EFFECTS OF REPLACING MAIZE (*Zea mays*) WITH GARRI WASTE BASED DIETS ON THE RELATIVE CARCASS AND ORGANS CHARACTERISTICS OF BROILER FINISHER BIRDS

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ABSTRACT

This study determined the effect of replacing maize with Garri waste based diets on the relative carcass and organs of broiler finisher birds. The research work was conducted in the poultry unit of the Teaching and Research Farm, College of Education, Ila-Orangun, Osun State for six weeks. A total number of 128 marshal broiler birds of five (5) weeks of age were purchased from a reputable farm in Osogbo, Osun State. The birds were randomly distributed into four (4) dietary treatments and replicated four (4) times. Each replicated with eight (8) birds, Experimental treatments were formulated at different replacement levels of 0%, 25% (12.50/100kg of diet), 50% (25.00/100kg of diet) and 75% (37.50/100kg of diet) Garri Waste (GW) respectively for maize into diets (treatments). Samples of test ingredient and Experimental diets were analyzed for their proximate composition according to A. O. A. C (2002) methods. Data were collected on Final life weight (FLW), Bled weight (BW), Defeathered weight (DW), Eviscerated weight (EW), Carcass weight (CW), Dressing (%), Breast (%), Back (%), Thigh (%), Drumstick (%), Neck (%), Wing (%), Shank (%), Head (%), heart (%), lung (%), kidney (%), liver (%), gizzard (%), spleen (%), proventiculous (%) including abdominal fat (%) and subjected to one - way analysis of Variance (ANOVA) using the model for completely randomized design at 5% probability test using SPSS 13.00 computer software of SAS package. Findings showed that birds fed T1 (0% GW) were significantly higher ($p < 0.05$) in FLW (3438.20g), BW (2839.50g), DW (2706.50g), EW (2428.20g) and CW (2263.20g). There was no significant difference ($p > 0.05$) for Dressing (%), Breast (%), Back (%) and Head (%) but there were numerical differences across these parameters. Bird fed 75% GW (T4) were significantly higher ($p < 0.05$) in kidney, lungs, liver, Proventiculus, heart and spleen with values 1.96, 2.01, 8.61, 1.67, 1.27 and 0.56 respectively while birds fed control had lower values ($p < 0.05$) in kidney, lungs, liver and proventiculus (0.70, 0.71, 2.40, and 0.50 respectively). However, birds fed T3 were significantly lower ($p < 0.05$) in heart and spleen (0.67 and 0.18) but these birds were significantly higher ($p < 0.05$) in abdominal fat. There was no significant difference ($p > 0.05$) in gizzard weight but had numerical higher value in T4 (4.19) and the lower value in T3 (2.16). It was concluded that up to 25% replacement of maize with Garri Waste has optimal carcass characteristics while 75% replacement of maize with Garri Waste had the largest internal organs. Thus, up to 25% Garri Waste based meal diet can be used to replace the conventional maize in the diet of broiler finisher chicken with the optimal Carcass qualities and 75% Garri Waste based meal diet can be used to replace the conventional maize in the diet of broiler finisher chicken with the larger internal organs weights.

Key words: Replacement, maize, garri waste, carcass, organs and broiler finisher bird.

Introduction

Broiler is any chicken that is bred and raised specifically for meat production. Most commercial broiler reach slaughters weight between four and seven weeks of age, although some are slower growing breeds that reach slaughter weight at approximately 14 weeks of age (Oloruntola *et al.,* 2016). Broiler birds convert feed to meat production reaching about 1.85 - 2.5 kg at slaughter age. Broiler production is one of the most important and promising sector in poultry industry in Nigeria that has quick return on investment as this contribute to the economic growth of the nation. Poultry feed composed of 60 - 65% energy, 30 - 35% protein and 2 - 8% minerals source (Oladokun and Johnson, 2012). The broiler business in Nigeria is one of the most popular and fast flourishing segment (Heise *et al,* 2015), gaining popularity among the developing countries because of its function in bridging the protein malnutrition and economic empowerment of the producers (Gebremedhn, 2015).

