Original Research Article

Journal of Biological Research & Biotechnology

Bio-Research Vol. 21 No.3; pp. 2158-2167 (2023). ISSN (print):1596-7409; eISSN (online):2705-3822

The effect of dietary supplementation with aqueous extract of freshly harvested *Talinum triangulare* (waterleaf) plant on the haematology, serum biochemistry and carcass quality of broilers

[1§]Aronu Chinwe Justina, [2]Anaga Aruh Ottah, [3]Ihedioha John Ihedioha, [4]Marire Benjamin Nwabueze, [2]Anika Sylvanus Maduka.

[1]Department of Animal Health and Production, Faculty of Veterinary Medicine, University of Nigeria, Nsukka
[2]Department of Physiology and Pharmacology, Faculty of Veterinary Medicine, University of Nigeria, Nsukka
[3]Department of Veterinary Pathology and Microbiology, Faculty of Veterinary Medicine, University of Nigeria, Nsukka
[4]Department of Animal Science, Faculty of Agriculture, Enugu State University of Technology, Nigeria

[§]**Corresponding author:** Aronu Chinwe Justina. Email/Phone: chinwe.aronu@unn.edu.ng, +2347030627496

Abstract

A study was conducted to investigate the effect of dietary supplementation with *Talinum triangulare* (waterleaf) plant extract on broiler production and meat quality. A total of 75-day-old broiler chicks were used for a 35-day study which commenced after four weeks of brooding. Feed and water were provided *ad libitum*. Aqueous extract from freshly harvested waterleaf plant were administered in drinking water of broilers at doses of 0, 250, 500, 1000, and 2000 mg/L of drinking water, for treatment groups 1, 2, 3, 4, and 5 (T1, T2, T3, T4, and T5) respectively. The effect of *T. triangulare* supplementation on the haematology, serum biochemistry and carcass quality were investigated. Blood for haematology and serum biochemistry was collected following standard protocols at day 0, 18, and 36 of the study. Carcass quality was evaluated at the end of the study. Results showed that treatment with aqueous extract of freshly harvested *T. triangulare* administered in drinking water of broilers had no significant effect on haematology parameters. 2158 significantly ($p<0.5$) reduced after treatment. However, high density lipoprotein values generally increased, though not significant at ($p>0.5$), and fat deposits around organs and abdomen was markedly depleted with treatment. Dietary supplementation with *T. triangulare* extracts in broilers resulted in healthier broiler lipid profile and meat, evidence is based on reduction in serum level of cholesterol and fat deposits in carcass.

Keywords: Broiler, *Talinum triangulare*, Supplementation, Haematology, Fat, Lipid profile, Cholesterol

Received May 5, 2023; **Revised** October 26, 2023; **Accepted** October 30, 2023

https://dx.doi.org/10.4314/br.v21i3.10
Journal Homepage: http://www.bioresearch.com.ng.
Publisher*: Faculty of Biological Sciences, University of Nigeria, Nsukka, Nigeria.*

INTRODUCTION

Meat, according to FAO stipulation, should form about 40 percent of the total protein consumed by man (Inês *et al*., 2012). The quality therefore has a lot to contribute to the general wellbeing of man (Ferguson, 2010). Although the legislation prohibiting use of growth promoters and antibiotics in Nigeria, if any, is yet to be enforced; yet enlightened consumers are becoming more health conscious and are developing taste for animal food products with low cholesterol content and improved carcass quality. This preference is due to the awareness that fatty meat is known to contribute immensely to the adverse lipid profile and high blood cholesterol status of consumers (Chizzolni *et al*., 1999).

The poultry industry is one of the fastest growing segments of the animal production industry, and plays a vital part in meeting the animal protein need of the nation's teeming population (Narrod *et al*. 2011; Sahel Capital, 2015). It is capable of bridging the existing wide gap between demand and supply for food animal products (Hussain *et al*., 2015). The goals in feeding poultry differ between different classes of poultry. In general, for poultry raised to provide meat, such as broilers and turkeys, the aim is to produce the maximum body weight gain at a minimum cost of feed while controlling the amount of fat on the carcass (Saleh *et al*., 2004). Meat quality refers primarily to desirability to the consumer (in terms of leanness, palatability, attractiveness), has become a serious issue worldwide (Micha *et al*., 2010).

