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Effect of replacing full-fat soybean meal with undefatted cashew reject kernel meal on the growth response, blood parameters, organ weight and abdominal fat weight of broiler chicks

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SUMMARY

This feeding trial examined the effects of replacing full-fat soybean meal with undefatted cashew reject kernel meal on the growth response, blood parameters, organ weight and abdominal fat weight of broiler chicks. Three hundred one-day-old unsexed Arbor-acre strain broiler chicks were randomly assigned to five dietary treatments with 60 birds each, replicated six times, in a 21-day feeding trial with a completely randomized design. The control diet (T1) was based on maize and full-fat soybean meal (SBM). Undefatted cashew reject kernel meal (UCRKM) was used to replace 12,50%; 25,00%; 37,50% or 50,00% of the full-fat SBM in the control diet; these diets were referred to as T2, T3, T4 and T5, respectively. Analysis of the chemical composition revealed that UCRKM contained 26,56% crude protein; 3,30% crude fibre; 2,99% ash; 35,05% ether extract; 23,07% nitrogen-free extract and 4 285,76 kcal kg^{-1} metabolizable energy. Significant differences ($P \leq 0,05$) were observed in the growth parameters; the feed conversion ratio of birds fed diets with UCRKM compared favourably with those fed T1. The red blood cell count, corpuscular indices, platelet count, levels of alanine amino transaminase, alkaline phosphatase, and creatinine, and the weights of the internal organs and abdominal fat were influenced by the diets ($P \leq 0,05$). UCRKM is therefore recommended as a replacement for up to 50,00% full-fat SBM in broiler starter diets.

KEY WORDS: haematology, organs, serum, starter broilers, performance

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INTRODUCTION

Poultry producers and feed nutritionists around the world are faced with the task of managing feed resources to ease the high cost of feed, which has led to the continuing search for new feedstuffs. According to Akande et al. (2015), the search for substitutes arises from the notion of independence and aims to achieve sustainability by using local resources. *Anacardium occidentale*, a drought-resistant tree indigenous to the tropical and subtropical region between 23°N and 23°S of the equator has gained a reputation as an economic crop (KGF, 2011), because its nuts have become an important industrial and export commodity in many parts of Africa, Asia and South America (Akinhanmi et al., 2008).

The world’s leading producers of cashew nuts are Vietnam, Nigeria, India, the Ivory Coast and Benin (FAO 2015; Heuze et al. 2017). The cashew shell and kernel made up the nut. The shell is toxic, while the kernel is edible. Cashew nutshell liquid has several uses and is a significant secondary product of the cashew industry (Quirino et al. 2014). It has gained an economic reputation in the production of polymer friction linings, laminating plates, solid coatings, adhesives for woodwork, epoxy resins (Kumar et al. 2002), and pesticides. The kernels are fit for human consumption because of their rich proximate composition. Aliyu and Hammed (2008) attributed the expansion in production to local consumption and export.

Damaged kernels are discarded or rejected for consumption or export during processing. Akande et al. (2015) estimated the rejection level to be as high as 30% of kernels, depending on the nut quality. However, Odunsi (2002), Ojewola et al. (2004), the FAO (2013) and Akande et al. (2015) have demonstrated their suitability as an animal feedstuff. These authors have established their protein efficiency value and comparative advantage over soybean meal and groundnut meal in chickens.

The expansion in cashew production, global output and demand from various countries indicate that the discarded kernels will be available as livestock feed (FAO, 2013). Ojediran et al. (2021) demonstrated that discarded cashew kernels were cheaper than soybean. Nonetheless, the paucity of information concerning cashew kernels as livestock feedstuff, e.g. for chickens, indicates that it has not received the interest it deserves from researchers. Therefore there is a need for further investigation of the kernel as a replacement for costly conventional protein feedstuffs. Consequently, this experiment focused on further investigating the nutritional value of undefatted cashew reject kernel meal and its effects when used in the diet of broiler chicks.

