; 1.5mg I; 0.3mg Co; 0.12mg Se and 120mg Antioxidant; SBM = Soyabean meal, JCKM = *Jatropha curcas* kernel meal, CP = Crude protein,CF = Crude fibre, ME = Metabolizable energy, RDFM = Raw defatted fermented meal, TDFM = Toasted defatted fermented meal, CDFM = Cooked defatted fermented meal, LDFM = Lye defatted fermented meal.

Data collection/Growth performance

The average daily feed intake (ADFI), average daily gain (ADG) and total weight gain were monitored and recorded throughout the feeding trial. Feed to gain ratio of the experimental birds was calculated.

Blood chemistry analysis

Three birds per treatment were randomly selected and 5ml of blood was collected into a pair of three sterilized glass bottles/tubes. For haematological examination, blood samples were collected into three sterilized bottles containing ethylene diamine tetra-acetic acid (EDTA), while those for serum biochemical studies were collected into three plain bottles (i.e without anticoagulant). Serum was obtained by centrifugation and serum samples were stored in a deep freezer (at minus 10^0C) until required for analysis.

Blood parameters such as packed cell volume (PCV) and haemoglobin (Hb) were determined using the micro haematocrit method and cyanomethehemoglobin methods respectively as described by Mitruka and Rawnsley (1977). Erythrocyte

count (RBC) and leukocyte count (WBC) were determined using the improved Neubauer haemocytometer after the appropriate dilution (Schalm et al., 1975). Differential leukocyte counts were determined by scanning Giemsa's stained slides in the classic manner (Schalm et al., 1975) while mean corpuscular value, mean corpuscular haemoglobin, and mean corpuscular haemoglobin concentration were calculated using the formula described by Ojediran et al. (2015). Cholesterol was determined by spectrophotometric methods. Alanine aminotransaminase (ALT), aspartate aminotransaminase (AST) and alkaline phosphatase (ALP) were determined manually by the spectrophotometric method respectively as described by Schmidt and Schmidt (1963). Total serum protein was determined using the biuret method as described by Reinold (1953) while albumin was determined using the BCG (Bromocresol green) method as described by Peters et al. (1982).

Weight of organs

At the end of the 4th week, all the birds were starved overnight and each bird was randomly selected per replicate, tagged, weighed and slaughtered for carcass analysis. After the birds had been slaughtered, an incision was carefully made around the abdomen with a pen knife to create space through which the visceral organs were brought out. The weights of the kidneys, heart, liver, lungs, gizzard, proventriculus and pancreas were taken. The organs were weighed using the sensitive electronic weighing scale and their respective weights were recorded and expressed as a percentage of live body weight.

Experimental design and statistical analysis

All data generated and estimated were subjected to analysis of variance for a 3 x 3 factorial model in a completely randomized design of the SAS (2000) software package. Significant means were separated using Duncan's multiple range test of the same package.

Results and Discussion

Interaction effects between treatment and inclusion levels on the growth performance of finisher broiler chickens fed graded levels of processed-fermented *Jatropha curcas* kernel meal are presented in Table 2. The final body weight (FBW), average daily feed intake (ADFI) and average daily gain (ADG) were significantly influenced. A linear decrease was observed in birds fed the dietary treatments. At the 5.0% inclusion level, birds fed on the JKM had similar FBW and ADG especially those feed RDFM and LDFM, although those fed CDFM and LDFM had similar ($P>0.05$) ADFI within the treatments. Birds fed on RDFM and LDFM had FBW and ADG that are comparable to those fed on the control diet up

to the 5.0% inclusion level, although birds fed on LDFM were not significantly different (P>0.05) from those fed on control diet at all inclusion levels. No significant difference was observed for feed conversion ratio and mortality. The performance recorded in this study when broilers were fed JKM at the finisher phase was better than that at the starter phase reported by Ojediran and Emiola (2018). This may be attributed to improved gut physiology. Akande et al. (2012) reported that lye treatment, followed by fermentation produced better results in terms of feed consumption and this is similar to the observations in this study. Broilers fed on LDFM had a higher feed intake at the 7.5% inclusion level.

