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ABSTRACT

Two hundred (200) day-old broiler chicks were used to evaluate the effects of graded levels of fermented *Jatropha curcas* seed meal on growth performance, carcass yield and internal organ characteristics of broiler chickens. The chicks were randomly assigned to five dietary treatments consisting of four replicates of ten birds per replicate in a completely randomized design. The dietary treatments were the inclusion levels of fermented *Jatropha curcas* meal at 0%, 2.5%, 5%, 7% and 10%. Data were collected for eight weeks on feed intake, weight gain and feed conversion ratio. At the end of the experiment, 8 birds were randomly selected from each treatment and slaughtered to determine the effect of graded levels of fermented J*atropha curcas* seed meal on carcass yield and internal organs characteristics. The result of growth performance revealed that all parameters measured were significantly (P<0.05) influenced by the dietary treatments except FCR. Carcass yield and internal organs characteristics were significantly different (P<0.05) across the treatment groups except for large intestine weight. Birds on 2.5% replacement level gave better weight gain than other treatments that contain fermented *Jatropha* seed meal.

Keywords: ***Jatropha curcas*, broiler chickens, fermentation, carcass, internal organs**

INTRODUCTION

Jatropha curcas seed cake is obtained as a by-product of oil extraction from the seed. It has crude protein (CP) content between 58%-64%. Therefore, it has high potential to complement and substitute groundnut cake meal which has 45% CP as a protein source in broiler diets (Boguhn, *et al.,* 2010; Sumiati *et al.,* 2011). It has been reported however that raw *Jatropha curcas* seed and oil are toxic to mice, rats, calves, sheep and goat, human and chickens due to the presence of some anti-nutritive factors in the seed (Makkar *et al.,* 1998). The use of raw *Jatropha* seed meal therefore is limited by its toxicity.

Several methods have been employed to reduce the anti-nutritive factors present in *Jatropha* seeds to make it useful especially to monogastric animals (Magdi, 2007; Akande *et al.,* 2012). These authors concluded that utilization potential of *Jatropha* seed could be improved by processing. Fermentation is one of the methods of biotechnology of feed improvement. Fermentation causes chemical changes in organic substances produced by action of enzymes which results into breakdown of complex organic substances into simpler ones through the action of catalysis. Through fermentation, feed materials are converted into useful by-products and also as a method of reducing the anti-nutrient and fiber contents of feed materials (Dhilon and Skirvaram, 1999; Oboh and Akindahunsi, 2003; Oboh, 2006; Aro *et al.,* 2008). A study by Feng *et al.,* (2007) showed that fermentation of soybean meal with *Bacilus subtilis* improved its *in vivo* digestibility in piglets. More recently, Tang *et al.* (2012), reported that cotton seed meal (CSM) fermented with *B. subtilis* replaced soyabean meal in yellow feathered broilers' diet up to 12% without any deleterious effects on their performance. These reports suggest that solid state fermentation could be a promising detoxification method, and can also degrade its crude fiber components because as the material ferments, microorganisms breakdown the celluloses and hemicellulose to soluble sugars, thereby decreasing its crude fibre. Fermentation could also enrich the feed material with desirable metabolites generated by *B. subtilis* and improve its flavor and palatability of the feed in which it is incorporated.

This study was therefore carried out to evaluate the performance, carcass yield and internal organs characteristics of broiler chickens fed graded levels of fermented *Jatropha curcas* seed meal.

MATERIALS AND METHODS

Collection and Processing of *Jatropha Curcas* Seeds

Jatropha curcas fruits were collected in Jalingo metropolis and surrounding villages in Taraba State, Nigeria. The fruits were cracked mechanically to remove the seeds. The seeds were cleaned of dirts and cooked for three (3) hours. The timing of the cooking commenced when the water start boiling after seeds were introduced. The cooked seeds were drained of water and packed in jute bags covered with polythene to allow natural fermentation to take place. The fermentation process lasted for 72 hours. The fermented seeds were sundried, defatted and milled to produce fermented *Jatropha* seed meal (FJSM).

Experimental diets and Design

Five experimental diets containing 0%, 2.5%, 5%, 7.5%, and 10% fermented *Jatropha* seed meal (FJSM) were formulated (Table 1). 200 day-old broiler chicks were randomly allotted to the five dietary treatments of 40 birds per treatment and were replicated four times with 10 birds per replicate in a completely randomized design. The birds were brooded for one week on a deep litter floor.

