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Performance, carcass characteristics and economy of broilers fed dried cabbage (*Brassica oleracea* var. capitata) leaf residue

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Abstract
A total of 144 one-day-old Arbor Acre broiler chickens were allotted to four dietary treatments in a completely randomized design, to assess growth performance, economics of production, and carcass characteristics of broilers fed diets substituted with dried cabbage leaf residue (DCLR). Four experimental broiler starter diets were formulated which replaced maize at 0% (control, T1), 4% DCLR (T2), 8% DCLR (T3), and 12% DCLR (T4). The birds were randomly allotted to the four treatments having four replicates of 9 birds each in a completely randomized design. The results showed that feeding DCLR to broilers had no effect (P>0.05) on the growth performance. Cost of feed, cost of feed consumed/bird and cost of production significantly increased (P<0.05) across the treatments. Revenue and gross profit were not significantly (P>0.05) different for all the treatments. Live weight and carcass weight of birds feds T4 compared favorably with the control diet. Dressing percentage increased for the substituted diets, with the highest weight observed in T4. The breast, drumstick and back significantly (P<0.05) increased in birds fed T2. The liver of birds fed T4 compared favorably with the control. It was observed that birds fed the substituted diets elicited better carcass characteristics compared to the control diet. It can be concluded that DCLR can be substituted up to 12% in a practical broiler diet, improve carcass characteristics, and can mitigate environmental hazards in communities where cabbage residues are abundant.

Keywords: broiler, carcass, cost indices, dried cabbage leaf residue, performance

Introduction

Cabbage waste is one of the several unwanted by-products generated by fruit producers and food industries in Nigeria that can be gotten rid of by using it as a feed source in broiler production. As cabbage production increases, there is a concomitant increase in the quantity of residues produced. These residues are often discarded into the environment where they pose major environmental concerns (e.g. landfill and nitrate leaching to water sources). The use of fruit and vegetable wastes as animal feed is an alternative of high interest because of its environmental and public benefits besides reducing the cost of animal production and giving higher profits to farmers (Wadhwa & Bakshi, 2013; Westendorf, 2000) [15, 16]. However, leaves might contain anti-nutritional factors such as thiocyanates and isothiocyanates, which may reduce animal growth performance (Pereira *et al*., 2002) [13]. The authors reported a reduction in feed intake, growth rate, and feed conversion ratio (FCR) as the level of cabbage leaf meal in the diet increased. Similar negative effects on feed intake and growth rate have also been observed for rabbits fed cabbage. Data regarding the feeding value of dried cabbage leaf residues (DCLR) for broilers are scanty. Hence the objective of this study is to evaluate the growth performance, economics of production, and carcass characteristics of broilers fed diets substituted with dried cabbage (*Brassica oleracea*) leaf residue (DCLR).

Materials and Methods

The ethics committee on Research and Innovation of the University of Ibadan approved this research on 28 April 2016.

This endorsement fit in to the ethical standards placed down in 1964 Declaration of Helsinki and its later amendment. Altogether birds were healthy during the experiment and no death was documented.
The study was carried out at the poultry unit of the Department of Animal Science and Animal Technology, Faculty of Agriculture and Agricultural Technology Research Farms, Benson Idahosa University, Benin City, Edo State. Chopped cabbage leaf residues were then dried in a forced air oven at 50^0C for 48h and ground through a 2-mm screen using a hammer mill and chemically analyzed (Table 1) for diet formulation.

Experimental animals, feeding and management
A total of 144 one day old Arbor Acre chickens were obtained and grown over a period of 35days. The animals were adapted for one week before the commencement of the experiment. Experimental animals were randomly allotted to four dietary treatments with four replicates each and nine animals per replicate. Dried cabbage leaf residues partially replaced corn and soybean meal in the control diet.

Table 1: Gross composition of experimental diets

	Diet 1	Diet 2	Diet 3	Diet 4
Ingredients	0%	4%	8%	12%
Maize	55.30	48.05	42.05	35.00
SBM	22.00	17.00	15.00	15.00
Fish Meal	11.50	12.25	13.75	14.75
Wheat Bran	7.50	11.50	11.50	11.00
Cabbage	0.00	4.00	8.00	12.00
Soya Oil	1.50	5.00	7.50	10.05
Tio_2	0.25	0.25	0.25	0.25
Vit Premix	0.20	0.20	0.20	0.20
Limestone	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25
Methonine	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00
Determined Analysis				
ME (Kcal/kg)	3439.58	3341.60	3226.89	3169.44
CP (%)	23.06	24.19	24.06	23.31
CF	5.60	6.30	7.85	8.10
ASH	5.70	8.59	7.92	8.64
Ether Extract	4.96	5.30	5.10	5.01
Dry Matter	93.30	93.06	92.75	92.60
NFE	67.68	54.62	54.07	52.15
NDF	32.30	31.10	31.90	32.10
ADF	7.10	5.50	5.90	6.30

