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Research Article ***Open Access***

Evaluation of cassava distillers' waste meal in the diet of broiler chickens

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SUMMARY

This study was designed to examine the growth performance, nutrient digestibility, blood components and carcass cuts of broiler chickens fed cassava distillers' waste meal (CDWM) as a replacement for maize in a 6-week feeding trial. A total of 300 one-day-old Abor-Acre chicks were assigned to five groups using a completely randomized design. Each group contained 60 chicks with 6 replicates. The CDWM was incorporated in the diets at 25%, 50%, 75%, and 100% as a replacement for the maize used in the control diet. CDWM had higher protein and fibre content than maize. Significant differences (p < 0,05) were observed in growth parameters, nutrient digestibility, packed cell volume and breast weight. Final weight and daily weight gain decreased as CDWM increased in the diet, while average daily feed consumed and the conversion ratio increased linearly; birds fed the control diet had the lowest and best feed conversion ratio, while those fed 100% CDWM in place of maize had the highest feed conversion ratio. Thus, the optimal inclusion level of CDWM in broiler diets as a replacement for maize should not exceed 25%. Further studies are needed to determine whether the addition of a multi-carbohydrase enzyme will allow for a higher percentage of CDWM in place of maize with in broiler diets.

KEY WORDS: Blood constituents, broiler, carcass characteristics, growth performance, nutrient digestibility

INTRODUCTION

The high productivity of cassava (Muniafu et al., 2015; Khor et al., 2016), its drought tolerance and its ability to grow on marginal lands (Jiang et al., 2019) has placed cassava tubers among raw materials

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used to produce bio-ethanol. It can be a substrate for most alcoholic beverages and the production of pharmaceutical and beauty products. Bio-ethanol from cassava root is power-efficient (De Vries et al., 2010) and does not compromise food security (Kang et al., 2014).

Cassava production in Africa accounts for half of the world's production and has doubled in the last decade, in comparison to a 25% rise in Asia and an 18% increase in Latin America (FAO 2018; FAOSTAT 2019). There are indications that this production increase will continue (Ikuemonisan et al., 2020). In 2009, Nigeria generated 45 million tonnes, which was a 36% increase over what was produced a decade earlier (IITA, 2013), amounting to 19% of global output (Adekanye et al., 2013). Nigeria produced about 59,5 million tonnes in 2018 (Ikuemonisan et al., 2020). About 10 tonnes can be harvested from one hectare (IITA, 2013) at any time of year at maturity.

After ethanol processing from cassava, cassava distiller's waste meal is generated. CDWM is similar to distiller's dry grain, except for the feedstock. Brewer's or distiller's dried grain (DDG) is the fermented grain residue from ethanol production from maize, barley or sorghum that had been dried. Swain et al. (2014) corroborated the earlier report of Wang et al. (2007) that DDGs can be an unconventional energy source in poultry diets at a reduced cost. Furthermore, Lumpkins et al. (2004) posited that modernization of the ethanol processing plant can reduce the nutrient content of the distiller's waste, but it can still be used as feedstock in broiler diets. The nutritional profile of CDWM is similar to that of maize, except for the removed fermented starch, which results in an increase in other components, such as fibre (Cheon et al., 2008; Ranjan, 2013).

Nevertheless, the use of CDWM for broiler chickens should be investigated as a potential feed ingredient to lower the demand for maize or other cereal grains. The use of CDWM as a feed resource will also reduce the environmental footprint associated with indiscriminate dumping of the waste, as it affects groundwater quality, ecosystems and human health.

MATERIALS AND METHODS

Ethical approval

Approval was given for the trial under the Animal Science Code by the Animal and Research Ethics Committee of the Department of Animal Nutrition and Biotechnology, Ladoke Akintola University of Technology (approval number ANB/17/19/0123-MP).

Experimental location

The feeding trial was conducted at the Broiler Unit of the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria.

Preparation of test ingredient

Cassava distiller's waste meal (CDWM) was procured from Allied Distillery, Sango-Ota, Ogun State. The CDWM was sundried to constant moisture content and then milled before being homogenized with other feedstuffs.