On the day of collection of the birds, they were given Vitalyte® soluble powder against stress condition. On the second day, they were vaccinated using Newcastle disease vaccine inta-ocular. On the 7th and 14th day, they were orally immunized against Newcastle disease (Lasota) and Infectious bursal disease (gumboro) respectively by dissolving 200 doses of each vaccine in 2 litres of chlorine free water. The birds were also prophylactically treated against coccidiosis using embazing forte® at 30g per 500 litres of water at the 21st day.

Table 1: Percentage composition of experimental chick diets

	Levels of replacement of groundnut cake by FJSM (%)				
Ingredients	0	2.5	5	7.5	10
Maize	54.63	54.63	54.63	54.63	54.63
Groundnut cake	25.00	22.50	20.00	17.50	15.00
FJSM	0.00	2.50	5.00	7.50	10.00
Wheat offal	12.07	12.07	12.07	12.07	12.07
Fish meal	4.00	4.00	4.00	4.00	4.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Limestone	1.50	1.50	1.50	1.50	1.50
Premix*	0.25	0.25	0.25	0.25	0.25
Methionine	0.20	0.20	0.20	0.20	0.20
Lysine	0.10	0.10	0.10	0.10	0.10
Total	**100**	**100**	**100**	**100**	**100**
Calculated analysis					
Crude protein	20.39	20.40	20.41	20.38	20.41
Crude fibre	3.67	3.81	3.99	4.18	4.36
Calcium	0.93	1.13	1.19	1.26	1.33
Phosphorus	0.87	0.95	0.97	1.00	1.02
Lysine	1.27	1.28	1.30	1.31	1.32
Methionine	0.54	0.56	0.60	0.61	0.63
ME (Kcal/Kg)	2774	2774	2814	2834	2854

**Vitamin-Mineral Premix provides per Kg the following: Vit. A 8000 IU; Vit. D_3 1600IU; Vit. E; 5IU; Vit. K 2.mg; Thiamine B_1 1.5mg; Riboflavin B_2 4mg; Pyridoxine B_6 1.5mg; Niacin 15mg; Vit.B_{12} 0.01mg; Pantothenic acid 0.5mg; Folic acid 5mg; Biotin 0.02g; Choline chloride 0.2g; Mn 0.08g; Antioxidant 0.125g; Zn 0.095g; Fe 0.02g; Cu 0.005g; I 0.0012g; Se 0.2g; Co 0.2g*

Data Collection

Growth performance measurements

Feed intake was determined as the difference between the left over and the quantity of feed offered the previous day. Similarly, weight gain was determined as the difference between the final weight and initial weight. Feed conversion ratio was measured as an index of feed utilization for each treatment group and calculated as the ratio of feed intake to weight gain.

Carcass and internal organs evaluation

Two birds from each replicate were randomly selected for carcass and internal organs measurements. The birds were tagged according to their replicates in a treatment and fasted for 8 hours to reduce the gastro-intestinal contents (Yakubu *et al.*, 2012). The birds were individually weighed and slaughtered. The slaughtered birds were defeathered completely to obtain the plucked weight. The internal organs were carefully removed and weighed to determine their fresh weights. The internal organs weights were expressed as the proportion of their body weight. The dressing percentages were expressed as a ratio of carcass weight and live weight multiplied by 100.

Chemical Analysis

The proximate composition of the experimental diets and fermented *Jatropha* seed meal were all carried out according to methods described by AOAC (2000). Tannin concentration was determined using the procedures described by Makkar *et al.* (1993), phobolesters (Ha'as and Mittelbach, 2000), trypsin inhibitors (Kadeka, 1974).

Statistical Analysis

Data collected were subjected to one way analysis of variance (Steel and Torrie, 1980) and significant differences between treatment means were compared using Duncan's Multiple Range Test (Duncan, 1955).

RESULTS

The result of proximate composition of raw and fermented *Jatropha curcas* seed meal is presented in Table 2. Dry matter (DM) content of the raw *Jatropha* seed was 89.82% and increased to 92.55% after fermentation. Higher crude protein (CP) content of 42.38% was observed in the fermented seed and lower in the raw seed (32.61%). Ash content increased from 7.33% in the raw seed to 8.34% in the fermented seed. Ether extract was higher (34.21%) in the fermented seed when compared to 11.34% in the raw seed. Higher crude fibre (CF) (4.13%) was observed in the raw seed as against 2.10% in the fermented seed. Nitrogen free extract was highest 33.81% in the raw seed and 23.75% when the seed was fermented. The values for tannin, trypsin inhibitors, saponin and phobol esters were 3.22, 22.16, 18.11 and 2.80% in the raw seed respectively while that of fermented seed were 0.71, 4.45, 5.81 and 1.06% respectively.

