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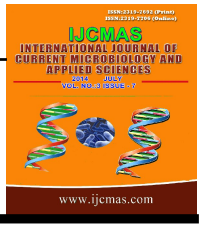

Original Research Article

Effects of Inclusion Level and Length of Fermentation on the Utilization of Jatropha (*Jatropha curcas* L) Seed Cake by Broiler Chickens

I.O.Oladunjoye*, T.Ojediran, C.Aringbangba, O.S.Akinrinlade and O.G.Opakunle

Department of Animal Production and Health, Ladoke Akintola University of Technology, PMB 4000, Ogbomoso, Oyo State, Nigeria
**Corresponding author*

Keywords

Aspegillus niger; Blood profile; Carcass characteristics; solid state fermentation; Nutrient utilization; Production performance

A B S T R A C T

A four weeks study was conducted to evaluate the effects of including varying level of Jatropha seed cake (JSC) fermented for different number of days in broiler starter diets on the production performance in order to recycle this by-product and prevent pollution. Diet 1 (Control diet) contained no JSC. Diets 2, 3, and 4 contained 4% JSC fermented for 7, 11 and 15 days respectively while diets 5, 6 and 7 contained 6% JSC fermented also for 7, 11 and 15 days respectively. The diets were fed to seven groups of forty birds each in a completely randomized design with four replicates per treatment. Data were collected on production performance, nutrient utilization, carcass characteristics, blood profile and production economy. Data collected were analyzed by ANOVA. The results revealed that birds that received JSC containing diets had lower ($P<0.05$) weight gain, live weight, dressed weight, carcass yield and nutrient digestibility than the control irrespective of the level and length of fermentation. Feed cost decreased with increase level of JSC in the diets while production cost was higher in birds that received JSC. Feed conversion by the birds that received JSC was poor compared to that of the control while feed intakes, mortality, gizzard weight, blood components except ALT were unaffected. Birds that received diets that contained JSC had smaller ($P<0.05$) liver and pancreas but higher ALT value than the control. It was concluded that broilers cannot tolerate 4% nor 6% JSC fermented for 15 days or less.

Introduction

One of the major obstacles to the development of livestock industries in most countries of the world is high cost of feed which often account for 60- 80 percent of the total cost of production (Lawrence *et a*l., 2008). This is usually due to high cost of protein and energy feedstuff such as cereals and legume seed cakes which usually constitute the bulk of compound feeds. A pragmatic approach that is been explored by animal scientists to solve this problem is the use of cheap and readily available but less utilized waste products of agro-industries to replace the conventional feedstuff in order to reduce feed formulation cost.

Jatropha seed cake (JSC) is a waste by-product of biodiesel production industry.

This industry processes extracted oil from jatropha seed into biodiesel that can be used in place of fossil fuel and turn out large quantity of JSC as waste. The use of biodiesel is greatly favoured in that it does not produce toxic gases that deplete ozone layer which explains the rapid growth that is being witnessed in this industry in most countries. The detoxification and reuse of this seed cake is very important for adding economic value and also to reduce potential environmental damage that may be caused by improper disposal of this by-product (Kasuya *et al*., 2013).

Jatropha seed cake has been perceived to be a promising feedstuff for livestock due to its high nutrient contents. It has been reported that the cake contained high protein content (Boguhn *et al*., 2010; Sumiati *et al*., 2011) and substantial amount of energy and minerals. Unfortunately however, it contains phorboesters which are tetracyclic diterpenoids polycyclic compounds that are known as tumor promoters and exhibits toxicity within a broad range of species. Indiscriminate dumping of JSC by biodiesel industries can lead to the contamination of the environment and poisoning of man and animals. Many processing methods have been explored to detoxify JSC with different degree of success. This include physical methods (Makkar and Becker, 1997; Chivandi *et al*., 2004; Gaur, 2009), combination of physical and chemical method (Sadubthummarak *et al*.,2013 and biological method (de Barros *et al*., 2011).