Experimental broiler management

A total of 300 day-old Abor-Acre chicks were randomly assigned to 5 groups of 60 chicks each, which were further replicated 6 times with 10 birds each and placed in brooding pens. The birds were reared in open-sided pens which were closed and well illuminated and heated during the brooding period. The temperature was monitored during this period. Each replicate was in a 1m x 1m pen within the same house. Tray feeders were used to administer the feed for the first 14 days. Cone drinkers were used in the starter phase, and then cone feeders of appropriate size and special bowl drinkers for broilers were used from the 15th day. Feed and water were provided *ad-libitum*. A starter diet was used for the first three weeks, and thereafter a finisher diet was used for the last three weeks of the experiment. Vaccination and medication were in accordance with local veterinary guidelines.

Experimental diets

The experimental diets were formulated using cassava distillers' waste meal (CDWM) as a replacement for a maize-based diet. A total of five test diets were formulated. The control diet (diet 1) was based on maize and soybean meal with no CDWM. CDWM was included at 25%, 50%, 75% and 100% in the experimental diets as a replacement for maize. Each of these dietary formulations was fed to one of the five sets of birds. The experiment lasted for 42 days, during which the growth performance of the birds was monitored continually.

Table 1

Gross composition of the experimental diets (%DM)

Ingredients	Control	25%	50%	75%	100%
Starter phase					
Maize	53,00	39,75	26,50	13,25	0,00
CDWM	0,00	13,25	26,50	39,75	53,00
*Fixed ingredients	47,00	47,00	47,00	47,00	47,00
Total	100,00	100,00	100,00	100,0	100,0
Calculated analysis					
ME (Kcal/kg)	2987,32	2830,81	2674,31	2517,80	2361,29
Crude protein	22,87	23,11	23,35	23,60	23,84
Crude fibre	4,00	8,35	12,70	17,06	21,41
Ether extract	3,68	3,62	3,37	3,21	3,06
Lysine	1,48	1,46	1,41	1,38	1,34
Methionine	0,60	0,59	0,55	0,52	0,50
Calcium	1,04	1,04	1,04	1,04	1,04
Phosphorus	0,61	0,60	0,58	0,57	0,56
Finisher phase					
Maize	45,00	33,75	22,50	11,25	0,00
CDWM	0,00	11,25	22,50	33,75	45,00
#Fixed ingredients	55,00	55,00	55,00	55,00	55,00
Total	100,00	100,00	100,00	100,00	100,00
Calculated analysis					
ME (Kcal/kg)	2811,03	2678,14	2545,26	2412,38	2279,49
Crude protein	20,00	20,20	20,41	20,61	21,82
Crude fibre	3,84	7,53	11,23	14,93	18,62
Ether extract	3,60	3,47	3,33	3,21	3,08
Lysine	1,23	1,20	1,17	1,14	1,12
Methionine	0,56	0,54	0,52	0,50	0,48
Calcium	1,65	1,65	1,65	1,65	1,64
Phosphorus	0,83	0,82	0,81	0,80	0,79

*Fixed ingredients (FI) Starter phase: Soybean meal-34.00%; maize bran-5,00%; Fish meal (72%)-2,50%; Groundnut cake-2,00%; Limestone-1,00%; Salt-0,25%; Bone-1,50%; Lysine-0,25%; Methionine-0,25%; Premix-0,25%

#Fixed ingredients (FI) Finisher phase: Soybean meal-23,00%; Maize bran-15,00%; Fish meal (72%)-2,50%; Wheat offal-3,00%; Palm kernel meal-3,50; Groundnut cake-2,50%; Limestone-1,50%; Salt-0,25%; Bone-3,00%; Lysine-0,25%; Methionine-0,25%; Premix-0,25%

Data collection

Growth response

Feed consumed was routinely calculated as the difference between feed given and feed left, while weight gain was measured on a weekly basis using a sensitive digital scale. The feed conversion ratio was estimated by dividing feed intake by weight gain (Ojediran et al., 2018).

Nutrient utilization

Prior to the termination of the experiment, two birds were selected from each replicate and moved to a metabolic cage for evaluation of nutrient utilization. The birds were allowed to acclimatize for the first three days, after which faecal samples were collected for three days. Fresh and dry faecal sample weights were recorded. The feed intake for three days were also recorded, the faecal samples were homogenized, and sub-samples were taken and analysed for proximate composition (Abioye et al., 2018) using the procedure of AOAC (2005).