Maize is major source of energy in poultry feeds and consists about 60% in poultry diet (Obun and Abia, 2003). It is a commonly used ingredient in a diet of poultry to supply the energy needs of poultry. Over the past five years, thousands of tonnes of maize have been imported to Nigeria (USDA, 2019). However, the cost of these ingredients in recent years has increased due to mainly global inflationary trends coupled with its industrial use for ethanol production, energy drinks, as starch for binding tablets and a stable food for people. The high cost of feed material is also as a result of increasing the competition for grains between man, livestock and industries.

Cassava is an important root crop in the tropics, widely grown throughout the tropical Africa, Asia and South America (Honig *et al*., 1983). It is a very cheap source of carbohydrates and is the main carbohydrate source in the diet of the teaming population of the third world countries where it is largely grown. Banjoko *et al.* (2008) posited that cassava is a supplementary staple food of more than 200 million Africans aside from its uses as livestock feed particularly for monogastrics. Cassava contains 1mg/g of cyanide while cereals and grains contain cyanide of 0.001 to 0.4u/g (Honig *et al*., 1983).

Garri waste is the product of the production of garri, a popular West African food. Tubers are peeled, crushed and then fermented. The resulting product is sieved and roasted. The product is sieved again to have the waste product called garri waste. The waste represents 15 - 17 % of the root in weight (Nwokore *et al*., 2005). One of the identified alternatives way of solving the problem of high cost of maize is through the use of non-conventional source of dietary energy to augment the conventional feed source (Rafiu *et al*., 2014). Garri waste is cheap and readily agro-industrial available alternative feedstuff that are of no industrial use, which at the equal time could help meet the dietary requirements of the birds.

Materials and Methods

Experimental Site

The research work was conducted in the poultry unit of the Teaching and Research Farm, College of Education, Ila-Orangun, Osun State. Geographical attributes of Ila-Orangun lies on latitude 80° North of the equator and Longitude 40° 30° East of the Greenwich Meridian. The Laboratory study was done at research laboratory of Animal Science Department, University of Ibadan, Oyo State.

Preparation of Test Ingredients

The garri waste used in the study was purchased from garri processing industry in front of College of Education, Ila-Orangun, and milled into the form that can be easily

picked by the birds. All other ingredients used in the feed formulation were obtained from a reputable feed mill in Osogbo.

Preparation of Experimental Diets

Four (4) experimental treatments were formulated at different replacement levels of 0%, 25%, 50% and 75% garri waste (GW) respectively for maize in the diets (treatments).

Treatment 1 (T1) 0% Garri waste meal replacement for maize.

Treatment 2 (T2) 25% (12.50/100kg diet) Garri waste meal replacement for maize.

Treatment 3 (T3) 50% (25.00/100kg diet) Garri waste meal replacement for maize.

Treatment 4 (T4) 75% (37.50/100kg diet) Garri waste meal replacement for maize.

Experimental Birds and Management

A total of 128 Marshal Broiler birds of five (5) weeks of age were purchased from a reputable farm in Osogbo, Osun State, Nigeria. The birds were housed in pens lined with wood shavings as litter material. The birds were randomly distributed into four dietary treatments and replicated four (4) times. Each replicated with eight (8) birds were given anti-stress and antibiotics in fresh water on arrival. The bird's body weight per replicate was taken at the beginning of the experiment and thereafter on weekly basis. The birds were supplied with feed and water ad-libitum. Feed was given twice per day at 7:30am and 2:00pm. The birds were subjected to six (6) weeks of feeding trial.

Data Collection

At the 42nd day of experiment, one bird in each replicate was selected and starved for twelve hours so as to reduce the gastro-intestinal tract content of the bird.

Data were obtained for the following parameters:

Final life weight (g) = Bird's weight before Slaughtered.

Bled weight (g) = Bird's weight after the drain of blood.

Defeathered weight (g) = Bird's weight after the removal of feathers.

Eviscerated weight (g) = Defeathered weight _ (Internal Organ + Intestine).