MATERIALS AND METHODS

Ethics approval

This feeding trial met the guidelines of the Animal Science code and was approved by the Animal and Research Ethics Committee of the Department of Animal Nutrition and Biotechnology, Ladoke Akintola University of Technology (approval number ANB/20/13056B).

Location and preparation of test ingredient

The feeding tests were performed at the Broiler Section of the Ladoke Akintola University of Technology Research Farm, derived-savannah zone, southwest Nigeria, 18°15'N, 4°5' E of the Greenwich meridian (Ojedapo et al. 2009). Undefatted cashew reject kernel was procured from a reputable processing firm. Graded nuts were sorted for processing according to quality standards.

Kernels found unsuitable for food were rejected. Those kernels were used in this experiment. They were left undefatted but milled and referred to as undefatted cashew reject kernel meal (UCRKM).

Experimental birds and management

Three hundred one-day-old unsexed Arbor Acres broiler chicks procured from a respected farm were raised for this study. They were intensively managed on a deep litter system. They were separated into five sets of 60 birds each and randomized to five dietary treatments. Each dietary group was sub-divided into six replicates of ten chicks per replicate. Each replicate was raised in a 1 m x 1 m cell. The birds had *ad libitum* access to the diets and water from the first day of the experiment. Occasional production practices were carried out, including vaccination, changing of litter, and administration of preventive medication. The study lasted for 21 days.

Experimental diets

The control (T1) diet consisted mainly of maize and full-fat soybean meal. UCRKM was used to replace 12,50%; 25,00%; 37,50% and 50,00% of the full-fat soybean meal in the control diet, and the resulting diets were referred to as T2, T3, T4 and T5, respectively (Table 1). The feed ingredients were in meal form and were compounded and administered as mash.

Table 1

Ingredients of broiler starter diets (0-3 weeks)

Ingredient (%)	Experimental group				
	T1	T2	T3	T4	T5
Maize	51,00	51,00	51,00	51,00	44,50
Fish meal	6,00	6,00	6,00	6,00	7,00
FFS	32,00	28,00	24,00	20,00	16,00
UCRKM	0,00	4,00	8,00	12,00	16,00
Wheat offal	5,50	5,50	5,50	5,50	11,00
Bone meal	2,50	2,50	2,50	2,50	2,50
Limestone	2,00	2,00	2,00	2,00	2,00
Lysine	0,25	0,25	0,25	0,25	0,25
Methionine	0,25	0,25	0,25	0,25	0,25
#Premix	0,25	0,25	0,25	0,25	0,25
Salt	0,25	0,25	0,25	0,25	0,25
Total	100,00	100,00	100,00	100,00	100,00
Calculated analysis					
ME (kcal/kg)	3 102,34	3 164,62	3 232,08	3 296,95	3 288,61
Crude Protein	22,01	21,39	20,73	20,10	20,53
Ether Extract	8,60	9,44	10,37	11,26	12,18
Crude Fibre	3,30	3,13	2,94	2,75	2,92
Lysine	1,50	1,60	1,65	1,70	1,81
Methionine	0,68	0,71	0,74	0,77	0,82

FFS - full-fat soybean meal, UCRKM - undefatted cashew kernel reject meal, ME - metabolizable energy

#2,5 kg of premix supplied vitamin A 12 500,000 IU; vitamin D 2 500,000 IU; vitamin E 40 000 mg; vitamin K_3 2 000 mg; vitamin B_1 3 000 mg; vitamin B_2 5 500 mg; niacin 55 000 mg; calcium pantothenate 11 500 mg; vitamin B_6 5 000 mg; vitamin B_{12}, 25 mg; folic acid 1 000 mg; biotin 80 mg; choline chloride 500 000 mg; manganese 120 000 mg; iron 100 000 mg; zinc 80 000 mg; copper 8 500 mg; iodine 1 500 mg; cobalt 3 000 mg; selenium 120 mg and anti-oxidant 120 000 mg