Blood analysis

At the end of the trial, two birds from each replicate were randomly selected from each replicate pen and sampled for blood analysis by jugular vein puncture. Blood samples were collected for haematological analysis in empty vacutainer bottles, while samples for serum biochemistry were dispensed into bottles containing EDTA. The haematological parameters measured were haemoglobin, erythrocyte count, leucocyte counts and packed cell volume (PCV), and corpuscular concentrations were calculated. PCV was evaluated by the micro-haematocrit method (Dacie and Lewis, 1999). Erythrocyte and leucocyte counts were determined using the improved Neubauer haemocytometer methods proposed by Jain (1986). Haemoglobin volume was measured by the cyanmethaemoglobin method (Jain, 1986). 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 (ALT), aspartate aminotransferase (AST), urea and glucose.

Carcass evaluation

Two broilers per replicate were randomly chosen at the end of the experiment, starved for about 12h to empty their gut, weighed, and killed by cervical dislocation. The bled weight, de-feathered weight and eviscerated weight were determined. Carcass cuts, including the shank, head, neck, thigh, breast, back and drumstick, were weighed and expressed as percentages of final live weight (Ojediran et al., 2018).

Chemical analysis

The proximate composition of samples of the cassava distillers' waste meal, experimental diets and faecal samples was determined according to AOAC (2005). The formula given by Pauzenga (1985) was used to estimate metabolizable energy.

Data analysis

Data were analysed by one-way ANOVA using SAS (2000). In the case of disparities in the means, Duncan's multiple range test in the same software package was used to separate the means.

RESULTS

The chemical composition of the CDWM is shown in Table 2. The table shows that CDWM contains 89,90% dry matter and 11,82% crude protein; 34,86% crude fibre; 2,83% ether extract and 3,54% and 36,85% ash and nitrogen-free extract, respectively.

Table 2

Chemical constituents of cassava distillers' waste meal (% DM)

Parameters	Quantity (%)
Dry matter	89,90
Crude protein	11,82
Crude fibre	34,86
Nitrogen free extract	36,85
Ether extract	2,83
Ash	3,54
Metabolizable energy (kcal/kg)	2252,82

The growth features of broilers given graded levels of CDWM are presented in Table 3. All parameters were significantly influenced by diet differences ($p \leq 0,05$). The weight indices (final and gain) decreased linearly ($p \leq 0,05$) as CDWM increased across the diets. Average daily feed intake increased significantly ($p \leq 0,05$), as did the feed conversion ratio.

Table 3

Growth features of broilers fed varying levels of cassava distillers' waste meal (1-6 weeks)

Treatment	Control	25%	50%	75%	100%	SEM	P-value
Initial weight (g)	46,04	45,48	45,38	45,20	46,02	0,28	0,27
Final weight (kg)	$2,12^{a}$	$1,77^{b}$	$1,52^{c}$	$1,28^{d}$	$0,87^{e}$	0,11	0,01
Daily intake (g/d)	$126,15^{d}$	$139,29^{c}$	$140,30^{c}$	$153,87^{a}$	$144,40^{b}$	2,40	0,01
Daily gain (g/d)	$49,38^{a}$	$41,06^{b}$	$35,11^{c}$	$29,40^{d}$	$19,69^{e}$	2,70	0,01
Feed conversion ratio	$2,55^{e}$	$3,39^{d}$	$4,00^{c}$	$5,23^{b}$	$7,33^{a}$	0,46	0,01

abcd = means with different superscripts in the same row are significantly different ($p \leq 0,05$) SEM = Standard error of mean

The nutrient utilization of broiler chickens fed CDWM is detailed in Table 4. Protein retention increased linearly ($p \leq 0,05$) as the level of CDWM inclusion increased. Other proximate parameters were also significantly affected ($p \leq 0,05$) by the level of CDWM. Their absorption increased with the level of CDWM.