There are a lot of conflicting reports on the effect of length of fermentation on the detoxification of anti-nutritional factors in JSC, while some workers reported that length of fermentation significantly affected the concentration of phorboesters (Kasuya *et al.*, 2013) many researchers reported that it does not have any effect on this compound. Also there a lot of conflicting reports on the use of JSC as feed for broiler chicken while Pasaribu *et al*., (2010) reported that inclusion of 4% resulted in growth depression in broilers, Annongu *et al*.,(2010) and Sumiati *et al* (2009) reported that 5% can be included in broiler diets without any adverse effects on growth when subjected to treatments. The present study was therefore conducted to evaluate the effects of inclusion level and length of fermentation using *Aspegillus niger* on the utilization of JSC by broiler chicken.

Materials and Methods

Location of the experiment

The study was carried out at the Poultry Unit of Teaching and Research Farm of Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria. Ogbomoso falls between latitudes $8^0$07'N and $8^0$12'N and longitudes $4^0$04'E and $4^0$15'E. The mean annual rainfall is 1247mm with relative humidity of between 75 and 95%. The location is situated at about 500m above the sea level with a mean annual temperature of 26.2^{0}C (Oguntoyinbo, 1978).

Collection and processing of jatropha seeds

The jatropha seeds that were used for the study were purchased from a middle man at Ibadan, Oyo State, Nigeria. The seeds were opened and the seeds separated from the shell. Seeds were then dried in the sun, milled and oil extracted using hydraulic press. The cake residue was collected and sun-dried in readiness for fermentation process.

Source, culture of Aspergillus niger and inoculation procedure

Isolated and purified culture of *Aspergillus niger* was obtained from the Department of

Pure and Applied Biology laboratory, Ladoke Akintola University of Technology, Ogbomoso. The fungus was grown in potato dextrose agar (PDA) which was supplemented with 20% sucrose at PH of 5.5 with temperature of 30^0C and then preserved in a refrigerator at 4^0C. Aqueous spore suspension of *A niger* was obtained after 7 days of culture. The moisture content of JSC (substrate) was increased to 60% and sterilized in a locally fabricated fermenter of 24Kg carrying capacity. Sterilization was carried out at 121^0C for 3 hours and the JSC allowed to cool. This was then inoculated with *A niger* and then left to ferment for 7 days at 30 ± 1^0C. Prior to autoclaving, each plate containing JSC was covered with muslin cloth and aluminium foil. The fermented product was then harvested, dried and milled to enhance mixing with other ingredients.

Experimental diets preparation

Seven broiler starter diets were formulated. The control diet (diet 1) contained 23% crude protein and 2900KCal/Kg metabolizable energy . Three other diets were formulated to contain 4% JSC fermented for either 7 days (diet 2) or 11 days (diet 3) or 15 days (diet 4) while the remaining three diets contained 6% JSC fermented for either 7 days (diet 5) or 11 days (diet 6) or 15 days (diet 7). All the diets were iso-nitrogenous and iso-caloric and meet the recommendation of NRC (1994) for broiler of this age. The composition of the diets is shown in Table 1.

Experimental birds and Management

Two hundred and eighty day old Arbor Acres strain of broiler chicks were used for the study. The birds were randomly divided into seven groups of forty chicks and the groups assigned to any of the seven diets in a completely randomized design. Each treatment was replicated four times. Birds in each replicate were housed separately in deep litter pens measuring 1.2x1m with wood shavings as litter material. The birds were brooded at 35^0C, 32^0C and 29^0C at the first, second and third weeks respectively. Feeds and water were offered *ad libitum*. Medication and vaccination were carried out according to the recommendation for the derived savanna region of Nigeria. The study was carried out for four weeks.

Data collection

Data were collected on feed intake, weight gain, feed conversion ratio, mortality, feed cost, feed cost per kilogram weight gain, nutrient digestibility, carcass characteristics, haematological and serum biochemical parameters.

Feed intake: Feed intake was estimated as the difference between the feed supplied and the feed rejected over 24 hours period.

Feed consumed = Feed supplied – Feed rejected

Weight gain: Birds in each replicate were weighed in group at the beginning of the experiment and weekly thereafter to monitor the growth. Weight gain was then determined as the difference in weights in two successive weeks.

Weight gain = Weight of the birds in the previous week – Weight of the birds in the current week

Feed conversion ratio: This was determined as the feed intake per unit weight gain.

Feed conversion ratio = Feed intake/Weight gain

Mortality: Record of mortality in each replicate was kept and expressed as a percentage of the total number of birds in the replicate at the beginning of the experiment.