Data collection

Data were gathered on growth parameters, including feed consumed, weight gain and feed conversion ratio, which was estimated as average feed intake divided by average weight gain. Feed intake was individually measured as the difference between feed administered and feed left over daily. Weight changes were recorded weekly using an electronic scale. Six chicks per treatment, chosen randomly, had blood drawn from the jugular vein into 5 ml sterilized clear tubes: six EDTA tubes for haematological tests, and six without EDTA for serum chemistry analyses. Haematological and serum chemistry parameters were determined as described by Ojediran et al, (2019). The haematological parameters measured were haemoglobin (Jain, 1986), erythrocyte count, leucocyte count (Jain, 1986), haematocrit (Dacie and Lewis, 1999), and lymphocyte count. Corpuscular concentrations were calculated. An automated haematology analyser (Mindray BC-3000) was used to analyse the parameters. Serum cholesterol was analysed according to Roschlan et al. (1974). The Biuret and Bromocresol green methods described by Peters et al. (1982) were used to determine serum protein and albumin, respectively. The spectrophotometric method of Schmidt and Schmidt (1963) was used to determine alanine aminotransferase, aspartate aminotransferase, alkaline phosphate, urea and creatinine.

Then the birds were slaughtered by neck cutting and bled completely. Internal organs (kidney, liver, heart, lungs, gizzards and pancreas, removed before scalding and defeathering) and abdominal fat was weighed using a sensitive electronic scale (kerro BL 30001E), and their percentages of live weight were determined.

Chemical analysis

The proximate composition of the discarded cashew kernel meal and full-fat soybean meal were determined according to AOAC (2012). Metabolizable energy (ME) was determined using the formula Kcal/kg = 37 · %CP + 81,1 · %Fat + 35 · %NFE (Pauzenga 1985).

Trial design and statistics

The feeding trial design was completely randomized. Data were analysed by one-way analysis of variance employing IBM SPSS version 21, while the means were separated by Duncan's multiple range test (at 5%) in the same software.

RESULTS

Chemical composition of undefatted cashew reject kernel meal

The chemical composition of discarded cashew kernel meal and full-fat soybean meal is shown in Table 2.

Table 2

Chemical composition of undefatted cashew reject kernel meal (UCRKM) and full-fat soybean meal

Chemical fraction (%)	UCRKM	FFSBM
Crude protein	26,56	37,50
Crude fibre	3,30	6,50
Ash	2,99	5,65
Ether extract	35,05	24,61
Moisture	9,03	10,01
Nitrogen free extract	23,07	15,73
Metabolizable energy (kcal/kg)	4 285,76	3 933,92

Growth performance

Table 3 presents the growth response of broiler starters fed undefatted cashew reject kernel meal (UCRKM) as a replacement for full-fat soybean meal. Significant differences ($p < 0,05$) were observed in final weight (FW), total weight gain (TWG), average daily feed intake (ADFI), average daily gain (ADG), feed conversion ratio (FCR) and recorded mortality. The final weight of birds on diet T2 was higher than in those fed diet T4 ($p < 0,05$) and comparable to that of birds on diets T1, T3 and T5 ($p < 0,05$). Birds fed a diet containing 12,5% UCRKM (T2) as a replacement for full-fat soybean meal consumed more feed than those in the other dietary treatments, while those fed diets T1, T3 and T4 were comparable. The birds fed diet T2 had the highest values for ($p < 0,05$) TWG and ADG, comparable to the values in birds fed diet T5. Birds fed diets T2 and T5 had the lowest FCR, which was significantly different ($p < 0,05$) from that of birds fed T3 but comparable ($p > 0,05$) to that of those fed T1 and T3. Birds fed the T5 diet had higher ($p < 0,05$) mortality than those fed diets T1-T4.