Table 4

Nutrient utilization of broiler chickens fed cassava distillers' waste meal

Parameters (%)	Control	25%	50%	75%	100%	SEM	P-value
Crude protein	95,45^{c}	96,07^{b}	96,04^{b}	96,69^{a}	96,83^{a}	0,15	0,01
Ether extract	96,79^{c}	97,19^{bc}	97,28^{b}	97,69^{ab}	97,79^{a}	0,11	0,01
Crude fibre	76,02^{d}	80,03^{c}	80,92^{c}	84,85^{b}	85,22^{a}	0,95	0,01
Ash	92,79^{c}	93,54^{bc}	94,13^{b}	95,35^{a}	95,39^{a}	0,29	0,01
Nitrogen free extract	4,27^{c}	24,35^{b}	28,86^{b}	45,39^{a}	46,81^{a}	4,31	0,01

abcd = means with different superscripts in the same row are significantly different ($p \leq 0,05$) SEM = Standard error of mean

The carcass cuts of broiler chickens fed CDWM are shown in Table 5. The bled weight and the weights of the shank, wings, drumstick, and thigh were not significantly affected ($p \geq 0,05$). However, significant differences ($P \leq 0,05$) were recorded in the weights of the breast, back, and abdominal fat and the eviscerated, de-feathered and carcass weights across dietary treatments. The values obtained for abdominal fat decreased as the level of CDWM in the diet increased. Birds fed a diet containing 25% CDWM had the highest eviscerated weight, while those whose diet contained 100% CDWM had the lowest eviscerated weight. Eviscerated weights in chickens given 0% and 25% CDWM were similar. The carcass percentage was highest in broilers receiving 0% CDWM, similar in birds whose diets contained 25-75% CDWM, and lowest in those receiving 100% CDWM. This trend is similar to that observed for breast weight.

Table 5

Carcass cuts (expressed as % of live weight) of broiler chickens fed CDWM

Parameters	**Control**	**25%**	**50%**	**75%**	**100%**	**SEM**	**P-value**
Wings	7,18	8,19	8,29	8,61	8,17	0,75	0,26
Breast	23,24^{a}	17,40^{b}	20,00^{b}	19,62^{b}	14,15^{c}	1,69	0,02
Back	10,92^{ab}	13,00^{a}	11,43^{ab}	10,05^{b}	9,95^{b}	1,24	0,00
Drumstick	9,69	9,69	9,56	9,14	8,67	0,83	0,30
Thigh	10,22	9,95	10,20	10,10	8,79	2,31	0,25
Abdominal Fat	1,06^{a}	0,59^{ab}	0,27^{ab}	0,06^{c}	0,03^{c}	0,15	0,05
Bled weight	96,07	93,56	96,70	93,46	88,55	0,01	0,08
Eviscerated weight	80,76^{ab}	92,79^{a}	87,75^{a}	73,45^{ab}	64,81^{b}	3,64	0,01
De-feathered weight	73,07^{ab}	71,01^{ab}	80,13^{a}	70,03^{ab}	62,31^{b}	2,17	0,00
Carcass weight	67,43^{a}	61,76^{b}	64,83^{ab}	61,35^{b}	54,00^{c}	1,31	0,02

abcd = means with different superscripts in the same row are significantly different ($p \leq 0,05$) SEM = Standard error of mean

The haematological parameters of broiler chickens given CDWM as a maize substitute are presented in Table 6. CDWM did not significantly alter the haematological parameters, except packed cell volume. The level of inclusion of CDWM affected the packed cell volume significantly. The packed cell volume for 100% CDWM inclusion was significantly ($p \leq 0,05$) lower than in the other treatments.

Table 6

Haematological variables of broiler chickens fed CDWM

Parameters	Control	25%	50%	75%	100%	SEM	P-value
Haemoglobin (g/dl)	11,43	10,00	10,43	10,27	10,80	0,23	0,20
Packed cell volume (%)	41,67[a]	41,33[a]	40,00[ab]	37,67[ab]	37,60[b]	0,69	0,01
Red blood cell($x10^6/mm^3$)	2,12	1,72	2,05	1,45	1,42	1,24	0,11
White blood cell ($x10^3/mm^3$)	20,05	14,61	15,25	20,05	12,05	1,50	0,10
Mean corpuscular volume (fl)	20,36	19,32	19,10	19,13	18,74	0,32	0,10
Mean corpuscular haemoglobin (pg)	0,66	0,69	0,67	0,78	0,71	0,02	0,06
MCHC (g/dl)	32,70	35,98	35,48	40,82	38,l2	1,72	0,10
Heterophils (%)	59,33	57,00	48,33	56,33	49,67	4,13	0,28
Lymphocytes (%)	42,33	43,00	51,67	46,67	50,31	4,10	0,26

ab = means with different superscripts in the same row are significantly different ($p \leq 0,05$) MCHC – mean corpuscular haemoglobin concentration SEM= Standard error of mean

Table 7 shows the serum biochemistry of broiler chickens receiving CDWM. The results revealed that the serum biochemistry parameters measured were not influenced significantly ($p \geq 0,05$) by the diets.