Table 2: Proximate composition of raw and fermented *Jatropha curcas* seed

Nutrients	Raw	Fermented
Dry matter	89.82	92.55
Crude protein	32.61	42.38
Ash	7.33	8.34
Ether Extract (EE)	11.34	34.21
Crude fibre	4.13	2.10
Nitrogen free extract	33.81	23.75
*ME (kcal/kg)	5177.82	3329.72
Antinutrients		
Tannin	3.22	0.71
Trypsin inhibitor	22.16	4.45
Saponins	18.11	5.81
Phorbolesters	2.80	1.06

*ME(Kcal/kg) was calculated using the formula of Pauzenga (1985). ME = 37 X CP + 81X EE + 35.5 X NFE

Growth performance of broiler chickens fed raw and fermented *Jatropha curcas* seed meal

The result of performance of broiler finisher chickens fed varying levels of fermented *Jatropha* seed meal (FJSM) is presented in Table 3. Significant differences (P<0.05) were observed for all the parameters evaluated for growth performance except for initial weight and feed conversion ratio (FCR) which were similar across the treatments. Final weight was highest (1980.31g) in 0% FJSM and decreases with the incremental levels of FJSM. Among the treatments that had FJSM however, 2.5% and 5% replacement levels had significantly higher final weight (1840.08g and 1679.08g respectively) when compared to birds on 7.5% (1425.40g) and 10% (1450.52g) FJSM replacement levels. Average daily feed intake was significantly different (P<0.05) across the replacement levels. ADFI was highest (97.73g) in birds on 0% FJSM while those on 10% had the lowest value (70.04g). The average daily weight gain (ADWG) was significantly (P<0.05) influenced by the dietary replacement levels of FJSM. ADWG decreases as the level of FJSM increases from 33.32g in 0% to 22.42g in 10% replacement level.

Table 3: Performance of broiler chickens fed fermented Jatropha seed meal

	Levels of replacement of groundnut cake by FJSM (%)					
Parameters	0	2.5	5.0	7.5	10.0	SEM
Initial weight (g)	114.40	112.78	114.66	114.63	113.88	1.14^{ns}
Final weight (g)	1980.31^{a}	1840.08^{ab}	1679.08^{b}	1425.40^{c}	1450.52^{c}	16.75^{*}
Total weight gain (g)	1865.92^{a}	1727.28^{ab}	1564.36^{b}	1310.77^{c}	1336.64^{c}	15.60^{*}
ADFI (g/d)	97.73^{a}	91.55^{a}	88.22^{a}	72.21^{b}	70.05^{b}	0.83^{*}
ADWG (g/d)	33.32^{a}	30.85^{ab}	27.94^{b}	23.41^{c}	22.42^{c}	0.27^{*}
FCR	2.93	2.96	3.15	3.08	3.12	0.03^{ns}

Means within a row with different superscript are significantly different (P<0.05)

NS = Not significant ADFI = Average daily feed intake, ADWG = Average daily weight gain
FCR = feed conversion ratio

Carcass and internal organs characteristics of broiler chickens fed raw and fermented *Jatropha curcas* seed meal

The result of carcass yield and internal organs characteristics is presented in Table 4. The results showed that all the parameters evaluated for carcass and internal organs characteristics were significantly (P<0.05) different across the dietary treatments except for dressing percentage, and large intestine weight. The carcass weight of 0% (1376.75g) and 2.5% (1382.50g) were significantly higher than the values of 5% (1348.48), 7.5% (925.65g) and 10% (910.18g). The dressing percentages were also significantly different (P>0.05) across the treatments and it reduces with an increase in the replacement levels of FJSM. The values ranged from 75.54-65%. The weight of the liver were similar in 5% (46.64), 7.5% (46.72) and 10% (47.92) replacement levels and significantly (P<0.05) higher than the values observed in birds on 0% (34.4) and 2.5% (38.32) replacement levels. Results for large intestine length, small intestine weight and length, ceacal weight and length were all significantly (P<0.05) different while large intestine weights were similar. Abdominal fat however decreases from 32.32-25.99 with increasing levels of FJSM.