Table 2. Interaction effects of the processed-fermented *Jatropha curcas* kernel meal on growth performance of finisher broiler chickens.

Parameters	Treatments	0%	2.5%	5.0%	7.5%	SEM
Initial B (g/b)	RDFM	511.67	513.33	511.67	511.67	6.87
	CDFM	511.67	485.71	490.95	492.86	4.91
	LDFM	511.67	513.33	513.33	514.33	6.01
	SEM	11.67	11.84	11.10	15.50	
Final B (g/b)	RDFM	1236.11^{a}	1126.67^{ab}	$1116.20^{b,x}$	1040.19^{b}	25.80
	CDFM	1236.11^{a}	1201.98^{a}	$984.76^{b,y}$	950.56^{b}	41.85
	LDFM	1236.11^{a}	1199.49^{ab}	$1174.54^{ab,x}$	1023.52^{b}	33.81
	SEM	51.89	40.85	33.17	33.72	
ADFI	RDFM	111.23^{a}	$95.17^{b,y}$	94.03^{b}	89.44^{b}	2.62
(g/b/d)	CDFM	111.23^{a}	$104.04^{ab,x}$	92.47^{b}	95.02^{b}	2.71
	LDFM	111.23	105.41^{x}	107.39	98.59	2.26
	SEM	1.28	1.61	4.81	3.03	
ADG	RDFM	34.50^{a}	29.21^{b}	$28.79^{b,x}$	25.17^{b}	1.17
(g/b/d)	CDFM	34.50^{a}	34.11^{a}	$23.52^{b,y}$	21.80^{b}	1.93
	LDFM	34.50^{a}	32.67^{ab}	$31.49^{ab,x}$	24.25^{b}	1.62
	SEM	2.32	2.02	1.19	1.30	
FCR	RDFM	3.25	3.27	3.27	3.56	0.07
	CDFM	3.25	3.05	3.98	4.51	0.25
	LDFM	3.25	3.34	3.44	4.06	0.15
	SEM	0.21	0.58	0.31	0.29	
Mortality	RDFM	0.00	0.00	0.00	0.00	0.00
	CDFM	0.00	0.00	0.00	4.76	1.19
	LDFM	0.00	0.00	0.00	0.00	0.00
	SEM	0.00	0.00	0.00	1.59	

[abc] Means with different superscripts in the same row are significantly different (P<0.05).[xyz] Means with different superscripts in the same column are significantly different. RDFM: Raw defatted fermented meal, CDFM: Cooked defatted fermented meal, LDFM: Lye defatted fermented meal, ADFI: Average daily feed intake, ADG: Average daily gain, FCR: Feed conversion ratio and SEM: Standard error of the mean.

All the dietary treatments had a lower feed consumption rate when compared to the control. Akande and Odunsi (2012) concluded that it is evident that the higher the inclusion of Castor bean cake, the lower the performance of birds in treated groups. They reported that the 10% inclusion compared favourably with

control while the 15% in lye treated group also compared well with control while up to 15% of the thermal and lye treatment could be used in feeding broiler chickens without a deleterious effect. The fermented product may be safely used at the 10% rate of inclusion. The inclusion level significantly influenced the ADG of broiler chickens fed processed-fermented JCKM. Birds fed on CDFM compared favorably with the control at the 2.5% inclusion level while birds fed on LDFM compared favorably with the control at the 5.0% inclusion level, though birds fed on the processed-fermented JCKM were comparable at the 7.5% inclusion. This differed from the report of Sumiati et al. (2009) who showed that feeding on 5% untreated as well as fermented *Jatropha curcas* did not influence the feed consumption of kampong chickens. Sumiati et al. (2009) reported that the supplementation of the enzymes to the diets containing fermented *Jatropha curcas* meal tended to raise final body weight of kampong chicken. The reason for this could be attributed to the microbial phytase supplementation (breaking of the bonds that held nutrients bound or trapped in cell walls and therefore unavailable for microbial degradation) that increased body weight gain, feed intake and feed efficiency in broiler chickens (Singh et al., 2003).