Table 3

Growth performance of broiler starters fed undefatted cashew reject kernel meal as a replacement for full-fat soybean meal

Parameter	Experimental group					SEM	P-value
	T1	T2	T3	T4	T5		
IW (g/b)	44,63	46,30	45,27	43,70	44,07	0,62	0,27
FW (g/b)	$322,00^{ab}$	$350,00^{a}$	$331,56^{ab}$	$290,33^{b}$	$335,00^{ab}$	7,87	0,02
TWG (g/b)	$277,37^{b}$	$303,70^{a}$	$286,29^{b}$	$246,63^{b}$	$290,93^{ab}$	5,95	0,04
ADFI (g/b/d)	$30,43^{b}$	$33,82^{a}$	$30,00^{b}$	$30,67^{b}$	$30,99^{b}$	0,48	0,04
ADG (g/b/d)	$21,11^{b}$	$25,06^{a}$	$20,43^{b}$	$21,46^{b}$	$22,78^{ab}$	0,56	0,04
FCR	$1,44^{ab}$	$1,35^{b}$	$1,47^{a}$	$1,43^{ab}$	$1,36^{b}$	0,02	0,02
Mortality (%)	$0,00^{b}$	$0,00^{b}$	$0,00^{b}$	$0,00^{b}$	$1,67^{a}$	0,02	0,04

^{abc} Means in the same row with different superscripts are significantly different ($p < 0,05$); SEM - standard error of mean, IW - initial weight, FW - final weight, TWG - total weight gain, ADFI - average daily feed intake, ADG - average daily gain, FCR - feed conversion ratio

Haematological responses

Table 4 shows the haematological parameters of broiler starters receiving undefatted cashew reject kernel meal (UCRKM) as a replacement for full-fat soybean meal. Differences ($p < 0,05$) were noted in red blood cell count (RBC), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC) and platelet counts (PLT), while white blood cell count (WBC), haemoglobin (Hb) and haematocrit (HCT) were not significantly influenced by the diet ($p > 0,05$). Birds fed diet T3 had significantly different ($p < 0,05$) RBC counts from those fed T5, while the values for those fed diets T1, T2 and T4 were comparable. MCV values ranged from 125,67 fL (T5) to 130,81 fL (T2). Birds on diets T2 and T5 differed significantly ($p < 0,05$). Birds fed diets containing UCRKM had higher MCH and MCHC than those receiving the control diet. The MCH values of birds fed diets T1 and T2 were significantly different ($p < 0,05$), while those of birds offered other feeds were comparable. Values obtained for MCHC in birds fed diets T2 and T5 were similar ($p > 0,05$), but were different ($p < 0,05$) from the MCHC of birds fed the control diet (T1). Platelet counts were similar in birds on diets T1 and T3 ($p > 0,05$) but different ($p < 0,05$) from those of birds fed T4.

Table 4

Haematological responses of broiler starters fed undefatted cashew kernel reject meal as a replacement for full-fat soybean meal

Parameter	Experimental group					SEM	P-value
	T1	T2	T3	T4	T5		
WBC (x10^3 µL)	194,13	178,73	179,20	208,57	210,300	5,52	0,19
RBC (x10^3µL)	$2,13^{ab}$	$1,85^{ab}$	$1,74^{b}$	$2,08^{ab}$	$2,34^{a}$	0,09	0,00
Hb (dL)	7,20	6,83	6,17	7,20	8,50	0,33	0,29
HCT (%)	27,53	23,93	22,40	26,40	29,37	1,01	0,19
MCV (fL)	$129,63^{ab}$	$130,81^{a}$	$130,00^{ab}$	$127,17^{ab}$	$125,67^{b}$	0,72	0,01
MCH (pg)	$33,23^{b}$	$37,30^{a}$	$35,43^{ab}$	$34,70^{ab}$	$36,13^{ab}$	0,52	0,01
MCHC (dL)	$25,66^{b}$	$28,50^{a}$	$27,27^{ab}$	$27,23^{ab}$	$28,77^{a}$	0,41	0,01
PLT (x10^3µL)	$177,33^{a}$	$169,67^{ab}$	$178,33^{a}$	$164,00^{b}$	$170,33^{ab}$	1,93	0,01