Economic analysis: Feed cost was estimated from the cost of the ingredients used in the preparation of the feed. Cost of JSC was estimated from the cost of purchasing jatropha seeds, cost of transportation, cost of extracting oil from the seeds, cost of fermentation and cost incurred on down line processing.

Metabolic trial

This was conducted during the last week of the study using 12 birds per treatment. The birds were housed in metabolic cages with facility for feeding and faecal collection. Birds were allowed 3 days pre-collection period, followed by 5 days collection using total faecal collection method. Feed intakes and faecal outputs were recorded throughout the duration of the study. The faeces collected from each treatment was oven-dried at 65^0C for 48 hours. The faeces from each treatment was bulk, milled and samples analyzed for proximate composition. The nutrients utilized was then calculated from the proximate composition of the feeds and faeces.

Carcass evaluation

Eight birds that had their weights close to the mean for their groups were selected for carcass evaluation. The birds were fasted for 24 hours, weighed individually, stunned, bled and dressed. The dressed carcasses were weighed and the weights expressed as percentages of the live weights. The visceral organs (Liver, kidneys, gizzard and pancreas) were excised, cleaned of the blood and tissues and then weighed on an electronic weighing scale. The weights of each organ were also expressed as percentages of the live weights of the birds.

Blood analysis

Blood collection: Blood was collected from four birds per treatment. Samples of the blood were collected into two vaccutainer tubes from each animal. Blood that was used for haematological studies was collected into tubes containing ethylene diamine tetraacetic acid (EDTA) as anti-coagulant while the one for serum biochemical studies was collected into a plain tube without anti-coagulant. Blood samples for serum biochemical indices were centrifuged at 3000rpm for 10 minutes to separate and the serum decanted and kept at -20^0C until it was analyzed**.**

Haematological analysis: Red blood cell (RBC) was estimated using haemocytometer method (Jain, 1986) while white blood cell (WBC) was determined using Neubauer haemocytometer after appropriate dilution. Packed cell volume (PCV) was determined using micro-haematocrit centrifugation method as described by Jain (1986). Haemoglobin (Hb) concentration was determined by a cyanmethaemoglobin method using Drabkin's solution as diluents (Kelly, 1979). Mean cell volume (MCV), mean cell haemoglobin concentration (MCHC) and mean cell haemoglobin (MCH) were calculated from RBC and WBC according to the formula of Jain (1986).

Determination of blood serum biochemical parameters: Total protein was determined according to the method described by Kohn and Allen (1995). Albumin was determined using Bromocresol Green method as described by Peter *et al.* (1982) while globulin content was determined by

difference between total protein and albumin. Aspartate amino transferase (AST) and alanine amino transferase (ALT) were determined spectrophotometrically as described by Rej and Hoder (1983). Glucose and creatinine were measured spectrophotometrically following the procedures in the commercial test kits (Biolabo, France).

Analysis of feeds faeces and jatropha seed cake: Feeds, faeces and samples of fermented JSC were analyzed for moisture, crude protein, crude fibre, ether extract and ash using the methods of AOAC (2008) while nitrogen free extract was determined by difference. Gross energy was determined using adiabatic bomb calorimeter.

Statistical analysis: Data generated were analyzed by one-way analysis of variance using the General Linear Model (GLM) procedure of SAS (1998). Significance was determined at $p<0.05$ and where this was indicated, Duncan's option of the same software was used to separate the means.

Results and Discussion

The proximate composition of JSC is shown in Table 2. The crude protein and crude fibre contents were 36.4% and 14.9% respectively. The ether extract was 27.0%.

Inclusion of either 4% or 6% JSC significantly ($P<0.05$) reduced final weight and average daily gain of the birds irrespective of fermentation length. Values observed for the birds that were fed 6% were numerically lower but not significant than those fed 4% jatropha seed cake. No significant ($P>0.05$) effect of diets was observed on the feed intake of the birds. Inclusion of JSC in the diets resulted in poor feed utilization by the birds irrespective of length of fermentation as reflected by higher ($P<0.05$) feed conversion ratio observed in the birds fed these diets. Mortality was however not affected ($P>0.05$) by inclusion of fermented jatropha seed cake in the diets.