Interaction effects between treatments and inclusion levels of finisher broilers fed graded levels of the *Jatropha curcas* kernel meal on the hematological parameters are presented in Table 3. Birds fed RDFM had their PCV, Hb MCH and MCV significantly different ($p<0.05$) and this is similar to those fed LDFM for WBC, heterophil, eosinophil and basophil.

Birds fed on CDFM diets had significantly different ($p<0.05$) RBCs and lymphocytes while MCH and MCV were significantly different ($p<0.05$) within treatments at the 5% inclusion level. The values obtained for PCV for all the treatment groups were within the normal range of 24.9–45.2% as reported by Mitruka and Rawnsley (1977), but it differed from the range of 22–26% reported by Ameenet al. (2007). Hemoglobin values did not agree with the findings of Akande and Odunsi (2012), who fed broiler chicks with detoxified castor kernel cake, and the values of hemoglobin tended to be decreasing across the dietary treatments. The values of PVC and RBC were within the ranges of 30–35% and 2.88–4.12 x 10^6 mm^3 as reported by Swenson (1970) and Campbell et al. (2003). Ologhobo et al. (1986) observed that an increase in WBC count above normal is an indication of the presence of exogenous substances and foreign bodies in the body.

The observation on lymphocyte agreed with the findings of Belewu et al. (2011) who fed goats on a cocktail of fungi treated *Jatropha curcas* kernel cake, and observed a decrease in the lymphocyte values when compared with the control. Lymphocytes are known to play key roles in the immune defense system of both humans and animals. Adeyemo and Longe (2007) observed that graded levels of cottonseed cake fed to broilers from one-day-old to 8 weeks of age did not affect the monocyte and basophil counts. Akande and Odunsi (2012) who fed broiler

chicks with detoxified castor kernel cake, observed an increase in eosinophil values compared to the control. Increased eosinophil indicated response to foreign materials. Zomrawi et al. (2012) reported that ginger root powder (*Zingiber officinale*) supplementation had no influence on platelet count and MCHC broiler chicks while the findings of Nworgu et al.(2013) who fed basil leaf (*Ocimum gratissimum*) supplement to growing pullets reported decreased MCV values compared to the control.

Table 3. Interaction effects on haematological parameters of finisher broiler chickens fed fermented *Jatropha curcas* kernel meals.