This study was aimed at the use of unconventional plant protein source as a substitute to the use of antibiotics in broiler production. The plant chosen for this study is *Talinum triangulare* (waterleaf), which belongs to the Purslane family (Portulacacae). It is a leafy vegetable found in West Africa, the West Indies, and South America (Akachukwu and Fawusi, 1995). The leaves and tender stems of *T. triangulare* are consumed as vegetable or as the constituent of sauces in most parts of Nigeria. *Talinum triangulare* grows spontaneously during the rainy season, and it is common in a variety of habitats including roadsides, open field and abandoned agricultural lands (Schippers, 1995). The American Bureau of Agricultural Research (BAR) has included *T. triangulare* as an ethnic food with high nutritional value; and had been promoting its consumption. *Talinum triangulare* is reported to possess high nutritive value with crude protein content comparing favourably with that of cowpea, peanut, millet, and cashew nuts (Leung et al., 1998; Egwin, 1979; Akachukwu and Fawusi, 1995). *Talinum triangulare* is cosmopolitan in nature (Souza and Lorenzi, 2005), easy to propagate and very economical since it can be planted almost in any soil (Amorim *et al*., 2013) and is available all through the year, in a tropical environment.

This study evaluated the efficacy of using *T. triangulare* as a possible health modulator to improve the quality of broiler meat.

MATERIALS AND METHODS

Experimental design

The experiment was carried out in the Department of Animal Health and Production, Faculty of Veterinary Medicine University of Nigeria, Nsukka Students Poultry Demonstration Farm. Laboratory facilities in the faculty were used for sample analyses.

A total of 75 Abhor Acre strains of broiler chicks purchased from Kosy Veterinary Consult, Enugu were used for the feeding trial. The day-old broiler chicks were brooded in deep litter pens, for four weeks, following standard protocols; after which they were randomly allocated to five experimental groups (T1-T5) of 15 broilers each. Each experimental group was further subdivided into 3 replicates of 5 broilers each (Table 1). Feed and water were administered *ad libitum*. The broilers were fed with Top feed® broiler feed formulations (a commercial poultry feed from Premier Feed Mills Ltd (PFM), Nigeria.): Super starter, starter and pelleted finisher were used for weeks one to two, three to six and seven to nine of the study, respectively.

Broiler chicks were duly vaccinated against the following diseases: Newcastle, Gumboro and coccidiosis. The dietary supplementation with extract from freshly harvested *Talinum triangulare* in drinking water of broilers lasted for five weeks post brooding.

Preparation of the extract

Talinum triangulare used for the feeding trial was harvested from a vegetable garden near the demonstration farm. It was identified at the herbarium belonging to the Department of Plant Science and Biotechnology, University of Nigeria, Nsukka. The method of Anaga *et al*. (2012) was used for plant extraction. Briefly, the leaves and succulent shoots of the plant were washed and allowed to drain. It was cut into small pieces and

grinded into a pasty consistency with a grinding machine. A litre of distilled water was used to rinse out from the grinding machine every 1kg of *T. triangulare* that was grinded. The mixture was left for 24 hours. Thereafter, it was turned intermittently for 24 hours and was filtered with a domestic sieve. The filtrate was collected in a plastic container and refrigerated. Fresh extracts were prepared on weekly basis. Graded doses of the test extract was fed at 0, 250, 500, 1000 and 2000 mg/L of drinking water for broilers in experimental groups T1, T2, T3, T4, and T5, respectively.

Data collection

Blood sampling was carried out on days 0, 18 and 36 of the feeding trial following standard protocol. Three birds were randomly selected from each replicate and 5ml of blood collected from the jugular vein, 2 ml was discharged into pre-labelled heparinized bottles and remaining 3 ml into clean sample bottles kept in slanted positions and allowed to clot. Serum was harvested after centrifuging the non-heparinized blood samples at 3,000 revolutions per minute for 3 – 5 minutes. Harvested sera were subjected to biochemical component assays while adhering to manufacturer's recommendations, and using commercial enzymatic kits.

Biochemical analysis

Haematology

The Packed cell volume (PCV) was determined using the Micro haematocrit method (Thrall and Weiser, 2002); while the red blood cell (RBC) count was done using the haemocytometer method (Campbell, 1994). The haemoglobin (Hb) concentration was determined by the cyanomethaemoglobin method (Higgins *et al*., 2003).