Table 4: Carcass yield and internal organs characteristics of broiler chickens fed fermented *Jatropha curcas* seed meal.

Parameters (g)	0%	2.5%	5%	7.5%	10%	SEM
Live weight	1955.21^{a}	1829.98^{ab}	1628.08^{b}	1399.75^{c}	1400.42^{c}	16.42*
Carcass weight	1376.75^{a}	1382.50^{a}	1348.48^{b}	925.65^{c}	910.18^{d}	11.88*
Dressing %	70.44^{a}	75.54^{a}	75.24^{a}	66.12^{b}	65.00^{b}	0.70*
Breast weight	350.74^{a}	345.68^{a}	357.72^{a}	236.79^{b}	183.80^{c}	14.74*
Wings weight	180.43^{a}	177.72^{a}	186.40^{a}	134.03^{b}	117.94^{b}	5.56*
Thighs weight	240.24^{a}	243.19^{a}	230.99^{a}	169.84^{b}	140.07^{c}	8.64*
Drumstick weight	208.26^{a}	212.35^{a}	205.40^{a}	148.26^{b}	129.06^{b}	7.81*
Internal organs						
Heart	10.36^{b}	11.36^{ab}	12.16^{a}	7.94^{c}	7.92^{c}	0.52*
Liver	34.4^{b}	38.32^{b}	46.64^{a}	46.72^{a}	47.92^{a}	2.94*
Lungs	13.63^{a}	77.21^{a}	12.66^{ab}	9.99^{bc}	8.57^{c}	1.03*
Gizzard	62.96^{bc}	12.75^{a}	73.51^{ab}	56.13^{c}	40.70^{d}	4.13*
Kidney	8.81^{c}	10.43^{b}	11.19^{b}	11.74^{b}	13.6^{a}	1.09*
Large intestine	3.32	3.33	3.23	3.32	3.27	0.48^{ns}
Large intestine (cm)	9.00^{b}	10.00^{b}	12.34^{ab}	12.75^{ab}	13.0^{a}	0.32*
Small intestine	73.77^{c}	74.96^{c}	112.35^{b}	116.54^{b}	196.00^{a}	6.69*
Small intestine (cm)	160.25^{c}	178.50^{ab}	180.20^{ab}	218.50^{a}	221.00^{a}	10.17*
Caecal	11.40^{c}	12.43^{c}	15.95^{b}	18.33^{a}	19.99^{a}	1.68*
Caecal length (cm)	30.46^{b}	31.67^{b}	33.31^{b}	38.00^{a}	38.33^{a}	1.58*
Abdominal fat	32.32^{a}	31.23^{a}	30.99^{a}	27.13^{b}	25.99^{b}	3.12*

Means within a row with different superscript are significantly different ($P<0.05$)

DISCUSSION

The DM content slightly increased from 89.82% in the raw seed meal to 92.55% in the fermented seed. The relative increase in the DM content of FMJ seed could be as a result of extraction of the oil after fermentation. The values observed in this study however is lower than 97.47% reported by Oladele and Oshodi (2007) and the range of 94.26-97.71% for whole seed kernel seeds and variously processed *Jatropha* seed by Ojediran *et al*., (2014). The increase in DM content after processing has been reported by several workers (Belewa and Sam, 2010; Akande, *et al*., 2012). The CP content of 42.38 % obtained for fermented *Jatropha* seeds was higher than 32.61% for the raw seeds. This could possibly be attributed to the oil extraction of the fermented seeds. These values are higher than 24.60% reported by Akintayo (2004) for unfermented *Jatropha* kernel, 32.88 Abou-Arab and Abu-Salem, (2010) and 13.40 Ogbobe and Akano, (1993) for untreated *Jatropha gossypifolia*. The variations in the values when compared to other workers could be attributed to the differences in the species of the *Jatropha* as observed by Makkar *et al*. (1998) and Ojediran *et al.* (2014). CF content decreased from 4.13% in the raw seed to 2.10% after fermentation. The CF content of the raw *Jatropha* seed is similar to the value of CF reported by Olomu (2011) for Lima bean (4.60%) and Kidney bean (4.20%), but lower than 9.25% reported by Ogbobe and Akano (1993) for untreated seed of *Jatropha gossypifolia*. The nitrogen free extract (NFE) decreased from 33.81% in the raw *Jatropha* seed meal to 23.75% after fermentation. The EE was higher (34.21%) in the fermented seed when compared to 11.34% in the raw seed. The metabolizable energy value was higher (5177.82Kcal/kg) in the raw seed and lower value (3329.72Kcal/kg) was observed in the fermented seed. This could be explained by the fact that oil has been known to improve the energy content of feeding materials as observed by Ojediran *et al*. (2014). The ME of both the raw and fermented Jatropha seed is higher than the value of 2430Kcal/kg reported by Olomu, (2011) for broad bean.