Parameters	Treatment	0%	2.5%	5.0%	7.5%	SEM
PCV(%)	RDFM	28.67^{ab}	32.33^{a}	32.00^{a}	27.33^{b}	1.57
	CDFM	28.67	29.67	30.00	30.33	1.64
	LDFM	28.67	30.33	27.67	28.67	1.6
	SEM	1.45	1.00	1.51	1.73	
Hb(g/dL)	RDFM	9.57^{ab}	10.80^{a}	10.67^{a}	9.10^{b}	0.51
	CDFM	9.57	9.90	9.97	10.13	0.54
	LDFM	9.57	10.10	9.13	9.57	0.35
	SEM	0.47	0.33	0.47	0.58	
RBC	RDFM	3.18^{b}	3.51^{a}	3.54^{a}	$3..44^{ab}$	0.08
($\times10^{3}$µl)	CDFM	3.18^{b}	3.42^{ab}	3.51^{a}	3.49^{ab}	0.10
	LDFM	3.18	3.30	3.53	3.31	0.08
	SEM	0.02	0.05	0.12	0.15	
WBC	RDFM	12.60	15.28	13.23	13.83	2.56
($\times10^{6}$ µl)	CDFM	12.60	15.62	15.47	16.08	1.90
	LDFM	12.60^{b}	16.88^{ab}	15.00^{ab}	20.47^{b}	2.52
	SEM	2.31	2.15	2.74	2.10	
Lymphocyte	RDFM	77.67	69.33	67.33	67.67	2.49
($\times10^{6}$ µl)	CDFM	77.67^{a}	66.67^{b}	66.67^{b}	65.33^{b}	2.84
	LDFM	77.67^{a}	62.67^{b}	68.33^{ab}	72.33^{ab}	3.54
	SEM	1.45	2.73	3.90	3.74	
Heterophil	RDFM	17.33	26.67	27.33	43.44	3.56
($\times10^{6}$ µl)	CDFM	17.33	25.33	30.00	24.33	2.32
	LDFM	17.33^{b}	33.00^{a}	25.67^{ab}	18.00^{b}	8.22
	SEM	1.76	4.24	3.83	8.96	
Eosinophil	RDFM	3.33	2.00	2.33	2.67	0.55
($\times10^{6}$ µl)	CDFM	3.33	1.33	2.33	2.33	0.39
	LDFM	3.33^{ab}	2.00^{b}	3.33^{ab}	3.67^{a}	0.71
	SEM	0.33	0.69	0.56	0.63	
Basophil	RDFM	0.33	0.00	0.33^{y}	0.33	0.17
($\times10^{6}$ µl)	CDFM	0.33	0.67	0.00^{y}	0.00	0.17
	LDFM	0.33^{ab}	0.00^{b}	$1.00^{a,x}$	0.33^{ab}	0.25
	SEM	0.33	0.11	0.11	0.22	
Platelet	RDFM	13.07	13.80	16.33	14.17	2.00
($\times10^{4}$)	CDFM	13.07	14.73	17.57	17.17	2.63
	LDFM	13.07	16.70	14.40	16.60	1.67
	SEM	1.91	2.61	1.76	2.12	

Table 3. Continued.

Parameters	Treatment	0%	2.5%	5.0%	7.5%	SEM
MCH(fl)	RDFM	30.09^{ab}	30.79^{a}	30.12^{ab,x}	26.46^{b}	1.00
	CDFM	30.09	28.97	28.32^{xy}	28.92	1.17
	LDFM	30.09	30.56	25.87^{y}	29.01	1.00
	SEM	1.25	1.12	0.68	1.16	
MCHC(%)	RDFM	33.38	33.40	33.33	33.29	0.08
	CDFM	33.38	33.37	33.28	33.36	0.10
	LDFM	33.38	33.36	33.03	33.37	0.04
	SEM	0.08	0.05	0.12	0.04	
MCV(pg)	RDFM	90.18^{ab}	92.18^{a}	90.38^{ab,x}	79.47^{b}	3.10
	CDFM	90.18	86.80	85.23^{xy}	86.58	3.49
	LDFM	90.18	91.78	78.33^{y}	86.92	3.03
	SEM	3.91	3.30	2.18	3.44	

^{abc} Means with different superscripts in the same row are significantly different (P<0.05).^{xyz} Means with different superscripts in the same column are significantly different. MCV – Mean corpuscular volume, MCH – Mean corpuscular haemoglobin, MCHC – Mean corpuscular haemoglobin concentration.

Table 4 shows the interaction effects between the treatments and inclusion levels of JKM on serum chemistry of finisher broiler chickens. Total protein and globulin were not significantly (P.0.05) different in RDFM and CDFM at all inclusion levels. However, there was a significant (p<0.05) difference in LDFM between inclusion levels. Alkaline phosphatase was highest at the 7.5% inclusion level for RDFM within treatments. There was no significant (p>0.05) difference in inclusion levels of RDFM. Creatinine was affected along the inclusion levels and within treatments (2.50%–7.50%). The cholesterol level in birds fed RDFM was significantly affected (p<0.05) while those fed CDFM and LDFM were significantly influenced (p<0.05) for triglycerides. Observations on total protein, ALP and AST agreed with the findings of Ojo et al. (2013) who fed finisher broilers with graded levels of raw *Jatropha curcas* based diets. The increase in ALP observed gave an indication that the hepatic capacity of the liver was grossly affected by *Jatropha curcas* (Kaneko, 1989). Aluwong et al. (2013) observed a decrease in ALT activities when broiler chicks were fed different levels of supplemental yeast, while Ojediran et al. (2015) reported that an increased AST, ALT and ALP values might be attributed to liver damage. The globulin values of RDFM and CDFM were not significantly different (P>0.05) from each other, signifying a similar ability to fight against disease. This result agreed with the work of Akinmutimi et al. (2002) who reported a significant decrease in serum globulin of starter broiler chicks fed differently processed sword bean meals. The higher the value of serum creatinine, the lower the protein quality of the test ingredient. This implies the nutritional inferiority of the protein quality of the diets (Aletor et al., 1992). Ojo et al. (2013) have reported that a significant elevation of creatinine and urea is a pointer to renal dysfunction in chickens given *Jatropha curcas.*