Table 7

Serum biochemistry of broiler chickens fed cassava distillers' waste meal

Parameters	Control diet	25%	50%	75%	100%	SEM	P-value
Cholesterol (mg/dl)	67,67	71,33	76,00	72,33	71,67	2,28	0,21
Total protein (g/dl)	4,87	4,53	4,57	4,77	4,70	0,08	0,06
Albumin (mol/dl)	1,97	2,13	1,30	1,53	1,97	0,13	0,06
Urea (mg/dl)	25,67	29,00	28,67	31,33	34,00	1,22	0,20
Glucose (mg/dl)	14,00	17,33	11,67	16,00	16,33	1,03	0,10
AST (μ/L)	446,00	474,00	436,00	460,67	478,00	7,26	0,10
ALT (μ/L)	41,67	54,67	47,33	52,67	56,67	3,17	0,20

ALT = Alanine aminotransferase, AST = Aspartate aminotransferase SEM= Standard error of mean

DISCUSSION

The survival of the poultry industry in Nigeria hinges on the ability to utilize under-exploited feed resources and agro-industrial by-products as component of broiler feed. Cassava distillers' waste meal

(CDWM), a by-product of ethanol processing plants, contains 11,82% crude protein (CP), which is higher than the CP content of maize. The fibre content of CDWM is also higher than that of conventional feedstuffs such as maize. This could be beneficial by improving the motility of the digesta through the gastrointestinal tract (GIT), as insoluble fibre types increase intestinal viscosity and the rate of feed passage, thereby increasing feed intake and the absorption rate (Jiménez-Moreno and Mateos, 2013). On the other hand, high fibre content has been associated with reduced nutrient availability for broilers (Zijlstra et al., 2012; Slama, 2019). Also, fibre has been reported to reduce absorption of amino acids and minerals in the GIT. This contradicts an earlier study by Ukachukwu (2008), who observed a non-significant increase in feed consumption with increasing levels of composite cassava meal fed to broiler chicks. This can be attributed to increased dietary fibre, which according to Chen et al. (1992) induces birds to consume more feed to meet their energy needs, as supported by the results of the present study.

The birds fed the control diet consumed less feed than those fed the 100% CDWM diet. A similar observation was reported by Udedibie et al. (2004), who replaced maize in broiler diets with sundried cassava root meal. The trend in feed intake is traceable to the high fibre content, capable of diluting the feed energy content. Rausch and Belyea (2006) and Jamroz et al. (2001) correlated increased fibre composition in the diet of monogastric animals with high feed consumption and reduced nutrient availability and digestibility. There were significant differences in average daily gains (ADG) of birds receiving varying levels of cassava distiller's waste meal; ADG decreased as CDWM in the diets increased. Birds fed the control diet had the highest daily gains (49,38 g/b), while those that received 100% CDWM in their diet had the lowest (19,69 g/b). However, broilers fed 0% and 25% CDWM had comparable ADG. The result showed broilers given the 0% and 25% CDWM diets had identical weight gain, which is in agreement with Wang et al. (2007), who found that DDGs can be included in the amount of up to 20% without reducing body weight or feed conversion efficiency. The feed conversion increased as the level of CDWM inclusion increased. Birds fed the control diet had a superior feed-to-gain ratio (2,41 g of feed to obtain 1 g of meat), while those fed 100% CDWM had the poorest feed-to-gain ratio (7,28 g of feed for 1 g of meat). The decrease in weight gain was linear; it decreased with the increase in the level of CDWM. Birds fed the control diet had the highest final weight (2,12 kg), while those fed 100% had the lowest (0,87 kg).

Average daily gains in this study decreased linearly with increasing CDWM. This is consistent with the findings of Lumpkins et al. (2004), who reported that the addition of maize DDG at 18% resulted in an adverse response in broiler chicks. Broilers fed the control diet had a better feed: gain ratio than those fed 25% CDWM. Increasing the level of CDWM in the diets resulted in a linear decrease in feed conversion efficiency. Balagopalan et al. (1988) had previously concluded that high fibre diets reduced digestibility and nutrient utilization by monogastric animals. Similarly, Isikwenu et al. (2000) demonstrated that elevated feed fibre decreases feed conversion efficiency, which was also confirmed by Jha and Mishra (2021).