^{abc} Means in the same row with different superscripts are significantly different ($p < 0,05$); SEM - standard error of mean, WBC - white blood cell count, RBC - red blood cell count, Hb - haemoglobin, HCT - haematocrit, MCV - mean corpuscular volume, MCH - mean corpuscular haemoglobin, MCHC - mean corpuscular haemoglobin concentration, PLT - platelet count

Serum biochemistry

Table 5 shows the serum biochemistry of broilers fed undefatted cashew reject kernel meal as a replacement for full-fat soybean meal. Aspartate amino transaminase (AST), total protein, albumin, globulin and urea were not significantly different ($p > 0,05$), while alanine amino transaminase (ALT), alkaline phosphatase (ALP) and creatinine were influenced by the diets ($p < 0,05$). ALT and ALP in birds fed UCRKM diets were comparable to those fed T1, except those fed T5. Alkaline phosphate increased linearly from T2 to T4 ($p < 0,05$), while birds fed T5 had the lowest value, which was significantly different from those of birds on diets T1, T3 and T4. The creatinine level in birds fed T4 was higher than in the other groups but comparable to the level in birds offered diet T1. The lowest ($p < 0,05$) level was recorded in birds given diet T2.

Table 5

Serum biochemistry of broiler starters fed undefatted cashew kernel reject meal as a replacement for full-fat soybean meal

Parameter	Experimental group					SEM	P-value
	T1	T2	T3	T4	T5		
AST (μ/L)	62,63	48,63	52,37	61,32	69,74	3,99	0,49
ALT (μ/L)	$24,42^{ab}$	$27,53^{a}$	$21,39^{b}$	$22,25^{b}$	$14,98^{c}$	0,96	0,00
ALP (μ/L)	$43,51^{a}$	$42,51^{ab}$	$43,46^{a}$	$44,18^{a}$	$36,22^{b}$	1,09	0,01
Total protein (g/dl)	2,39	1,88	2,65	2,76	1,89	0,14	0,14
Albumin (g/dl)	1,09	1,01	1,04	1,13	1,19	0,04	0,71
Globulin (g/dl)	1,31	0,87	1,60	1,64	0,66	0,16	0,21
Urea (μmol/L)	4,32	3,36	2,91	3,74	2,59	0,26	0,26
Creatinine (mg/L)	$0,86^{ab}$	$0,69^{b}$	$0,70^{b}$	$0,92^{a}$	$0,76^{b}$	0,03	0,00

^{abc} superscript means in the same row with different superscript letters are significantly different ($p < 0,05$); SEM - standard error of mean, AST - aspartate amino transaminase, ALT - alanine amino transaminase, ALP - alkaline phosphate

Organ weight

Table 6 shows the organ weight of broilers fed full-fat cashew reject kernel meal as a replacement for full-fat soybean meal. Significant differences ($p < 0,05$) were found in the weight of various internal organs and abdominal fat, except for the liver. Birds on diet T4 had the heaviest ($p < 0,05$) kidneys, while kidney weight was lowest in birds offered diet T3 ($p < 0,05$). A similar trend was observed for the heart weight. Birds fed diet T4 had the highest weight for the kidney, heart, lungs, whole gizzard and empty gizzard. The weight of abdominal fat was significantly different ($p < 0,05$) in birds offered diets T1 and T5, at 0,92% and 1,58%, respectively. Pancreas weight was higher in birds on diets T1 and T3, and the lowest ($p < 0,05$) in those fed diet T5.