Carcass Weight (g) = Eviscerated weight _ (head + shanks)

Dressing (%) = (carcass's weight/final weight) * 100

Breast (%) = (Breast's weight/carcas weight) * 100

Back (%) = (Back's weight/carcass weight) * 100

Thigh (%) = (Thigh's weight/carcass weight) * 100

Drumstick (%) = (Drumstick's weight/Carcass weight) * 100

Neck (%) = Neck weight/Carcass weight) * 100

Wings (%) = (Wing's weight/Carcass weight) * 100

Shanks (%) = (Shank's weight/Carcass weight) * 100

Head (%) = (Head's weight/Carcass weight) * 100

Heart (%) = (Heart's weight/Carcass weight) * 100

Lung (%) = (Lung's weight/ Carcass weight) * 100

Kidney (%) = (Kidney's weight/ Carcass weight) * 100

Liver (%) = (Liver's weight/ Carcass weight) * 100

Gizzard (%) = (Gizzard's weight/ Carcass weight) * 100

Spleen (%) = (Spleen's weight/ Carcass weight) * 100

Proventiculous (%) = (Proventiculous's weight/ Carcass weight) * 100

Abdominal fat (%) = (Abdominal fat's weight/ Carcass weight) * 100

Statistical Analyses

Data generated were subjected to one-way analysis of variance in a completely randomized design using the statistical

package (SAS, 2007) while the significant means among treatments were separated using Duncan Multiple Range Test of the statistical package at 5% significant level.

Table 1: Gross Composition of Experimental Diet

Ingredients	**T1Control**	**T2 (25%GW)**	**T3 (50%GW)**	**T4 (75%GW)**
Maize	50.00	37.50	25.00	12.50
Fish meal	2.50	2.50	2.50	2.50
Soyabeansmeal	15.70	15.70	15.70	15.70
Groundnut cake	10.00	10.00	10.00	10.00
Garri waste(GW)	_____	12.50	25.00	37.50
Wheat offal	17.00	17.00	17.00	17.00
Bone meal	2.50	2.50	2.50	2.50
Limestone	1.50	1.50	1.50	1.50
Lysine	0.20	0.20	0.20	0.20
Methionine	0.10	0.10	0.10	0.10
Salt	0.25	0.25	0.25	0.25
Finisher premix*	0.25	0.25	0.25	0.25
Total	**100.00**	**100.00**	**100.00**	**100.00**
Analyzed Nutrient Content				
CP%	20.33	20.84	20.51	9.08
CF%	3.00	2.95	3.08	3.07
ME kcal/kg	3156.08	3105.34	3021.1	2933.23

*Premix composition (per kg diet):vitamin A(12,000 I.U), vitamin D3(2,500 I.U), vitamin E (30 I.U), Vitamin K(2 mg), vitamin B1(2.250mg) Vitamin B2 (6mg), Vitamin B6 (4.500mg), Vitamin B12(0.015meg), Niacin(40.00mg), panthothenic (15.00mg), Folic acid (1.50mg), Biotin (0.050meg), Choline chloride (300.00mg), Manganese (80.00mg), Zinc (50.00mg), Iron (20.00mg), Copper (5.00mg), Iodine (1.00gm), Selenium (1.00mg), Cobalt (0.50mg), Antioxidant (125.00mg).

Table 2: Proximate Composition of Garri waste (GW) and Maize

Parameters	Garri waste (G W)	Maize
Crude protein	1.78	9.00
Crude fibre	2.45	2.22
Crude fat	0.43	3.40
Ash	1.20	1.10
Moisture content	9.80	6.40

Table 3: Proximate Composition of Experimental Diets

Parameters	T1 (0% G W)	T2 (25% G W)	T3 (50% G W)	T4 (75% G W)
Dry matter	91.60	90.90	90.05	88.60
Moisture content	8.40	9.10	9.87	11.50
Ash	2.50	2.90	3.70	4.40
Crude fat	6.81	6.50	6.20	5.89
Crude fibre	4.70	4.90	5.24	6.87
Crude protein	22.75	22.05	21.00	19.62

Results and Discussion

Dry matter content and crude protein were decreasing as the garri waste (GW) was increasing across the treatments with T4 (75% GW) containing the least (88.60 and 19.61) respectively and T1 (0% GW) containing the highest (91.60 and 22.75) respectively. Other treatments were between 90.90, 9.50 and 22.05, 21.00 respectively. Meanwhile, Ash, Crude fat, Crude fibre and Moisture Content were increasing as Garri waste was improving across the treatments. Control T1 (0% GW) had 2.50, 5.89, 4.70 and 8.40 respectively and T4 (75% GW) had 4.40, 6.81, 6.87 and 11.40 respectively while other treatments were between 2.90 and 3.70, 6.20 and 6.50, 4.90 and 5.24 and 9.10 and 9.50 respectively.