Feed cost decreased with increase level of jatropha seed cake in the diets. Length of fermentation however had no significant ($P>0.05$) effect on feed cost. Inclusion of jatropha seed cake in broiler starter diets increased production cost as reflected by higher cost per kilogram weight gain obtained in the birds fed these diets. The highest cost was obtained at 4% inclusion level of 15 days fermented jatropha seed cake while the lowest was obtained in those that received control diet.

Inclusion of fermented JSC depressed digestibility of dry matter, crude protein, crude fibre, ether extract and nitrogen free extract irrespective of level of inclusion and length of fermentation.

Table 5 shows the effects of inclusion of JSC in broiler diet at starter phase. Birds that received diets that contained JSC had lower ($P<0.05$) live weight and dressed weight than the control group irrespective of level of inclusion and length of fermentation. Also the carcass yield of the broilers that were fed JSC was lower than those fed diets that contained no JSC.

Similarly, livers, kidneys and pancreas of the birds that were fed diets that contained JSC were smaller ($P<0.05$) compared to those that received control diet. No significant effect of diets was however observed on the weight of gizzard.

The effects of inclusion of JSC fermented for varying number of days is shown in Table 6. No significant effect of diets was observed in the PCV, RBC, Hb, WBC, MCV, MCH and MCHC contents of the

blood. The PCV and MCHC ranged from 36.7-38.6% and 25.8-26.7% respectively while RBC and WBC ranged from 2.7×10^6- $3.2\times10^6/mm^3$ and 16.2×10^3- $17.0\times10^3/mm^3$ respectively. The values obtained for Hb ranged from 8.8-9.4g/dl. Also dietary treatments had no effect on the total protein, albumin, globulin, blood serum glucose, creatinine, alkaline phosphatase and AST. However, the ALT concentration was significantly higher ($P<0.05$) in the birds that received diets that contained JSC irrespective of the length of fermentation when compared with the birds fed control diet. The ALT values obtained for the birds that received 4% and 6% were similar irrespective of length of fermentation.

The crude protein content of the JSC used in this study (36.4%) was lower than the values of 60% reported by Boguhn *et al*., (2010) but higher than the range of 20.47-21.40% and 22.39-28.87% reported by Sadubthummarak *et al* (2013) and Inekwe *et al* (2012) respectively. The crude fibre content of the JSC used in the present study (14.9%) was however lower than the value of 21.36% reported by Pasaribu *et al*.(2010) and 32.58-44.22% reported by Sumiati *et al* (2009) for untreated and fermented samples. The difference could be due to edaphic factor or level of contamination with shell during processing.

The lower weight gain observed in the birds fed JSC compared with the control is in line with the findings of Pasaribu *et al* (2010) who also observed growth depression in broilers fed 4% JSC processed in different ways and that of Simiati *et al* 2011) who observed growth depression in broilers fed 3-9% JSC fermented with *Rhizopus oligosporus*. It however contradicts the reports of Sumiati *et al* (2009) who reported that there was no weight difference in Kapong chicken fed 5% fermented jatropha meal supplemented with enzymes. The difference between the present study and that of the previous one could be due to addition of the enzymes and the strain/breed of chicken used. The growth repression observed in this study can be attributed to residual anti-nutritional factors like phorboesters, cursin, trypsin inhibitors, phytic acids and tannins that have been reported to be present in Jatropha seed (Goel *et al.*, 2007; Makkar *et al.*, 1998). The fact that weight gain of the birds that received diets that contained JSC were similar irrespective of length of fermentation suggests that fermentation of JSC for up to 15 days cannot completely eliminate anti-nutritional factors in JSC. This contradicts the findings of da Luz *et al.*, (2014) who reported that fermentation of JSC using *Pleurotus ostreatus* reduced phorboesters by 99% after 60 days of incubation. However, the difference in the organisms were used and length of incubation could have accounted for this difference.