Serum biochemistry

Determination of serum total cholesterol (TChol) was done following the enzymatic colorimetric test (CHOD-PAP method) for the *in vitro* determination of cholesterol in serum or plasma, using Quimica Clinica Applicada (QCA) Cholesterol test kit (QCA, S. A. Spain) (Allian *et al*., 1974). High Density Lipoprotein (HDL) was determined using Dextran sulphate – Mg (II) method for the *in vitro* determination of HDL-cholesterol in serum, (Albers *et al*., 1978). Determination of Serum Triacylglycerol (TAG) was accomplished following the glycerol-phosphate oxidase method (enzymatic test) for the *in vitro* determination of triacylglycerol in serum, (Jacobs and VanDemark, 1960). The very low-density lipoprotein (VLDL) was estimated as one-fifth of the triglycerides (Warnick *et al*., 1990). The Friedewald formula was used to calculate low density lipoprotein (LDL): Total Cholesterol - HDL Cholesterol - (Triglycerides/5). Liver function test was accomplished using serum levels of liver enzymes to determine liver function. Serum glutamic oxaloacetic transaminase (GOT) / aspartate amino transferase (AST)**:** GOT (AST) was determined by the Reitman-Frankel colorimetric method for *in vitro* determination of GOT/AST in serum or plasma (Reitman and Frankel, 1957) using Quimica clinica applicada (QCA) cholesterol test kit (QCA, S. A. Spain). Determination of serum glutamic pyruvic transaminase (GPT) / alanine amino transferase (ALT) was accomplished using the Reitman-Frankel colorimetric method for *in vitro* determination of GPT/ALT in serum or plasma (Reitman and Frankel, 1957). For the *in vitro* determination of serum alkaline phosphatase (ALP) in serum or plasma, the phenolphthalein monophosphate method was used (Babson *et al*., 1966). Direct burette method for the *in vitro* determination of total protein (TP) in serum or plasma was used (Lubran, 1978).

Statistical analysis

Data collected were analysed using analysis of variance (ANOVA) with computer software package (SPSS version 16.0) and treatment means compared using the Duncan's New Multiple Range Test (DNMRT) (Daniel, 1995). Significance was accepted at five percent probability.

RESULTS

Result showed that dietary supplementation with aqueous extract of freshly harvested waterleaf plant generally had no significant effect on haematology parameters (Table 1). However, Red Blood Cell count was depleted on day 18 at a high dose of 2000mg/ L waterleaf extract supplementation (Table 1c).

Table 1. Packed Cell Volumes (PCV %), Haemoglobin Concentration (HbC g/dL), and Red Blood Cell (RBC 10^6/µL) ± SEM of Broilers Treated with Aqueous Extract of *Talinum triangulare* in Drinking Water.

Treatment Groups	Experimental Time in Days		
	Day 0	Day 18	Day 36
(a) PCV (%)			
T1 (0 mg/L)	25.00 ± 1.53	21.67 ± 0.88	23.17 ± 2.24
T2 (250 mg/L)	26.67 ± 1.45	22.33 ± 1.17	26.83 ± 2.20
T3 (500 mg/L)	25.83 ± 1.92	20.33 ± 0.60	27.17 ± 0.83
T4 (1000 mg/L)	25.00 ± 1.76	21.50 ± 0.29	27.33 ± 2.40
T5 (2000 mg/L)	28.33 ± 3.44	19.67 ± 0.33	27.67 ± 0.88
No significant differences between the groups (p>0.05)			
(b) HbC (g/dL)			
T1 (0 mg/L)	8.93 ± 0.91	8.75 ± 0.39	9.46 ± 0.13
T2 (250 mg/L)	8.68 ± 0.63	9.22 ± 0.44	9.87 ± 0.95
T3 (500 mg/L)	9.31 ± 0.49	7.94 ± 0.54	9.60 ± 0.49
T4 (1000 mg/L)	7.83 ± 0.65	7.88 ± 0.63	9.60 ± 0.88
T5 (2000 mg/L)	8.62 ± 1.15	8.19 ± 0.57	10.00 ± 0.14
No significant differences between the groups (p>0.05)			
(c) RBC (10^6/µL)			
T1 (0 mg/L)	3.67^{ab} ± 0.06	2.54^{a} ± 0.05	2.41 ± 0.36
T2 (250 mg/L)	3.32^{c} ± 0.10	2.47^{ab} ± 0.18	2.46 ± 0.39
T3 (500 mg/L)	3.37^{bc} ± 0.13	2.48^{ab} ± 0.09	2.76 ± 0.15
T4 (1000 mg/L)	3.58^{abc} ± 0.05	2.36^{ab} ± 0.04	2.79 ± 0.36
T5 (2000 mg/L)	$3.81^{\mathbf{a}}$ ± 0.11	$2.19^{\mathbf{b}}$ ± 0.06	2.37 ± 0.42

^{abc} Different superscripts in a column (days of treatment) indicate significant differences between the group on such a day (P<0.05).

Supplementation significantly (p<0.05) increased total cholesterol levels in the serum of broilers treated with 500 and 1000 mg/L dose (Table 2a). Treatment with *T. triangulare* generally lowered total cholesterol on day 18 (Table 2a). Enhanced HDL values with treatment were dose related up to 1000 mg/L dose of supplementation (Table 2b). Significant (p<0.05) reductions were recorded with LDL in T3 and T4 (Table 2c), also with VLDL (Table 3a) and Triacylglycerol in T2 and T4 (Table 3b) due to treatment.