The result of the anti-nutrients in *Jatropha* seed revealed that the raw seed has the highest quantity of all the anti-nutrients when compared with the fermented seed. The tannin content reduced from 3% in the raw seed to 0.70% after fermentation. While the trypsin inhibitors also reduced from 22.16% in the raw seed to 4.45% in the fermented seed. Fermentation also influenced the concentration of saponin and phobo lesters in *Jatropha* seed. In the raw seed, the values were 18.11 and 2.80% respectively while in the fermented seed it was 5.18 and 1.06% respectively. All the values obtained for anti-nutritive factors were higher than those reported by Ojediran *et al*. (2014). Even though fermentation resulted in increased nutrient composition, it did not influence complete removal of the anti-nutritive factors. Makkar *et al*. (1998) reported that phobolesters which is a major anti-nutritive factor in *Jatropha curcas seed* is not safe for livestock beyond 0.09mg/g. The saponin content of 18.11for raw and 5 . 8 1 for fermented Jatropha seed are higher than the values reported by Ojediran *et al*. (2014). It is evident that fermentation and deffattening has little effect on saponin concentration.

The daily weight and final body weight in this study was significant (P<0.05) among the treatment groups, though inferior to what was reported by Kanyinji and Sichangwa (2014) for fermented cotton seed meal and also lower than the values reported by Annongu *et al.* (2010).

FCR which is an index of feed utilization was within the range of 2.82 – 2.85 recommended by Oluyemi and Roberts (2000) for broiler chickens. Oladunjoye *et al.,* (2014) however reported superior values for FCR than what was observed in this study. It is likely that the residual anti-nutritive factors in the diets could have limited the efficient utilization of all the *Jatropha* seed based diets. The use of *Jatropha curcas* meal in animal nutrition is faced with several problems of anti-nutritional factors such as lectin, saponin, tannin, phytate, trypsin inhibitors and phorbol esters (Makkar and Becker, 1999).

It is evident that inclusion levels of FJSM had a significant (P<0.05) influence on carcass yield and internal organs characteristics except for large intestine weight. The values for weight and length of small intestine tended to increase as the level of fermented Jatropha seed meal is increased. This could possibly be explained by the fact that anti-nutritive factors inhibit proper digestion of feeding stuff and as such resulted into accumulation of too much of the feed consumed in the small intestine and resulted into its elongation. Similar observation was also reported by Yusuf *et al.* (2006). Substituting groundnut cake with FJSM beyond 2.5% shows a depressed performance in all the parameters evaluated for carcass yield. Aletor *et al.* (1989) observed that nutrition exert several influence on the development of carcass trait, organs and muscular growth in broilers. Dressing percentage range of 75.44-66% observed in this study is higher than the range of 60.42-66% reported by Yakubu *et al*. (2012) when they replaced groundnut cake with cotton seed cake in broilers and also higher than 66.70 – 73.25% reported by Omolade *et al.,* (2015) on broiler chickens fed diets containing roselle extract. The dressing percent obtained in this study was however lower than the range of 73.15 – 89.49% reported by Ogbu *et al.,* (2015) for raw and processed pigeon pea (*Cajanus cajan*) seed meal.

CONCLUSION

The result of this study therefore suggests that fermentation improves the crude protein content of Jatropha curcas seed meal and also resulted into reduction of all the anti-nutritive factors evaluated. The performance parameters measured however decreases with increase in the levels of Jatropha curcas seed meal except for birds on 2.5% replacement level that were similar to those on 0% level. In conclusion, the result obtained has demonstrated that fermented FJSM can be included at 2.5% in the diets of broiler chickens without adverse effect on performance, carcass characteristics and internal organs.

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