This study revealed that the feed intake of the birds was not affected by inclusion of 4% and 6% JSC in the diets irrespective of length of fermentation. This is in line with the findings of Annongu *et al.*, 2010 who also reported no difference in feed intake of albino rat fed up to 15% JSC treated using the combination of boiling, fermentation and extraction with equal volume of hexane and ethanol. It however contradicts the report of Pasaribu *et al.*, (2010) who reported lower feed intake on broiler chicken fed 4% jatropha seed meal processed using either physical or chemical or combination of the two and that of Sumiati *et al.*, (2011) who observed lower feed intake in broilers fed 3-9% JSC fermented with *Rhizopus oligosporus.*

The poor feed conversion that was observed in the birds that were fed JSC in this study

can be attributed to residual anti-nutritional factors in jatropha seed as earlier mentioned. Phorboesters and curcin which are the recalcitrant anti-nutritional factors in jatropha seed are known to cause diarrhea and inflammation of digestive system which interfere with digestion and absorption of nutrients (Makkar and Becker, 1997). The present study however contradicts the report of Annongu *et al.*, (2010) who reported that the feed efficiency of rats was not adversely affected by inclusion of up to 15% treated jatropha seed meal in their diets.

In this study, mortality of the birds was not affected by inclusion of JSC in their diet. This implies that the residual anti-nutritional factors in the JSC used did not reach the lethal dosage for the bird. Annongu *et al.*, (2010) also reported 100% survival in rats fed up to 15% treated JSC.

The decrease that was observed in feed cost as JSC increase in the diets can be attributed to lower price of JSC compared with soy bean meal. The fact that length of fermentation did not have any significant effect on feed cost implies that additional increase in the length of days of fermentation did not add appreciably to the cost of fermentation. The increase that was observed in the feed cost per kilogram weight gain of the group of birds that received diets that contained JSC can be attributed to higher feed conversion ratio recorded in these groups.

The depression that was observed in nutrient digestibility of the birds that were fed diets that contained JSC can be attributed to residual anti-nutritional factors in JSC. Sumiati *et al* (2011) also reported that *Rhizopus oligosporus* was unable to effectively detoxify the anti-nutritional factors in jatropha seed meal.

The smaller live weight, dressed weight and carcass yield that were observed in birds that received diets that contained JSC can be attributed to poor growth (Uchegbu *et al*., 2004) which could be due to protein synthesis inhibitory action of curcin (Barbbieri and Battellim, 1993) and also inhibition of digestion and absorption of protein and minerals by Phorboesters, phytic acid and tannins.

In this study, the livers, kidneys and pancreas of birds that were fed diets that contained JSC were smaller compared to that of the control. This can also be attributed to the effect of residual anti-nutritional factors in JSC. Araujo *et al*., (2010) also attributed regressive changes in the kidneys and liver of sheep fed diets containing dried and crushed fruit shell of *Jatropha curcas* in substitution for Mombaca grass hay to the anti-nutritional factors contained in it.

This study revealed that dietary treatments had no effect haematological and serum biochemical indices except ALT. This corroborates the findings of Annongu *et al*.,(2010) who also observed no difference in the haematological parameters of Olympiad cockerel chicks fed 5% JSC treated by combined physical and biochemical methods. The higher concentration of ALT observed in the birds that were fed JSC can be attributed to the damaging effect of residual anti-nutritional factors on liver. The haematological and biochemical indices values were however within the range reported by Mitruka and Rawnsley (1977) for normal chicken.

Table.1 Broiler starter diets

	Level of JSC in the diet						
	0%		4%			6%	
Ingredient(%)	Control	JSCF7	JSCF11	JSCF15	JSCF7	JSCF11	JSCF15
Maize	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Soy bean meal	18.0	14.0	14.0	14.0	12.0	12.0	12.0
Groundnut cake	13.0	13.0	13.0	13.0	13.0	13.0	13.0
Fish meal	3.0	3.1	3.1	3.1	3.3	3.3	3.3
JSC	0.0	4.0	4.0	4.0	6.0	6.0	6.0
Palm kernel cake	6.0	5.9	5.9	5.9	5.7	5.7	5.7
Wheat offal	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Oyster shell	1.95	1.95	1.95	1.95	1.95	1.95	1.95
Dicalcium phosphate	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Table salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Total	100	100	100	100	100	100	100
*CP (%)	22.3	22.25	22.25	22.25	22.15	22.15	22.15
*CF (%)	3.0	3.2	3.2	3.2	3.3	3.3	3.3
*M. E. (Kcal/kg)	2920	2918	2918	2918	2917	2917	2917