Table 6
Organ weight of broiler starters fed full-fat cashew kernel reject meal as a replacement for full-fat soybean meal

Parameter (%)	Experimental group					SEM	P-value
	T1	T2	T3	T4	T5		
Kidney	$0,86^{ab}$	$0,48^{c}$	$0,42^{d}$	$0,99^{a}$	$0,64^{bc}$	0,06	0,00
Heart	$0,82^{ab}$	$0,82^{ab}$	$0,66^{b}$	$0,94^{a}$	$0,71^{ab}$	0,04	0,01
Liver	2,23	2,77	2,73	2,39	2,47	0,09	0,23
Lungs	$0,81^{ab}$	$0,63^{b}$	$0,71^{ab}$	$0,89^{a}$	$0,76^{ab}$	0,03	0,04
Empty gizzard	$3,09^{b}$	$3,13^{b}$	$3,06^{b}$	$4,39^{a}$	$3,35^{b}$	0,13	0,00
Abdominal fat	$0,92^{b}$	$1,35^{ab}$	$1,05^{ab}$	$0,79^{b}$	$1,58^{a}$	0,91	0,03
Pancreas	$0,76^{a}$	$0,55^{ab}$	$0,72^{a}$	$0,44^{b}$	$0,31^{c}$	0,04	0,00

^{abc} Means with different superscripts are significantly different ($p < 0,05$); SEM - standard error of mean

DISCUSSION

Chemical composition of undefatted cashew reject kernel

Analysis of the composition of the undefatted cashew reject kernel meal shows that it had moderate protein content but high caloric value. Akande et al. (2015) reported 22,10% crude protein; 0,90% crude fibre; 3,73% ash; 40,23% ether extract; 24,04% nitrogen-free extract and 6 542 kcal kg^{-1} gross energy for undefatted cashew reject kernel meal. Oddoye et al. (2012), on the other hand, reported that cashew kernel reject had 22,9% crude protein; 27,5% crude fibre; 58,0% ether extract and 13,5% nitrogen-free extract. Ojewola et al. (2004) attributed such differences to factors such as processing technology, storage time, climatic conditions and the type of soil on which the crop was grown.

Growth performance

Observations of live weight, intake, gain and FCR in the starter phase were at variance with the non-significant values reported by Oddoye et al. (2013). Feed intake and weight gain were higher in birds fed 12,50% UCRKM as a replacement for full-fat soybean meal. This may be related to the inclusion level or improved palatability. Akande et al. (2015) observed reduced consumption in birds fed undefatted cashew reject kernel meal. This was attributed to the feed energy content, which increased with increasing levels of the meal. Oddoye et al. (2012) reported contrasting observations. The weight gain of the birds in this study receiving diets with 25% to 50% UCRKM in place of full-fat soybean meal was comparable to that of the birds on the control diet. The feed conversion ratio showed that the feeds were well tolerated, similar to the control diet. This could be because the two switched ingredients were both undefatted. However, contrasting results for feed intake, weight gain and FCR were reported by Ojediran and Emiola (2018) in chicks fed treated *Jatropha curcas* kernel meal. Mortality reported by Ojediran and Emiola (2018) was higher than in the present study, which can be attributed to residual anti-nutrients.

Haematological parameters

The nutritional and clinical health state of livestock can be indirectly assessed by haematological examination (Ojediran et al., 2015). The recorded white blood cell counts indicated that the birds' immune system was not compromised (Soetan et al., 2013). This could be attributed to the tolerable level of anti-nutrients, as the cashew kernel rejects had been processed for human consumption. An elevated WBC count is an indication of the presence of exogenous substances and foreign bodies in the body (Campbell et al., 2003). RBC values obtained in the birds fed varying levels of undefatted cashew kernel reject meal as replacement for full-fat soybean meal compared favourably with those of birds fed the control diet. In contrast, Mmereole (2008) reported depressed RBC values in broilers fed rubber seed meal, which they attributed to residual anti-nutrients. Mean corpuscular indices, i.e. MCV, MCH and MCHC, are RBC indices. MCV indicates the size of red blood cells (Dacie and Lewis 1995). MCV is reduced in cases of intense iron deficiency resulting in anaemia (Aina and Ajibade, 2014). Thus the MCV results show that birds fed UCRKM did not experience iron deficiency. Observations of MCV and MCHC values in this study were similar to those of Talebi et al. (2005). The figures revealed that platelet counts were also not outside the normal range for the age of the birds.