[1]Composition of vitamin premix per kg of diet: vitamin A, 12500 I.U; vitamin E, 40mg; vitamin K3, 2mg; vitamin B1, 3mg; vitamin B2, 5.5mg; niacin, 5.5mg; calcium pantothenate, 11.5mg; vitamin B6, 5mg; vitamin B12, 0.025mg;choline chloride, 500mg, folic acid,1mg; biotin, 0.08mg; manganese, 120mg;iron 100mg; zinc, 80mg; copper, 8.5mg; iodine, 1.5mg; cobalt, 0.3mg;selenium, 0.12mg, anti-oxidant, 120mg, TiO_2: Titanium dioxide premix prepared by mixing 1g of titanium dioxide with 4g of maize

All diets were formulated to meet or exceed (NRC, 1994) nutrient requirements for broilers. Fresh water and feed were available to all birds *ad libitum* throughout the experimental period. Birds were group weighed by pen, and feed intake and BWG was determined weekly.

Performance parameters
The parameters measured include feed intake, weight gain, live weight, while feed conversion ratio and cost indices were calculated for.
Feed intake (FI) was determined by subtracting the leftover feed from the known quantity of the experimental diets given on a weekly basis.
Feed intake = feed offered – feed left in the feeding trough

The initial live weights of the chicks were measured and recorded at the beginning of the experiment and subsequently on weekly basis using a digital weighing scale.
Weight gain of the bird was gotten by subtracting the initial live weight from the final live weight of the bird at the end of each week.

Weight gain = final weight – initial weight
Feed Conversion Ratio is the total feed consumed divided by the weight gain of the broilers.
FCR = Feed consumed
Weight gain

Feed cost analysis
The market cost of feedstuff during the study was used to calculate the total cost of feed, cost of feed per kg, and cost per kg live weight, cost of feeding, cost of FI/kg BWG (₦), Cost of Production (₦/kg), Revenue (₦kg) and Gross profit (₦/kg).

Cost of feed (₦/kg) = Cost of feed/diet
100
Cost of feeding = FI x Cost of feed/diet
Feed cost/weight gain = Cost of feed x BWG (kg)
Cost of FI/kg BWG (₦) = Feed cost x BWG
Cost of Production (₦/kg) = Cost of feed + other expenses
Revenue (₦kg) = Final weight x Selling price
Gross profit (₦/kg) = Revenue – Cost of production

Evaluation of Carcass Quality

At the end of the 35 days feeding trial, 2 birds per replicate were randomly selected with their live weights taken before carcass evaluation after fasting them for 16 hours. The birds were slaughtered by severing their jugular veins with a sharp surgical knife. The birds were soaked in hot water, de-feathered, and washed. The internal contents were neatly removed and weighed (evisceration) followed by the cutting of the carcass into retail parts and weighed. Dressed weight was recorded after evisceration. The weights were expressed as percentages of dressed weight.

Chemical and Statistical Analysis

The dried cabbage leaf residue (DCLR) and experimental diets were analyzed for proximate composition. All data obtained were subjected to analysis of variance procedure of Statistical Analysis Software. Significant differences between the treatment means were separated using the Least Significant Difference (LSD) method.

Results

Table 2: Proximate Analysis of dried cabbage leaf residue (DCLR)

Components	DCLR (%)
Dry Matter	92.7
ME(Kcal/kg)	1957.09
CF	25.2
Ash	23.3
CP	11.81
EE	2.40
NFE	37.29
NDF	58.05
ADF	27.2

CF=Crude Fibre, CP=Crude Protein, EE=Ether Extract, NFE=Nitrogen Free Extract, NDF=Neutral Detergent Fibre, ADF=Acid Detergent Fibre

The result of the proximate composition of DCLR shows that CF and Ash content were relatively higher than the CP and EE content. The differences observed could be due to differences in cabbage varieties or soil types.