Table 2. Total Cholesterol, High Density Lipoprotein (HDL) and Low-Density Lipoprotein (LDL) ± SEM (in mg/dl) of Broilers Treated with Aqueous Extract of *Talinum triangulare* in Drinking Water

Treatment Groups	Time in Days		
	Day 0	Day 18	Day 36
(a) Total Cholesterol (mg/dl)			
T1 (Control) 0 mg/L	128.25 ± 7.07	138.18 ± 15.85	122.00^{ab} ± 1.15
T2 (250 mg/L)	130.79 ± 3.53	133.33 ± 11.22	102.67^{b} ± 10.41
T3 (500 mg/L)	139.68 ± 16.80	124.24 ± 10.92	132.00^{a} ± 6.11
T4 (1000 mg/L)	138.4 ± 7.07	123.03 ± 5.18	138.67^{a} ± 10.41
T5 (2000 mg/L)	137.78 ± 7.49	128.48 ± 1.21	124.00^{ab} ± 4.16

^{abc} Different superscripts in a column (days of treatment) indicate significant differences between the group on such a day (P<0.05).

Treatment Groups	Time in Days		
	Day 0	Day 18	Day 36
(b) HDL (mg/dl)			
T1 (0 mg/L)	69.84 ± 6.35	69.09 ± 5.55	54.00 ± 7.02
T2 (250 mg/L)	70.48 ± 6.69	76.97 ± 9.05	62.67 ± 3.53
T3 (500 mg/L)	71.11 ± 7.07	80.00 ± 3.78	60.67 ± 0.67
T4 (1000 mg/L)	74.28 ± 9.40	78.18 ± 6.39	68.67 ± 5.70
T5 (2000 mg/L)	76.19 ± 11.00	74.55 ± 1.05	68.67 ± 5.93
No significant differences between the groups (p>0.05)			
(c) LDL in (mg/dl)			
T1 (0 mg/L)	34.25 ± 2.69	49.20^{a} ± 10.33	28.00 ± 9.08
T2 (250 mg/L)	37.88 ± 5.67	41.52^{ab} ± 2.37	24.28 ± 9.54
T3 (500 mg/L)	46.30 ± 13.00	22.62^{b} ± 2.80	40.46 ± 7.32
T4 (1000 mg/L)	41.07 ± 3.93	23.22^{b} ± 6.80	40.53 ± 14.32
T5 (2000 mg/L)	39.93 ± 6.44	33.32^{ab} ± 5.81	21.65 ± 4.47

^{abc} Different superscripts in a column (days of treatment) indicate significant differences between the group on such a day (P<0.05).

Table 3. Very Low-Density Lipoprotein (VLDL in mg/dl), Triacylglycerol (in mg/dl) of Broilers Treated with Aqueous Extract of *Talinum triangulare* in Drinking Water

Treatment Groups	Time in Days		
	Day 0	Day 18	Day 36
(a) VLDL (mg/dl)			
T1 (0 mg/L)	24.16 ± 2.20	19.89 ± 1.32	40.00^{a} ± 1.22
T2 (250 mg/L)	22.43 ± 5.06	14.85 ± 2.32	15.72^{c} ± 0.61
T3 (500 mg/L)	22.27 ± 1.75	21.62 ± 4.99	30.87^{ab} ± 3.71
T4 (1000 mg/L)	23.06 ± 1.51	21.62 ± 5.67	29.47^{b} ± 4.21
T5 (2000 mg/L)	21.65 ± 5.03	20.61 ± 3.90	33.68^{a} ± 2.43

^{abc} Different superscripts in a column (days of treatment) indicate significant differences between the group on such a day (P<0.05).

(b) Triacylglycerol (mg/dl)			
T1 (0 mg/L)	120.79 ± 10.98	99.46 ± 6.60	200.00^{a} ± 6.08
T2 (250 mg/L)	112.16 ± 25.28	74.23 ± 11.60	78.59^{c} ± 3.06
T3 (500 mg/L)	111.37 ± 8.73	108.11 ± 24.97	154.39^{ab} ± 18.56
T4 (1000 mg/L)	115.30 ± 7.56	108.11 ± 28.36	147.37^{b} ± 21.05
T5 (2000 mg/L)	108.24 ± 25.16	103.06 ± 19.51	168.42^{ab} ± 12.15

^{abc} Different superscripts in a column (days of treatment) indicate significant differences between the group on such a day (P<0.05).