Table 4 showed the carcass characteristics of broiler finisher birds fed graded levels of garri waste meal. All parameters were significantly ($p < 0.05$) different except Dressing (%), Breast (%), Back (%) and Head (%). Birds fed control T1

(0% GW) was significantly higher ($p < 0.05$) in Final life weight (3438.20g), Bled weight (2839.50g), Defeathered weight (2706.50), Eviscerated weight (2428.20g) and Carcass weight (2263.20g) while birds fed T4 (75% GW) were significantly ($p < 0.05$) lower in these parameters. No significant difference was indicated ($p > 0.05$) in Dressing (%), Breast (%) and Head (%). However, there were numerical differences in these parameters across the treatments, that is, there was decrease from T1 (66.35, 48.73 and 4.72 respectively) to the least which is T4 (56.84, 32.24 and 2.92 respectively). Also, Back (%) was not significantly ($p > 0.05$) difference across the treatments but had highest values in T2 (18.48) and lowest values in T4 (8.10). Birds fed T1 (0% GW) were significantly ($p < 0.05$) higher in Thigh (%), Drumstick (%), Neck (%) and Wing (%) (25.16, 28.46, 15.02 and 21. 89 respectively) while these parameters were significantly ($p < 0.05$) lower in the birds fed T4 (13.32, 12.63, 5.87 and 9.58 respectively). However, Shank (%) was higher ($p < 0.05$) in birds fed T4 (75% GW) with the value of 8.50 and lower ($p < 0.05$) in birds fed T3 (50% GW) with 3.86.

Table 4: Relative Carcass Characteristics of Broiler Finisher Chicken Fed Varying Levels of Garri Waste Based Diets.

Parameters	T1 (0% GW)	T2 (25% GW)	T3 (50% GW)	T4 (75% GW)	
Final live weight (g)	3458.20^{a}	2644.20^{ab}	2517.50^{ab}	1994.80^{b}	189.53
Bled weight (g)	2839.50^{a}	2318.50^{ab}	2151.80^{ab}	1823.50^{b}	154.27
Defeathered weight (g)	2706.50^{a}	2199.00^{ab}	2023.80^{ab}	1658.80^{b}	154.89
Eviscerated weight (g)	2428.20^{a}	1848.80^{ab}	1725.50^{ab}	1362.20^{b}	139.93
Carcass weight (g)	2263.20^{a}	1732.50^{ab}	1635.20^{ab}	1007.50^{b}	154.33
Dressing (%)	66.35	65.09	64.86	56.84	1.84
Breast (%)	48.73	46.56	37.53	32.24	3.64
Back (%)	16.78	18.48	14.95	8.10	1.97
Thigh (%)	25.16^{a}	18.26^{ab}	14.95^{b}	13.32^{b}	1.65
Drumstick (%)	28.46^{a}	16.34^{b}	13.63^{b}	12.63^{b}	2.39
Neck (%)	15.02^{a}	8.07^{b}	7.24^{b}	5.87^{b}	1.32
Wing (%)	21.89^{a}	13.67^{ab}	9.84^{b}	9.58^{b}	1.81
Shank (%)	6.21^{ab}	5.17^{ab}	3.86^{b}	8.50^{a}	0.37
Head (%)	4.78	3.27	3.24	2.92	0.32

^{abc} mean in the same row wit h different superscripts are significantly different ($p<0.05$).

S. E. M. = Standard error of mean.

Table 5 showed the relative internal organs characteristics of broiler finisher birds fed graded levels of garri waste meal. All parameters in relative internal organs were significantly ($p<0.05$) different across the treatments except gizzard. Birds fed 75% GW were significantly higher ($p<0.05$) in kidney (%), lungs (%), liver (%) and Proventiculus (%) with values 1.96, 2.01, 8.61 and1.67 respectively and control had lower values 0.70, 0.71, 2.40, and 0.50 respectively. Heart (%) and spleen (%) follows the same trend with values 1.27 and 0.56 respectively but birds fed 50% GW had lower values 0.67 and 0.18 respectively. Bird fed 50% GW is significantly higher ($p<0.05$) in abdominal fat weight with value 1.88 and 0% GW had lower value of 0.02. There was no significant difference ($p>0.05$) in gizzard (%) but had numerical higher value of 4.19 in bird fed 75% GW and the lower value in bird fed 50% GW with 2.16.