Table 4. Interaction effects of the treatment and graded levels of processed-fermented *Jatropha curcas* kernel meals on serum chemistry of finisher broiler chickens.

Parameter	Treatment	0%	2.5%	5.0%	7.5%	SEM
Total protein (g/dl)	RDFM	3.36	3.42^{x}	2.99	4.39	0.60
	CDFM	3.36	3.16^{xy}	3.19	3.06	0.23
	LDFM	3.36^{a}	$1.86^{b,y}$	3.06^{ab}	2.92^{ab}	0.50
	SEM	0.24	0.54	0.21	0.77	
Albumin (g/dl)	RDFM	1.56	1.75	1.56	1.56	0.13
	CDFM	1.56	1.58	1.60	1.35	0.14
	LDFM	1.56	1.41	1.53	1.61	0.26
	SEM	0.14	0.20	0.13	0.23	
Globulin (g/dl)	RDFM	1.80	1.68^{x}	1.43	2.83	0.47
	CDFM	1.80	1.58^{x}	1.59	1.72	0.09
	LDFM	1.80^{a}	$1.22^{b,y}$	1.55^{ab}	1.31^{b}	0.24
	SEM	0.10	0.34	0.08	0.54	
ALP (U.I/I)	RDFM	346.97	362.36	394.72	483.29^{x}	60.65
	CDFM	346.97^{d}	400.19^{c}	493.34^{a}	$469.96^{b,xy}$	7.03
	LDFM	346.97^{b}	442.26^{a}	417.25^{a}	$431.19^{a,y}$	27.07
	SEM	2.17	52.34	53.44	18.36	
AST (U.I/I)	RDFM	195.71	195.10	198.24	185.16	13.49
	CDFM	195.71	175.73	174.69	185.33	17.97
	LDFM	195.71	195.28	193.01	196.33	6.79
	SEM	8.66	22.15	11.14	9.05	
ALT (U.I/I)	RDFM	6.35	5.49	5.49	6.24^{y}	2.61
	CDFM	6.35	4.53	4.04	5.71^{y}	2.35
	LDFM	6.35	8.11	7.84	11.81^{x}	2.97
	SEM	4.29	1.82	3.16	1.30	
Creatinine (mg/d)	RDFM	0.60^{b}	$0.73^{a,xy}$	$0.70^{ab,y}$	$0.74^{a,y}$	0.06
	CDFM	0.60^{c}	$0.69^{b,y}$	$0.70^{b,y}$	$0.79^{a,xy}$	0.04
	LDFM	0.60^{b}	$0.84^{a,x}$	$0.94^{a,x}$	$1.02^{a,x}$	0.09
	SEM	0.04	0.06	0.06	0.10	
Cholesterol (mg/d)	RDFM	121.11^{ab}	146.48^{a}	102.65^{b}	112.80^{ab}	18.89
	CDFM	121.11	117.18	144.17	123.88	21.56
	LDFM	121.11	140.02	128.26	122.26	17.64
	SEM	13.90	18.27	24.07	21.20	
Triglyceride (U.I/I)	RDFM	76.34	54.11	53.04	64.20	24.46
	CDFM	76.34^{a}	44.16^{b}	47.83^{b}	44.44^{b}	6.78
	LDFM	76.34^{ab}	38.17^{b}	87.60^{a}	57.65^{ab}	20.80
	SEM	11.69	9.54	20.17	27.99	
ACP (U.I/I)	RDFM	6.19	5.34	3.94	3.94	2.17
	CDFM	6.19	5.91	5.06	4.78	1.80
	LDFM	6.19	6.75	5.06	5.34	1.99
	SEM	4.16	1.78	0.71	1.30	