Table 4. Liver Function Test ± SEM of Broilers Treated with Aqueous Extract of Waterleaf in Drinking Water

Treatment Groups	Liver Enzymes Evaluated at Day 36 of the Experiment			
	ALT (iu/L)	ALP (iu/L)	SGOT/AST (iu/L)	TP (g/dl)
T1 (0 mg/L)	14.40 ± 2.56	200.54 ± 11.17	103.72 ± 1.88	3.03 ± 0.47
T2 (250 mg/L)	8.28 ± 0.62	204.87 ± 12.47	99.98 ± 3.25	3.75 ± 0.47
T3 (500 mg/L)	8.70 ± 3.77	193.51 ± 7.62	99.60 ± 2.65	3.37 ± 0.46
T4 (1000 mg/L)	6.57 ± 1.88	184.87 ± 18.93	101.85 ± 4.96	4.11 ± 0.27
T5 (2000 mg/L)	6.43 ± 1.78	181.89 ± 1.77	105.60 ± 3.25	3.81 ± 0.39

No significant differences between the groups (p>0.05) for all the parameters determined

Treatment with *T. triangulare* extract had no significant impact on liver enzymes studied (Table 4), but had significant effect on fat deposition in the abdomen. Fat harvested from the abdominal region and around organs, for T1-T5 experimental groups, weighed 105 ± 0.32^{a}, 68.10 ± 0.01^{b}, 44.90 ± 0.25^{c}, 18 ± 0.17^{d}, and 97 ± 0.12^{a} (T1>T5>T2>T3>T4), respectively. Hyper pigmentation and lethargy were observed with broilers in T5 treated with 2000 mg/L of the extract. About 25 % of broilers in T5 had problem with standing and walking.

DISCUSSION

Lower values of RBC at 2000 mg/L dose of *T. triangulare* supplementation suggest that the extract may have a hemolytic effect on blood cells at very high doses. In contrast to our observation, Ekpo *et al*. (2007) reported that lower doses of waterleaf extract (WLE) (100 and 250mg/kg), significantly increased the serum level of total bilirubin while higher doses did not exert this effect, they attributed this observation to possible hemolytic effect of extract in the animal.

Pharmacological therapy to increase the level of HDL cholesterol includes use of fibrates and niacin. Niacin (B3) increases HDL by selectively inhibiting hepatic diacylglycerol acyltransferase 2, and reduces triacylglycerol synthesis and VLDL secretion through a Niacin receptor 1 and 2 pathway (Meyer *et al*., 2004; Soudijn *et al*., 2007). It has been reported that *T. triangulare* contains high levels of both niacin and soluble fibers (Leung *et al*., 1998; Ezekwe *et al*., 2002), thus accounting for the slightly elevated HDL and reduced triacylglycerol values reported in this study. The fact that supplementation with *T. triangulare* extract, between the 500 and 1000 mg/L dose (T3 and T4), reduced the LDL significantly by more than 50 percent at Day 18 of treatment when compared to the control is worthy of note (Table 2c). Blood tests typically reports LDL-C, which represents the quantity of cholesterol contained in LDL. Higher levels of LDL particles are known to promote health problems and cardiovascular disease (Imes and Austin, 2012). For this reason, LDL are called “bad cholesterol” particles. Whatever lowers the quantity of cholesterol contained in LDL particles is said to promote health generally and healthy cardiovascular system particularly (Ostlund *et al*., 2003). *Talinum triangulare* treatment in this study also reduced the VLDL, also classified as “bad” cholesterol (Table 3a).

Reduction of triacylglycerol level in T2 animals by about 61 % on Day 36, when compared to the control (T1), was observed. In humans, high levels of triacylglycerol in the blood stream have been linked to atherosclerosis and by extension, the risk of heart disease and stroke (Beitz 1993; Brunzell *et al*., 2008). The risk can be partly accounted for by a strong inverse relationship between triacylglycerol level and HDL-cholesterol level (Da Luz *et al*., 2008).

Similar results obtained across groups for liver enzymes show that the extract had no harmful effect on liver cells and functionality. Lower ALT values (within normal range) when compared with the control (though statistically not significant), shows increase in membrane stability conferred on the liver cells by *T. triangulare* extract. This hepatoprotective property will enhance nutrient metabolism, excretion of by products and nutrient recycling (Adefolaju, *et al*., 2008). This agrees with Adefolaju *et al.* (2008) who reported that waterleaf improves hepatoprotective activity against oxidative liver damage, and suggested that waterleaf is able to do this due to its antioxidant property. Iwalewa *et al.* (2005), Ezekwe *et al.* (2002), and Ofusori *et al.* (2008) also reported the antioxidant property in waterleaf.

Result from carcass evaluation showed that inclusion level at 500 and 1000 mg/L (T3 and T4) led to abdominal fat depletion. *Talinum triangulare* is a mucilaginous vegetable with high oxalate content and is rich in saponins (Swarna and Ravindhran, 2013). High oxalic acid in *T. triangulare* would inhibit calcium and iodine absorption in-vivo (Wardlaw *et al*., 2004). This may explain the hyper pigmentation, lethargy and other signs of hypothyroidism observed with groups administered high dose of *T. triangulare* extract (2000 mg/L of water). However, accumulation of iodine in the blood may directly inhibit thyroid gland function as is the case with administration of the drug Amiodarone (an antiarrhythmic - iodine containing drug). Amiodarone – induced hypothyroidism sequel to the drug inhibiting the conversion of thyroxine (T_4) to T_3 (Amico *et al*., 1984), occur as a result of the inhibition of 5´-deiodinnase activity (Harjai and Licata, 2006). Thyroid hormone deficiency induces a hyper lipidemic response both in overt and subclinical hypothyroid patients (Pucci *et al*., 2000) characterised by increase in LDL and apolipoprotein B (Duntas, 2002). Miller *et al*. (2011)