Table 3: Growth performance of broiler chickens fed dried cabbage residues

Parameters	Cabbage leaf residues (%)				SEM
	0 T1	4 T2	8 T3	12 T4	
Initial BW (kg)	0.193	0.200	0.200	0.195	0.04
Final BW (kg)	1.053	1.028	0.997	0.992	0.97
BWG (kg)	0.28	0.275	0.231	0.311	1.37
Feed Intake (kg)	0.706	0.700	0.689	0.700	0.03
FCR	2.797	2.756	3.062	2.415	1.31

Means without superscript are not significantly different (P>0.05), BW=Body weight, BWG=Body weight gain, FCR=Feed conversion ratio

The growth performance of broiler chickens fed dried cabbage residues presented in Table 3 shows the initial body weight (kg), final body weight (kg), body weight gain, feed intake and feed conversion ratio. Though T1 recorded higher final body weight (1.053 kg), higher body weight gain (0.280 kg) and feed intake (0.706 kg), the ability of the birds to convert feed to flesh (FCR) was higher in T3 (3.062 kg) while T4 recorded the least in all the parameter evaluated in the table except for initial BW.

Table 4: Economics of production of broiler chickens fed cabbage residues

Parameters	0 T1	4 T2	8 T3	12 T4	SEM
Feed Intake	0.706	0.700	0.689	0.700	0.04
Cost of feed (₦/kg)	416.67^a	443.01^b	468.28^c	488.46^d	4.34
CFC/bird	293.98^a	310.11^b	322.63^c	341.92^d	4.81
BWG/b	0.28	0.275	0.231	0.311	1.37
Feed cost/BWG	107.64	121.84	108.00	151.88	8.80
CFP (₦/kg)	1008.94^a	1034.93^b	1057.50^c	1081.30^d	6.93
Av. Final Weight	1.053	1.028	0.997	0.992	0.97
Revenue (₦kg)	2105.55	2055.56	1994.45	1983.33	35.83
Gross profit (₦/kg)	1096.62	1020.63	936.95	902.03	38.80

^{abc} Means in the same column without superscript in common are different at P<0.05, CFC: Cost of feed consumed. CFP: Cost of Production

Results of the economics of production (Table 4) revealed that the cost of feed, cost of feed consumed/bird, and cost of production significantly increased (P<0.05) across the treatments with T1 having the least values of ₦416.67/kg, ₦293.98 and ₦1008.94/kg respectively, while the highest values were recorded in T4 having ₦488.46/kg, ₦341.92 and ₦1081.30/kg respectively. In the same vein the gross profit also decreased across the treatment with T1 having the highest gross profit of ₦1096.62/kg and T4 had the least profit of ₦902.03/kg.

Table 5: Carcass characteristics of broilers fed cabbage leaf residues

Parameters	0 T1	4 T2	8 T3	12 T4	SEM
Live weight(kg)	1.112^a	1.384^{bc}	1.326^c	1.105^a	0.140
Carcass weight(kg)	1.029^a	1.245^{bc}	1.234^c	1.055^a	0.029
Dressed weight(kg)	0.777^a	1.033^{bc}	1.048^c	0.921^d	0.029
Dressing (%)	69.94^a	74.63^{ab}	79.25^{bc}	83.59^c	1.70
Prime cuts					
Neck	0.055^a	0.053^a	0.053^a	0.070^b	0.002
Breast	0.220^a	0.304^b	0.273^c	0.241^d	0.008
Wing	0.087^a	0.104^{bc}	0.103^c	0.087^a	0.002
Drumstick	0.204^a	0.269^b	0.253^c	0.222^d	0.007
Back	0.138^a	0.188^b	0.173^c	0.153^d	0.005
Shank	0.053^a	0.071^{bc}	0.072^c	0.055^a	0.002
Organ weights					
Gizzard	0.038	0.037	0.036	0.036	0.001
GIT	0.086^a	0.137^{bc}	0.135^c	0.103^d	0.006
Liver	0.019^a	0.036^{bc}	0.035^c	0.02^a	0.002
Heart	0.002^a	0.006^{bcd}	0.005^c	0.006^d	0.001

^{abc} Means in the same column without superscript in common are different at P<0.05

The live weight and carcass weight of bird feds T4 were not significantly different (P<0.05) from the control diet. Dressed weight and dressing percentage increased for the substituted diets, with the highest weight observed in T4. The cut weights of the neck, breast, wing, drumstick, back and shank were significantly (P<0.05) affected due to the supplementation of DCLR. The visceral organs such as the GIT, liver and heart were also (P<0.05) influenced by the inclusion of DCLR.