Table 5: Relative Internal Organs Characteristics of Broiler Finisher Chicken Fed Varying Levels of Garri Waste Based Diets.

Parameters	T1(0%GW)	T2(25%GW)	T3(50%GW)	T4(75%GW)	SEM ±
Kidney	0.70^{b}	1.17^{ab}	0.94^{b}	1.96^{a}	0.17
Lungs	0.71^{b}	1.21^{ab}	0.92^{b}	2.01^{a}	0.18
Liver	2.40^{b}	3.89^{b}	2.51^{b}	8.61^{a}	0.83
Proventiculus	0.50^{b}	0.89^{b}	0.73^{b}	1.67^{a}	0.15
Heart	0.86^{ab}	0.85^{ab}	0.67^{b}	0.27^{a}	0.10
Spleen	0.22^{b}	0.24^{b}	0.18^{b}	0.56^{a}	0.05
Gizzard	2.41	4.10	2.16	4.19	0.37
Abdominal fat	0.02^{b}	0.18^{b}	1.88^{a}	0.78^{b}	0.22

^{abc} mean in the same row with different superscripts are significantly different ($p<0.05$).

S. E. M. = Standard error of mean.

The dressing (%) values (56.84 - 66.35%) are closed to 63 - 71% range reported previously by Odunsi *et al.,* (1999) as optimum for meat chicken and Kwari *et al.* (2011) reported the same percentage for broilers served with unprocessed Roselle seed diets and Oluyemi and Roberts (2000) for 9 week old broilers. The dressing % values is also in line with the reports of Okeudo *et al*., (2005) who reported that dressing percentage of birds linearly increased with increasing levels of energy content. The highest Breast (%) of birds fed control closely followed T2 and T3 may be an indication of better conversion of dietary nutrients into meat (Nwaeze, 2015). The numerical higher values obtained for Back (%) in T2 relative to the control shows that the diet supported tissue deposition of this part (Ogbonna, 1991). Tigh (%) and Drumstick percentage were appreciably higher in the birds fed 0% GW, followed by 25% GW. It could be as a product of huge amount of muscle deposited in this cut which proves that the diets encourage the deposition of muscles into these areas

(Duwa *et al.,* 2012). The average percentage of weight of Back in this study ranges from 8.10 to 18.48%. Broiler back which is almost entirely a bone and its development is more influenced by the content of Calcium in the diet than protein or energy (Resnawati, 2004) contains more bone tissue which shows that the mineral content in feed is more and has influence on the Back %.

Relative gizzard weight, kidney weight, liver weight and proventiculus are largest in birds served diets containing 75% GW which are significantly, different from the 3-dietry treatment. This is in line with report made by Dorpoto, 2010. It could also be as a result of continuous work of these organs while handling hydrogen cyanide (HCN). The gizzard weight obtained was higher than the 1.2% of live weight reported by Hubbard Breeders (2013). Duwa *et al*. (2012) reported higher gizzard weight for birds fed boiled and soaked roseller seed meal diets. Presence of anti nutritional factor had also been associated with the enlargement of organs because of their higher detoxification activities (Aderemi, 2003).

Conclusion

It is concluded from the results obtained from this study that up to 25% replacement of Maize with garri waste has the optimum carcass characteristics while 75% replacement of maize with garri waste had the largest internal organs.

REFERENCES

Aderemi, F. A. (2006). Microbial degradation of cassava root sievate (CRS) and it's utilization by layers. Journal of Animal Veterinary Advancement, 5 (9): 758-761

Banjoko, O. S., Agunbiode. J. A., Awojobi, H. A., Adeyemi, O. A., and Adebayo, M. O. (2008). "Nutritional Evaluation of Layers Diet based on Cassava products and Soya Beans as influenced by Protein Supplementation and Processing "procc. 33rd Annual Conference of NSAP, Ayetoro, Ogun State Nigeria 373 – 376.