Serum biochemistry

Organ abnormalities in livestock are identified by analysing serum chemistry (Malik et al., 2013). Adeyemi et al. (2000) showed that serum composition is correlated with diet quality. The generally similar values among the dietary groups, including those fed the control diet, show that replacement of full-fat soybean meal with UCRKM was not detrimental to the birds. All parameters were within the normal physiological range expected for the birds. The significance recorded for ALT, ALP and creatinine was in contrast with the findings of Ojediran et al. (2022), who incorporated cassava distillers' waste meal in the diet of broilers. In the present study, when 50% of soybean meal was replaced with UCRKM, the birds had lower ALT, ALP and creatinine values. As reported by Ojediran et al. (2015), ALT and AST are liver enzymes whose levels in the blood are elevated above normal levels by liver damage. The reduced ALT values in the birds fed diets 3-5 (50-100% replacement of soybean meal with UCRKM) do not suggest liver impairment, biliary obstruction or steatohepatitis (Rochling, 2001). Serum ALP can be reduced due to intestinal damage (Rivets et al., 1975). However, Hyder et al. (2013) claimed that elevated ALP indicates cholestasis of the liver in hepatic bile obstruction. This does not seem to be the case in this study, as the values recorded in birds fed diets 1-4 were similar, unlike those fed diet 5, which showed a significant reduction. Total serum protein can be affected by physiological status, age, livestock type and antigen exposure (Ojediran et al., 2015). The globulin levels were not elevated, which suggests the absence of infections, liver damage, kidney dysfunction or haemolytic anaemia. Serum albumin increases when protein consumption surpasses the quantity required for development. Elevated intercellular levels of some enzymes in the blood reflects a compromised organ (Wilson, 2008), which is not applicable in this case. Akande et al. (2014) concluded that creatinine may be affected when toxins present in feed reach the liver before the kidney. In the present study, the level of creatinine, which is a kidney marker, did not follow a particular pattern, which suggests that the use of UCRKM did not adversely affect kidney functions (Akande et al., 2015).

Organ and abdominal fat weight

Organ weight in broilers is known to indicate an anatomic response to the feed provided relative to the body size and age of the birds (Ojediran et al., 2016). The weights of the kidney, heart, lungs and gizzard showed no hypertrophy, although they were higher in birds fed diet T4. Akande et al. (2012) fed *Ricinus communis* to broilers and attributed slight changes in organs to the toxicity of residual anti-nutritional factors. Ojediran et al. (2016) correlated enlargement of the liver and kidney to possible congestion when fed broilers were fed *Jatropha curcas* kernel meal. Observations of the heart, lungs, empty gizzard and abdominal fat corroborate the report of Ani et al. (2013), who included *Gongronema latifolium* leaf meal in diets for broilers. The increased weight of the empty gizzard in birds fed diet T4 suggests that as the organ for mechanical digestion, the muscle was overworked. Ojediran et al. (2017) attributed increased abdominal fat to reduced dietary protein, which is not applicable in this case, as the birds fed diets containing 12,50-37,50% UCRKM as a replacement for full-fat soybean meal (T2-T4) had comparable abdominal fat weight to those fed without UCRKM (control). The higher abdominal fat observed in birds fed diet T5 can be traced to the energy level, shown in Table 1. Also, the birds fed diets T4 and T5 had lower pancreas weight, which suggests that the increased use of UCRKM does not increase pancreatic juice secretion.

CONCLUSIONS

UCRKM can be used to replace up to 50% of full-fat soybean meal in the diet of broiler chicks, as evidenced by the feed conversion ratio and serum metabolites. Further studies could investigate the use of higher levels of replacement.

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