Discussion

The analysis showed that DCLR values were relatively higher than that reported by (Negesse *et al*., 2009) [10]. The relatively high ADF content of DCLR is likely due to the high pectin content of brassica plants (Cassida *et al*., 2007) [2]. The differences observed could also be due to differences in cabbage varieties or soil types. Cabbage leaves are said to contain more mineral concentrations. This is in agreement with the amount of ash (23.3%) content in the DCLR. The nutrient (proximate) compositions of the diets are adequate and within the recommended range.

For broiler finishers as reported by (NRC, 1994) and (Oluyemi & Roberts, 2000) [12]. Final weight, body weight gain, feed intake, and FCR were not altered by DCLR inclusion (Table 3), suggesting that moderate levels (i.e. 12%) of DCLR had no adverse effect on broiler growth performance. However, (Thacker & Petri, 2009) [14] reported no adverse effects on broiler performance when dietary NDF was increased from 10.6 to 13.4%. Similarly, increasing dietary NDF contents from 11.6 to 14.9% had no adverse effects on body weight gain (BWG) and FCR of broilers from 1 to 21 d of age (Hern´andez *et al*., 2011) [3]. The parameters in the present study did not conform to the earlier assertion of (Ogundipe & Sanni, 2002; Ilaboya *et al*., 2021; Mustafa & Baurhoo 2018) [11, 5, 8] that cabbage supplementation improves performance.

The improved dressed weight of birds fed 12% DCLR may be associated with the beneficial effect of drying which resulted in better nutritive value and digestibility. The improvements observed for these parameters in the present study conform to the earlier assertion of (Ilaboya *et al*., 2016; Ilaboya *et al*., 2021) [1, 5], that sun drying processing of cocoyam peel meal improves carcass performance of animals. The GIT, liver and heart were significantly (P<0.05) influenced by the inclusion of DCLR except for gizzard and spleen that were not significantly (P>0.05) affected. Nevertheless the gizzard of the birds fed substituted diets compared favorably with the control diets (0% DCLR inclusion). (Jim´enez-Moreno *et al*., 2016) attributed the beneficial effects of feeding pea hulls to the improvements in gizzard function and the structure of intestinal mucosa. The results revealed that birds fed DCLR diets were heavier in weight than those on control diet in most parameters evaluated. The improvements in the parameters in the present study conform to the earlier assertion of (Mustafa & Baurhoo 2018) [8] that inclusion of DCLR improves broiler chicken carcass performance. The breakdown of fibrous material in the DCLR enables the birds acquires more nutrients from the feed thus depositing them as tissues in the body. These observations were consistent with the previous report of (Ilaboya *et al*., 2016; Aguihe *et al*., 2016) [1, 4] who observed a significant variation in percent weight of liver and breast, when they supplemented fibrous feed in the diets of broiler chickens. Broilers reared on diets with mixed ingredients of plant origin, variation in the chemical structure of these ingredient (non-starch polysaccharides) and presence of anti-nutrients (Phytin, hydrocyanic acid and tannis), often leads to reduced performance of birds. Inclusion of sun dried cabbage leaf residues to diets can reduce the adverse effects of some of these compounds (Iyayi & Losel 2000) [6]. The results showed that birds on dried cabbage leaf residues were better than those on the control diets.

Feed cost is the highest recurrent cost in poultry production and thus has a major impact on the profitability of the industry and the affordability of poultry products for consumers. An increase in the price of feed ingredients has a severe negative impact on livestock production in developing countries. Revenue and gross profit were not significantly (P>0.05) different for all the treatments. The cost of production increased in the substituted diets and this could be attributed to increase in the cost of feed. This result disagrees with (Ogundipe & Sanni, 2002) [11] who advised the use of agro-industrial byproducts for the sole purpose of reducing the cost of production which constitutes 60- 70% of the total cost. The improved dressed weight of birds fed 12% DCLR may be associated with the beneficial effect of drying which resulted in better nutritive value and digestibility (Wadhwa & Bakshi, 2013) [15].

Conclusion

The results showed that the inclusion of dietary DCLR up to 12% of the diet had no adverse effect on broiler performance and carcass characteristics. The use of cabbage leaf residue will mitigate environmental hazards in communities where cabbage leaves are abundant as a nuisance.

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Conflict of Interest

The authors declare that they have no conflicts of interest associated with this manuscript.

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