The significant differences in nutrient digestibility parameters indicate that CDWN affected the digestibility of these nutrients. Crude protein retention increased with the increase in CDWM inclusion in the broiler finisher diet. There is evidence suggesting that fibre affects nutrient breakdown by encapsulating nutriments in the plant cells, resulting in low enzyme activity (Walugembe et al., 2014). Fibre has been reported to affect digesta viscosity. Zijlstra et al. (2012) and Slama et al. (2019) noted that absorption of extremely viscous digesta is minimal due to reduced contact with villous membrane enzymes, resulting in low nutrient breakdown. According to Wils-Plotz et al. (2013), soluble fibre pectin influences digesta viscidity, with anti-nutritive results and a depressed growth rate in chicks. This suggests that the fibre content of the feed, despite high nutrient digestibility, may be responsible for the decreasing growth response in this study.

The weights of the wings, drumstick, and thigh indicated that CDWM had no adverse effect on these carcass cuts. This is in agreement with Okorie (2001) and Egbunike et al. (2009), who fed broilers varied diets based on cassava leaf meal and cassava peels, respectively. The decreased weight of breast meat across the dietary treatments may be attributed to the fibre acting as a diluent to the nutrients and causing a reduction in adipose tissue (fat), which is reported by Adejuyitan et al. (2009) to prevent cardiac disorders and colon cancer in humans. Carcass dressing weight is more important to poultry meat consumers than live weight, which includes feathers. Therefore the dressing weight is of economic importance to commercial farmers. Carcass weight decreased as the level of CDWM increased. This corroborates the findings of Eruvbetine et al. (2003), who reported that the dressing percentage of birds fed cassava leaf meal and tuber concentrate decreased as the level of the test ingredients increased. Birds fed the 100% CDWM diet had a poorer dressing percentage than those on the 0% diet, which is attributable to high dietary fibre. This supports an earlier report by Atuahene et al. (1986) of reduced live weight but higher visceral weight for broilers receiving graded cassava peel.

Oryschak et al. (2010), who studied the relative dietary value of extruded and unextruded wheat and maize DDGs with solubles at 0%, 5%, or 10% for broilers and compared the resulting growth performance, found no unintended consequences on breast meat yield. However, Wang et al. (2007) revealed that next-generation qualitative DDGs could be tolerated by broiler chickens in levels as high as 15-20% with negligible effects on performance, but possibly at the expense of carcass cuts such as breast yield.

PCV in broiler chickens was significantly influenced by different levels of CDWM. PCV, RBC and haemoglobin positively correlate with protein quality, protein level and dietary quality (Ojediran et al., 2020). In the current study, red blood cell counts in the dietary treatments, except the control diet and 50% CDWM, were slightly lower than the value recommended by Jain (2000). Brown and Clime (1972) observed that a decreased RBC count is usually associated with low quality feeds and protein deficiency. PCV, an indicator of blood dilution (Ojediran et al., 2020), was within the range recommended by Mitruka and Rawsley (1977) in all groups. Haemoglobin and WBC were within the ranges recommended by Jain (2000) in all groups. MCHC in birds fed the control diet was within the range recommended by Jain (2000), while the values in those receiving 25%, 50%, 75% and 100% CDWM were above the recommended range. Edovien and Switzer (1977) attributed the increased values to restricted energy intake. The MCV was below the value recommended by Jain (2000) in all groups. The heterophil values in this research showed that the broilers had no microbial infection, but may have had inflammation.

The serum biochemistry of the broilers indicates that CDWM had no effect on serum parameters, and thus that the integrity of the liver and kidney were not compromised. Ahamefule et al. (2006) observed that abnormalities in serum parameters are in response to the elevated metabolic rate of the organ(s), in a bid to eliminate deleterious or anti-nutritional substances.

CONCLUSIONS

Cassava distillers' waste meal (CDWM) has a very high fibre content and low protein content. It significantly reduced average daily gains and did not improve other parameters, such as feed conversion ratio, packed cell volume and breast weight. Thus, the optimal inclusion level of CDWM as a replacement for maize in broiler diets should not exceed 25%.

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