^{a,b,c} Means along the same row with different superscripts differ significantly ($p<0.05$). ^{x,y,z} Means along the same column with different superscripts differ significantly ($p<0.05$).AST – Aspartate aminotransferase, ALT – Alanine aminotransferase, ALP – Alakaline phosphatase, TRY – Triglyceride and ACP – Acid phosphatase.

Creatinine is a breakdown product of creatine. It is usually 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). Ojo et al. (2013) and Ojediran et al. (2015) reported that residual anti-nutrients in *Jatropha curcas* can cause damage to the kidney thereby distorting renal function.

Results of treatment and inclusion effects of processed-fermented *Jatropha curcas* kernel meals on organ parameters of finisher broiler chickens are presented in Table 5. Birds fed CDFM had a significantly influenced ($p<0.05$) kidney, lungs and proventriculus weights. An increase in weight was observed as the level of inclusion increased. Rahma et al. (2013) showed there were no significant differences in liver weights between rats fed casein diet and those fed detoxified *Jatropha* seed flour diet. Similar observations were made in the case of detoxified castor proteins (Puttaraj et al., 1994). However, high kidney weights in rats fed with field bean and navy bean diets have been attributed to low availability of essential amino acids (Ramamani, 1976).

Table 5. Treatment and inclusion effects of processed-fermented *Jatropha curcas* kernel meals on organ parameters of finisher broiler chickens (% live weight).

Parameters	Treatments	0%	2.5%	5.0%	7.5%	SEM
Liver	RDFM	4.02	4.13	4.06	4.92	0.19
	CDFM	4.02	3.51	4.16	4.08	0.14
	LDFM	4.02	3.83	4.67	4.67	0.16
	SEM	0.09	0.22	0.16	0.20	
Kidney	RCDFM	1.25	1.13	1.23	1.39	0.06
	CDFM	1.25^{ab}	1.13^{b}	1.36^{a}	1.38^{a}	0.04
	LDFM	1.25	0.97	1.20	1.48	0.07
	SEM	0.03	0.06	0.04	0.07	
Lungs	RDFM	0.84	0.90	0.98	0.97	0.06
	CDFM	0.84^{b}	0.86^{b}	1.05^{ab}	1.17^{a}	0.05
	LDFM	0.84	0.75	1.10	1.09	0.06
	SEM	0.04	0.07	0.04	0.06	
Heart	RCDFM	0.66	0.69	0.69	0.73	0.04
	CDFM	0.66	0.71	0.73	0.76	0.03
	LDFM	0.66	0.65	0.63	0.77	0.02
	SEM	0.02	0.04	0.03	0.04	
Gizzard	RDFM	6.68	6.96	6.16	5.99	0.29
	CDFM	6.68	5.35	6.16	6.84	0.33
	LDFM	6.68	5.83	7.27	6.88	0.26
	SEM	0.08	0.44	0.27	0.44	
Pancrease	RDFM	0.005	0.005	0.004^{xy}	0.005	0.0003
	CDFM	0.005	0.004	0.003^{y}	0.005	0.0004
	LDFM	0.005	0.003	0.005^{x}	0.005	0.0004
	SEM	0.0001	0.0005	0.0003	0.0004	

Table 5. Continued.