observed that moderate intake of predominantly unsaturated fat (30-35%) and plant-based protein (17-25%) may produce a triacylglycerol-lowering effect, whereas, very high intake may produce a reverse effect. This may explain why fat deposition around the internal organs and perinea region of the abdomen depleted at moderate doses (500-1000 mg/L of drinking water) but was restored at a high dose of 2000 mg of extract/L of drinking water. Report on loss of feathers around the head and neck region, hyper pigmentation, ruffled feathers, and lethargy, as was observed with broilers treated with high dose of the extract in T5, may be indicative of hypothyroidism (Dickson, 1993). Miller *et al*. (2011) had observed that caution must be exercised when animals are fed with plant proteins. He explained that plant proteins often come with plant toxins; therefore, high level of consumption has been linked to increased disease risk, thus acceptable level of inclusion for each plant needs to be established.

CONCLUSION

Supplementation with *T. triangulare* up to 1000 mg/L of drinking water had no overt deleterious effect on overall health status of broilers and may therefore be classified as a healthy supplement or nutraceutical for broilers. *Talinum triangulare* supplementation exhibited anti-atherogenic property; this it achieved by increasing the HDL-C and reducing the VLDL, LDL, and Triacylglycerol levels in the sera of broilers. Inclusion levels of the extract of *T. triangulare* between 500 to 1000mg/l depleted fat deposits on organs and abdominal region significantly. This finding supports production of heart-friendly broiler meat and egg (as suggested by Aronu *et al*., 2020) which will meet the desire of health-conscious consumers who abhor poultry products, and meat and milk generally for fear of cholesterol content and its relationship with coronary heart diseases.

The challenge of using freshly harvested vegetables in dietary studies lies in the fact that unlike the dried form the former varies relatively in nutrient and water composition, this is in addition to the influence of soil composition, time and age at plant harvest, climatic and environmental factors, etc. Sequel to this observation most likely, *Aronu et al*. (2019) has suggested that more research be carried out to determine how much of *Talinum triangulare* is required to replace a given quantity of the conventional feed stuff on dry matter basis without any deleterious consequences on the health and productivity of poultry.

Conflict of interest

Authors have no conflict of interest to declare

Author contributions

Conceived and designed the experiments: SMA, CJA, and AOA. Performed the animal study: CJA, BNM, and AOA. Performed laboratory and data analyses, JII, and CJA. Wrote the paper, CJA, BNM, and JII. All authors read and approved the manuscript for publication.

REFERENCES

Adefolaju, G. A., Ajao, M. S., Olatunji, L. A., Enaibe, B. U. and Musa, G. (2008). Hepatoprotective effect of aqueous extract of Water leaf (*Talinum triangulare*) on carbon tetrachloride (CCL_4) induced live damage in Wister rats. *The Internet Journal of Pathology*. Doi: 10.5580/1c4b.

Akachukwu, C. O. and Fawusi, M. A. O. (1995). Growth characteristics, yield and nutritional value of waterleaf, *Talinum triangulare* (Jacq) wild in a semi-wild environment. *Journal of Discovery and Innovation,* **7**: 163-172.

Albers, J. J., Warnick, G. R. and Cheung, M. C. (1978). Quantification of high-density lipoproteins, *Lipids,* 926-932.

Allian, C. C., Poon, L. S., Chan, C. S., Richmond, W. and Fu, P. C. (1974). Enzymatic determination of total cholesterol. *Clinical Chemistry,* **20**(4): 470-475.

Amico, J. A., Richardson, V., Alpert, B. and Klein, I. (1984). Clinical and chemical assessment of thyroid function during therapy with Amiodarone. *Archives of Internal Medicine*, **144**: 487-490.

Amorim, A. P. O., Olivera, M.C.C., Amorim, T. A. and Echevarria, A. (2013). Antioxidant,siron chelating and tyrosinase inhibitory activities of extracts from *Talinum triangulare* Leach Stem. Available from: www.mdpi.com/journal/antioxidants,2,90-99.

Anaga, A. O., Onuoha, A., Igboeli, O. O. and Ezeja, M. (2012). Antihyperglycemic effects of the methanol leaf extract of diaphananthebidens in normoglycemic andstreptozotocin – induced hyperglycaemic rats. *Asian Pacific Journal of Tropical Medicine*, **5** (3): 192-196.

Aronu, C. J., Anaga, A. O., Marire, B. N., Anika, S. M.