* premix composition per 5kg: Vitamin A, 20000000IU, Vit. D3 4000000IU; Vitamin E 460mg; Vitamin K3 40mg; Vitamin ; Vitamin B1 60mg; Vitamin B2 120mg; Niacin 1000mg; Calcium pantothenate 200mg; Vitamin B6 100mg; Vitamin B125mg; Folic acid 20mg; Biotin 1mg; Chlorine chloride 8000mg; Manganese 2400mg; Iron 2000mg; Zinc 1600mgCopper 170mg; Iodine 30mg; Cobalt 6mg; Selenium 24mg; Anti-oxidant 2400mg; CP= Crude protein; CF= Crude fibre; ME=Metabolizable energy; JSC= Jatropha seed cake; JSCF7= Jatropha seed cake fermented for 7 days; JSCF11= Jatropha seed cake fermented for 11 days; JSCF15= Jatropha seed cake fermented for 15 days; * Calculated value.

Table.2 Proximate composition of Jatropha seed cake (Dry matter basis)

Component	Percentage
Dry matter	89.2
Crude protein	36.4
Crude fibre	14. 9
Ether extract	12.7
Ash	9.0
NFE	27.0

NFE=Nitrogen free extract

Table.3 Effects of Jatropha seed cake fermented for varying number of days on growth performance of broilers

	0% JSC	4%JSC			6%JSC				
Parameter	Control	JSCF7	JSCF11	JSCF15	JSCF7	JSCF11	JSCF15	SEM	Pvalue
Initial wt (g)	37.3	37.4	37.2	37.5	37.3	37.5	37.2	-	-
Final wt(g)	768^{a}	723.^{b}	720^{b}	709^{b}	715^{b}	710^{b}	709^{b}	22	0.15
ADG (g)	26.1^{a}	24.5^{b}	24.4^{b}	24.0^{b}	24.2^{b}	24.0^{b}	24.1^{b}	1.3	0.02
Feed intake(g)	38.6	38.7	39.5	39.2	38.8	39.3	39.15	4.0	0.02
FCR	1.48^{b}	1.58^{a}	1.62^{a}	1.65^{a}	1.60^{a}	1.60^{a}	1.62^{a}	0.08	0.03
Mortality (%)	3.62	3.57	3.63	3.56	3.61	3.55	3.58	0.2	0.17
Feed cost(N)	76.0^{a}	74.5^{b}	74.7^{b}	74.8^{b}	72.6^{c}	72.8^{c}	72.9^{c}	1.0	0.02
Cost/Kg wt gain (N)	112^{f}	118^{c}	121^{b}	123^{a}	116^{e}	117^{d}	118^{c}	0.6	0.02

abcdef: Means bearing different superscripts along the same row are significantly different (P<0.05); Wt = weight; ADG = Average daily gain; FCR = Feed conversion ratio; JSC = Jatropha seed cake; JSCF7= Jatropha seed cake fermented for 7 days; JSCF11 = Jatropha seed cake fermented for 11 days; JSCF15 = Jatropha seed cake fermented for 15 days; Wt= weight; N= Nigerian Naira

Table.4 Effects of level of Jatropha inclusion and length of fermentation on nutrients utilization

	0% JSC	4%JSC			6%JSC				
Parameter	Control	JSCF7	JSCF11	JSCF15	JSCF7	JSCF11	JSCF15	SEM	Pvalue
Dry matter (%)	72.5^{a}	69.8^{b}	69.7^{b}	69.1^{b}	69.3^{b}	69.3^{b}	69.4^{b}	1.3	0.03
Crude protein (%)	75.7^{a}	73.5^{b}	73.7^{b}	73.4^{b}	72.9^{b}	73.1^{b}	73.2^{b}	1.5	0.02
Crude fibre (%)	68.3^{a}	66.1^{b}	65.8^{b}	65.9^{b}	65.7^{b}	65.6^{b}	65.8^{b}	1.5	0.03
Ether extract (%)	73.4^{a}	71.2^{b}	70.9^{b}	70.8^{b}	71.1^{b}	71.3^{b}	70.7^{b}	1.6	0.02
NFE (%)	78.7^{a}	75.8^{b}	75.5^{b}	75.4^{b}	75.3^{b}	75.7^{b}	75.2^{b}	1.6	0.03

ab: Means bearing different superscripts along the same row are significantly different (P<0.05); NFE = Nitrogen free extract; JSC = Jatropha seed cake; JSCF7= Jatropha seed cake fermented for 7 days; JSCF11 = Jatropha seed cake fermented for 11 days; JSCF15 = Jatropha seed cake fermented for 15 days