Parameters	Treatments	0%	2.5%	5.0%	7.5%	SEM
Proventiculus	RDFM	0.10	0.97	1.24	1.03	0.07
	CDFM	0.10^{ab}	0.80^{b}	0.89^{b}	1.24^{a}	0.06
	LDFM	0.10	0.79	1.05	1.05	0.06
	SEM	0.02	0.06	0.08	0.09	
Spleen	RDFM	0.28	0.08	0.21	0.22	0.03
	CDFM	0.28	0.21	0.21	0.26	0.02
	LDFM	0.28	0.10	0.13	0.18	0.04
	SEM	0.03	0.03	0.03	0.03	

^{a,b,c} Means along the same row with different superscripts differ significantly ($p<0.05$). ^{x,y,z} Means along the same column with different superscripts differ significantly ($p<0.05$). RDFM: Raw defatted fermented meal, CDFM: Cooked defatted fermented meal, LDFM: Lye defatted fermented meal.

Conclusion

This study reveals that finisher broilers could consume up to the 2.5% inclusion level of RDFM and CDFM but up to the 5.0% inclusion level of LDFM comparable with those fed the control diet for final body weight. Nevertheless, feeding JKM to these broilers does not compromise the feed conversion ratio. Observations on the mortality showed that the birds could tolerate all dietary treatments at up to the 5% inclusion level and as much as the 7.5% inclusion level for RDFM and LDFM respectively. The effects of the dietary inclusion levels showed that ALP and CRT increased as the inclusion levels of the test ingredient increased, signifying a compromised kidney integrity attributable to the effect of residual anti-nutrients in JKM.

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UTICAJI METODA PRERADE I NIVOA UKLJUČIVANJA SAČME ZRNA BILJKE *JATROPHA CURCAS* NA PERFORMANSE, OSOBINE ORGANA, HEMATOLOŠKE I BIOHEMIJSKE PARAMETRE BROJLERA U ZAVRŠNOM TOVU

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R e z i m e

Tri stotine 21-dnevnih brojlerskih pilića uzgajano je korišćenjem faktorijalnog modela 3 x 3 po potpuno slučajnom planu sa 10 grupa tretmana koje su imale 3 ponavljanja od po 10 pilića. Pilići su uzgajani korišćenjem komercijalne starter smeše u početnoj fazi, pre nego što su raspoređeni u grupe sa različitim obrocima u 21-dnevnom hranidbenom ogledu u završnoj fazi tova. Ispitivana je interakcija između tretmana i različitih nivoa uključivanja prerađene-fermentisane sačme zrna biljke *Jatropha curcas* (L) (engl. *Jatropha curcas* (L) *kernel meal* – JKM) na performanse brojlera. Zrna biljke *Jatropha curcas* bila su prerađena uz pomoć tri različita metoda: sirova obezmašćena fermentisana sačma (engl. *raw defatted fermented meal* – RDFM), kuvana obezmašćena fermentisana sačma (engl. *cooked defatted fermented meal* – CDFM) i obezmašćena fermentisana sačma tretirana ceđem (engl. *lye treated defatted fermented meal* – LDFM). Nivoi uključivanja sačmi su iznosili 2,5%, 5,0% i 7,5% tako da je obrok 1 (kontrola) sadržao 0% JKM, dok su obroci 2, 3, 4 sadržali 2,5%, 5,0% i 7,5% RDFM, obroci 5 6, i 7 sadržali su 2,5%, 5,0% i 7,5% CDFM i obroci 8, 9, 10 su sadržali 2,5%, 5,0% i 7,5% LDFM. Ishrana brojlera sa različito prerađenim i fermentisanim JKM ($p>0.05$) nije imala negativan efekat na konverziju hrane. Rezultati su ukazali na poboljšanje ($p<0,05$) u prirastu brojlera koji su hranjeni CDFM-om i LDFM-om na nivoima uključivanja od 2,5 odnosno 5,0%. U njihovom krvnom serumu bilo je značajno ($p<0,05$) povišenih nivoa alkalne fosfataze i kreatinina. Bubrezi, pluća i žlezdani želudac pilića hranjenih CDFM-om pokazali su značajne razlike ($p<0,05$) među tretmanima. Prema tome, brojleri u završnom tovu mogu da tolerišu nivo uključivanja LDFM do 5,0%.

Ključne reči: *Aspergillus niger,* krv, brojleri, rast, sačma zrna biljke *Jatropha curcas*, masa organa.

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