(2020). Supplementation with aqueous extract of *Talinum triangulare* and effect on haematology, and serum biochemistry in growing pullets. *Turkish Journal of Veterinary and Animal Science* **44**: 487 – 494.

Aronu, C. J., Okolo, C. C., and Akubueze U. H. (2019). Dietary supplementation with aqueous extractof *Talinum triangulare* at different phases of broiler production and effect on growth, serum biochemistry and carcass quality. Search. *Indian Journal of Animal Research.* **B11561**: 1-7

Babson, A. L., Greeley, S. J., Coleman, C. M. and Philips, G. E. (1966). Phenolphthalein monophosphate as a substrate for serum alkaline phosphatise. *Clinical Chemistry* 482.

Beitz, D. C. (1993). Lipid metabolism. In: Dukes Physiology of Domestic Animals, 11th edition edited by Melvin J. Swenson. Co-editor William.O. Reece; Cornell University Press USA. 453-472.

Brunzell, J. D., Davidson, M., Furberg, C. D., Goldberg, R. B., Howard, B. V., Stein, J. H. and Witzium, J. L. (2008). Lipoprotein management in patients with cardiometabolic risk; consensus statement from *the American Diabetes Association and the American College of Cardiology Foundation,* **31** (4):811-821.

Campbell, J. Y. (1994). Inspecting the mechanism: An analytical approach to the Stochastic Growth Model. *Journal of Monetary Economics,* **33** (3): 463-506.

Chizzolni, R., Zanardi, E., Dorigoni, V. and Ghidini, S. (1999). Calorific value and cholesterol content of normal and low-fat meat and meat products. *Trends in Food Science and Technology,* **10**: 119-128.

Da Luz, P. L., Favarato, D., Favia-Neto Junior, J. R., Lemos, P. and Chaqas, A. C. P. (2008). High ratio of triglycerides to HDL – cholesterol predicts extensive coronary disease. *Clinics* **63(4)** : 427 – 432.

Daniel, W. W. (1995). Biostatistics. A Foundation for Analysis in the Health Science 6th ed John (Willey and sons Book, New York.

Dickson, W. M. (1993). "Endocrine glands and function". In: Dukes Physiology of Domestic Animals, 11th edition edited by Melvin J. Swenson. Co-editor William.O. Reece by Cornell University press USA.

Duntas, L. H. (2002). Thyroid disease and lipids. *Thyroid* **12**: 287-293.

Egwin P. O. (1979). A New Biochemical Rating System for Vegetable Food Protein. *Nigerian Journal of Physiological Sciences* **13**: 323-329.

Ekpo, A., Eseyin, O., Kalu, N., Jackson, O. and Edoho, E. J. (2007). Studies on the biochemical effects of *Talinum triaangulare* in rat. *Journal of Pharmacology and Toxicology* **2** (3): 300-303.

Ezekwe, M. O., Besong, S. A., Igbokwe, P. E. and Ezekwe, E. I. (2002). Beneficial influence of purslene and waterleaf supplementation on cardiovascular disease risk in humans. *FASEB Journal* **16**(4): A639.

Ferguson, L. R. (2010). Meat and cancer. *Meat Science* **84**: 308-313.

Friedewald, W. T., Levy, R. I. and Fredrickson, D. S. (1972). Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clinical Chemistry* **18**:499 – 502.

Goldberg, I. J., Huang, L. S., Huggins, L. A. and Yu, S. (2012). Thyroid Hormone reduces cholesterol via a non-LDL Receptor-Mediated Pathway. *Endocrinology*, **153**(11), 5143-5149.

Harjai, K. J. and Licata, A. A. (2006). Effects of Amiodarone on thyroid function. *Annals of Internal Medicine* **126**, 63-73.

Higgins, T., Bentler, E. and Doumas, B. T. (2003). Haemoglobin, iron and bilirubin Teitz. Fundamental of Clinical Chemistry (6th edition), 28: 509-526.

Hussain, J., Rabbani, I., Aslam, S. and Ahmad, H. A. (2015). An overview of poultry industry in Pakistan. *Worlds Poultry Science Journal* **71**: 689-700.

Imes, C. C. and Austin, M. A. (2012). Low density lipoprotein cholesterol,napolipoprotein B, and risk of coronary heart disease: from familial hyperlipidemia to genomics. Journal of Biological Research for Nurses 2012.

Inês, V., Jose, M. L. S., Antonio. B. and Magda, A. F. (2012). Meat safety: A brief review on concerns common to science and consumers. *The International Journal of Sociology of Agriculture and Food,* **19**(2): 275-288.

Iwalewa, E. O., Adewunmi, C. O., Omisore, N. O., Adebanji, O. A., Azike, C. K., Adigun, A. O., Adesina, O. A and Olowoyo, O. G. (2005). Pro- and antioxidant effects and cytoprotective potentials of nine edible vegetables in southwest Nigeria. *Journal of Medicinal Foods, Winter* **8**(4):539-44.