Table.5 Effects of level of Jatropha inclusion and length of fermentation on carcass and visceral organ weight

	0% JSC	4%JSC			6%JSC				
Parameter	Control	JSCF7	JSCF11	JSCF15	JSCF7	JSCF11	JSCF15	SEM	Pvalue
Live wt (g)	763^{a}	642^{b}	632^{b}	635^{b}	640^{b}	644^{b}	632^{b}	18	0.03
Dressed wt (g)	528^{a}	418^{b}	415^{b}	418^{b}	411^{b}	417^{b}	409^{b}	15	0.02
*Carcass yield (%)	69.3^{a}	65.1^{b}	65.6^{b}	65.8^{b}	64.2^{b}	64.8^{b}	64.7^{b}	5.0	0.02
*Liver (%)	2.4^{a}	1.6^{b}	1.5^{b}	1.4^{b}	1.6^{b}	1.3^{b}	1.5^{b}	0.4	0.03
*Kidneys(%)	3.4^{a}	2.7^{b}	2.6^{b}	2.5^{b}	2.7^{b}	2.5^{b}	2.6^{b}	0.4	0.02
*Pancreas (%)	0.16^{a}	0.11^{b}	0.12^{b}	0.11^{b}	0.11^{b}	0.12^{b}	0.11^{b}	0.12^{b}	0.12^{b}
*Gizzard (%)	2.65	2.55	2.70	2.60	2.80	2.75	2.50	0.5	0.12

ab: Means bearing different superscripts along the same row are significantly different (P<0.05); JSC = Jatropha seed cake; JSCF7= Jatropha seed cake fermented for 7 days; JSCF11 = Jatropha seed cake fermented for 11 days; JSCF15 = Jatropha seed cake fermented for 15 days; * Percent live weight; Wt= weight

Table.6 Blood profile of broiler starter fed different level of fermented jatropha seed cake

	0% JSC	4%JSC			6%JSC				
Parameter	Control	JSCF7	JSCF11	JSCF15	JSCF7	JSCF11	JSCF15	SEM	Pvalue
PCV (%)	37.4	36.7	36.9	38.1	38.5	37.7	38.6	3.0	0.13
RBC ($\times 10^6/mm^3$)	3.2	2.8	2.9	3.1	2.7	3.1	3.0	0.4	0.12
Hb (g/dl)	9.1	9.3	9.0	8.9	8.8	9.2	9.4	0.8	0.11
WBC ($\times 10^3/mm^3$)	16.6	16.8	16.2	16.4	16.3	16.7	17.0	0.7	0.12
MCV(u^3)	111.4	112.6	110.3	112.8	111.8	110.9	113.3	5.0	0.13
MCH (uug)	33.5	34.1	33.7	34.6	34.9	33.8	34.2	3.0	0.12
MCHC (%)	26.5	25.9	26.3	26.0	25.8	26.7	26.6	3.0	0.14
Total Protein (g/dl)	5.7	5.8	5.6	6.1	5.9	6.2	6.3	2.5	0.12
Albumin (g/dl)	2.8	2.7	2.6	2.5	2.4	2.7	2.6	0.7	0.23
Globulin (g/dl)	2.9	3.1	3.0	3.6	3.5	3.5	3.7	1.0	0.13
Glucose (mg/dl)	164	163	162	163	164	165	162	5.0	0.12
Creatinine (mg/dl)	1.4	1.5	1.3	1.2	1.3	1.4	1.2	0.5	0.11
Al. P(IU/l)	34.7	34.2	34.8	34.9	34.3	34.6	35.1	1.2	0.12
ALT (IU/l)	17.6^b	27.3^a	26.5^a	27.8^a	26.7^a	27.4^a	26.9^a	3.5	0.14
AST (IU/l)	138	142	139	140	137	141	137	7.0	0.13

ab: Means bearing different superscripts along the same row are significantly different (P<0.05); JSC = Jatropha seed cake; JSCF7= Jatropha seed cake fermented for 7 days; JSCF11 = Jatropha seed cake fermented for 11 days; JSCF15 = Jatropha seed cake fermented for 15 days; AlP= Alkaline phosphate; ALT= Alanine aminotransferase; AST= Aspartate aminotransferase

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