Duwa, H., Oyawoye, E. O. and Njidda, A. A (2012). "Haematological Responses and Serum biochemical Indices of Broilers Fed differently Processed Sorrel Seed (*Hibiscus sabdariffa*) Meal in Semi-arid Region of Nigeria" *British Journal of Poultry Sciences* 1 (1), 05-10

Doporto, C.O. (2012) Utilization of cassava, sweet potato and cocoyam meals as dietary sources for poultry. *World J. Eng. Pure Appl. Sci*., 2:67.

Gebremedhn, B. A. A. (2015). Review of Mango (*Magnifera indica*) Seed Kernel Waste as Diet for Poultry College of Dry Land Agricultural and Natural Resources, Department of Animal, Range Land and wildlife science, Mekelle University. Mekelle, Ethopia, *journal of Biology, Agriculture and Health*.

Heise, 1. 1., Orisan, A. and Theuvsen, L. (2015). The Poultry Market in Nigeria: Market Structures and Potential for Investment Review, 18, 197–214.

Honig, D. H., Hockridge, M. E., Gould, R. M. and Rackis, J. J. (1983). "Determination of Cyanide in Soya Beans and Soya Beans Products *Journal of Agricultural Food*

Chemistry, 31: 272.

Kwari, I. D., Igwebuike, J. U., Mohammed, I. D. and Diarra, S. S. (2011). "Growth, Haematology and Serum Biochemistry of Broiler Chickens fed raw or Differently Processed Sorrel (*Hibiscus sabdariffa*) Seed Meal in a semi-arid Environment". *International Journal of Science and Nature*, 2(1), 22-27.

Nwaeze, U. U. (2015). Comparing the Caecal Microbial Population and Carcass Characteristics of Grower Rabbits Fed Cassava and Maize Sievate Based Diets. B. Agric Thesis. Michael Okpara University of Agriculture, Umudike.

Nwokore, S. O., Adegunloye, H. D., Ikhinmwin, A. F. (2005). Nutritional Composition of Garri Sievate Collection from some Locations in Southern Nigeria. *Pakistan Journal of Nutrition*, 4(4): 257 – 261.

Obun, C. O. and Abia, E. E. (2003). Performance and Hematological Changes of Broiler Chicks Fed. Agro Chemical treated Maize. *Journal of Sustainable Agric and the Environment,* Umudike, Abia State Vol. 5(2), 2003, 313 – 318pp.

Odunsi, A. A., Farinu, G. O., Akinola, J. O. and Togun, V. A. (1999). Growth, Carcass Characteristics and Body Composition of Broiler Chicken Fed Wild Sun Flower (*Tithonia diversifolia*) Farage Meal.*Tropical Animal production Investment,* 205-211.

Ogbonna, J. U (1991). Studies on the Value of Processed Cassava Peels in the Nutrition of Cockerel. Phd Thesis. University of Ibadan, Nigeria.

Okeudo, N. J, Ndidi, K. U, Izugbekwe, V. and Akanno, E. C (2005). Growth rate, carcass characteristics and organoleptic quality of broiler fed graded levels of palm kernel cake. *International Journal of poultry science,* 4: 330-333.

Oladokun, V. O. and Johnson, A. (2012). Feed Formulation Problem in Nigeria Poultry Farms: A Mathematical Programming Approach. *America Journal of Scientific and Industrial Research.*

Olorunda, J. O. and Aibor M. S. (2016). A Technical Handbook of Environmental Health in the 21st Century for Professional Students. Akure: His Mercy Publisher.

Oluyemi, J. A. and Roberts, F. A. (2000). Poultry Production in Warm Climate, Macmillan Press Limited, (1st Edition) London Pp: 147-168.

Raifiu, T. A., Babatunde, G. M. and Odunsi, A. A. (2014). Performance, Carcass Meat Characteristics of Broilers Fed Process. Mango Kernel Meal Based diets. *International Journal of Applied Research and Technology.*

Resnanwati, H. (2004). Cuts Carcass Weight and Fat Abdomen Broiler Chicken fed flour Containing Earthworm (*Lumbricus Rubellus*). www.peternakan. Lithang. Deptan. go. I'd. Accessed July 2, 2008.

United State Department of Agriculture. USDA (2019) Livestock and poultry: World markets and trade (PDF).