Jacobs, N. J. and VanDemark, P. T. (1960). Method of Triglyceride estimation. *Archives of Biochemistry and Biophysics* **8**: 250 – 255.

Leung, W. T. W., Busson, F. and Jardin, C. (1998). Physical and chemical properties of leafy vegetables. *PROTA,* **2**: 522-527.

Lubran, M. M. (1978). The measurement of total serum proteins by the Biuret method. *Annals of Clinical and Laboratory Sciences* **8** (2): 106-110.

Meyer, C., Kamanna, V. S. and Kashyap, M. L. (2004). Niacin therapy in atherosclerosis. *Current Opinion in Lipidology* **15**(6): 659 – 665.

Micha, R., Wallace, S. K. and Mozaffarian, D. (2010). Red and processed meat consumption and risk of incidence of coronary heart disease, stroke and diabetes mellitus. A systemic review and meta-analysis. *Circulation*, **121**: 2271-2283.

Miller, M., Stone, N. J., Ballantyne, C., Bittner, V., Criqui, M. H., Ginsberg, H. N., Goldberg, A. C., Howard, W. J., Jacobson, M. S., Kris-Etherton, P. M., Lennie, T. A., Levi, M., Mazzone, T. and Pennathur, S. (2011).Triglyceride and vascular disease: a scientific statement from the American Heart Association. *Circulation,* **123**: 2292-2333.

Narrod, C., Tionco, M. and Costales, A. (2011). Global poultry sector trends and external drivers of structural change. In: Poultry in the 21st Century. FAO; 2011: 1-48. Ftp://ftp.fao.org/docrep/fao/011/i0323e01.

Ofusori, D. A., Adelakun, A. E., Ayoka, A. O., Oluwayinka, O. P., Omotoso, E. O., Odukoya, S. A. and Adeyemi, D. O. (2008). Waterleaf (*Talinum triangulare*) Enhances Cerebral Functions in Swiss Albino Mice. *Journal of the neurological sciences* **25** (4): 239-246.

Ostlund, R. E., Racette, S. B. and Stenson, W. F. (2003). Inhibition of cholesterol absorption by phytosterol-replete wheat germ compared with phytosterol-depleted wheat germ. *The American Journal of Clinical Nutrition* **77** (6): 1385–1589.

Pucci, E., Chiovato, L. and Pinchera, A. (2000). Thyroid and lipid mechanism. *International Journal of Obesity* (London) **24**(Suppl 2): S109-S112.

Reitman, S. and Frankel, S. A. (1957). Colorimetric method for determination of serum glutamic oxaloacetic and glutamic pyruvic transaminases. *American Journal of Clinical Pathology* **28**:5.

Sahel Capital (Mauriius) Limited. (2015). An assessment of the Nigerian poultry sector. Sahel Capital Partners and Advisory Ltd, 11: 1-3.

Saleh, E. A., Watkins, S. E., Waldroup, A. L. and Waldroup, P. W. (2004). Effects of dietary nutrient density on performance and carcass quality of male broilers grown for further processing. *International Journal of Poultry Sciences*, **3**(1): 1-10.

Schippers, R. R. (1995). African indigenous vegetables: An overview of the cultivated spices chathan, UK 1995: 214.

Soudijn, W., van Wijngaarden, I. and Ijzerman, A. P. (2007). Nicotinic acid receptor subtypes and their ligands. *Medicinal Research Reviews* **27**: 417–433.

Souza, V. C. and Lorenzi, H. (2005). Botânica Sistemática; guiailustrado para identificação das famílias de Angiospermas da flora brasileira, baseadoem APG II. Nova Odessa, São Paulo: Plantarum. Instituto Plantarum de Estudos da Flora Ltda,: 640.

Swarna, J. and Ravindhran, R. (2013). Pharmacognostical and phytochemical evaluation of *Talinum triangulare* (jacq) willd; *International Journal of Pharmacy and Pharmaceutical Sciences*, **5**: suppl 2.

Thrall, M. A. and Weiser, M. G. (2002). Haematology. In: Hendrix C. M. (Ed.) Laboratory Procedures for Veterinary Technicians,4th Edition, Mosby Incorporated, Missouri, USA: 29 – 74.

Wardlaw, G. M., Hamp, J. S. and Disilvestro, R. A. (2004). Perspectives in Nutrition, (McGraw-Hill, USA), 413-445.

Warnick, G. R., Knopp, R. H., Fitzpatrick, V. and Branson, L. (1990). Estimating low-density lipoprotein cholesterol by the Friedewald equation is adequate for classifying patients on the basis of nationally recommended cutpoints. *Clinical Chemistry,* **36** (1): 15–19.