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Effect of Soil Nutrient Status on Carcass Quality of Pond-Raised Tilapia, *Oreochromis niloticus* (Linnaeus, 1758)

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ABSTRACT

The effect of nutrient status of soil on carcass quality of fish raised in earthen ponds was investigated between March and August 2016. Three soil profile pits were dug side by side three existing earthen ponds in three different geomorphological locations of Imo State at Umuagwo, Ulakwo and Uboma. Three homogenous soil horizons (0-20, 20-60, 60-150 cm) were identified and evaluated for nutrient composition by standard methods (USDA, 1971). Ten adults of O*reochromisniloticus* of average weight of 250.0 ± 5.4g randomly selected from the associated earthen ponds were chemically evaluated for carcass composition in accordance with AOAC (2005). Soil textural class for the pond at Umuagwo was dominantly sandy, sandy loam at Ulakwo and clay loam at Uboma. Soil nutrient analysis showed that the sandy soil was grossly poor in total nitrogen (0.04 – 0.08) and soil exchangeable bases, K (0.01 - 0.04%), Na (0.003-0.005%) as against the clay soil which had appreciably higher reserve of total nitrogen (0.21-0.32%), organic carbon (1.22-2.50%) and exchangeable bases, K (0.06-0.18%), and Na (0.020.09%). Nutrient composition of fish carcass from the clay pond in terms of two most important nutritive factors of crude protein (32.1 ± 3.0%) and fat (6.36 ± 0.1%) was significantly higher (P< 0.05) than in the sandy pond (14.7± 2.0%), 4.4. ± 0.5%) and the sandy loam (14.9 ± 25 %, 4.7 ± 0.2 %) respectively. The implication of this in site selection of earthen ponds is discussed.

Key words: Soil nutrient, carcass quality, *Oreochromisniloticus.*

INTRODUCTION

The value of any food product, including fish is a function of it's nutritive properties, evaluated in terms of health promoting factors such as crude protein content, lipid, vitamins, minerals and other valuable substances present (Novikov, 1983, Njoku, 2015). The awareness of the unique nature of fish nutrients in human diets and health management has tremendously increased in recent times, resulting in an unprecedented demand for fish in preference to other sources of animal protein. Fish is now a dietary delicacy and preferred menu in households and all important occasions as well as for patients on special diets.

It is speculated (Njoku, 2004) that the quality of dietary nutrient in pond-raised fish may be related to the nutrient status of the environment in which the fish was cultured, including the water and the underlying soil conditions. Consequently the study seeks to investigate the effect of soil nutrients status on carcass quality of *Oreochromisniloticus* raised in earthen ponds in Imo state. It is believed that the study will contribute to innovations in modeling the aquatic ecosystem and the design of modern aquatic productive systems. Quantification of proximate composition of fish carcass is also a requirement in aquatic food regulation and commercial specifications in global trade (Waterman, 2000).

MATERIALS AND METHOD

A. SELECTION OF FISH PONDS AND EXPERIEMENTAL DESIGN

Three existing earthen fish ponds were selected for the trial at Umuagwo in Ohaji-Egbema LGA, Ulakwo in NgorOkpala LGA and Uboma in Ihitte-Uboma LGA of Imo state. Each pond measured approximately 30m x 25m x 1.5m (750m^2) and stocked with 7,500 fingerlings of tilapia (O*reochromisniloticus)* of mean body weight of 15.0 ± 0.8 grams at the rate of 10 fingerlings/m^2 . The fish were fed with commercial feed concentrates at 5% body weight divided into two feeding regimes of mornings (0600 hours) and evenings (18000 hours) and six days in the week. The trial was designed as a completely randomized experiment (CRD) with three replications. The mathematical model (Njoku*et al*. 1998) is as follows:

CRD: xij = M + Ti + Eij
Where xij = value of independent observation
M = Unknown population variable
Ti = Treatment effect
Eij = error term

B. SOIL PROFILE PIT SELECTION AND SOIL CHEMICAL (NUTRIENT) ANALYSIS

In each of the pond locations at Umuagwo, Ulakwo and Uboma, a soil profile pit was dug. Each pit measured 1m x 1m x 1.5m deep. The depth was chosen in line with the maximum permissible depth of fish ponds as 1.5 meters (Njoku, 2000). The colour of the various soil horizons in the soil profile was qualitatively determined on exposure by visual method and by use of colour chart (FAO, 1977). Thereafter soil samples were collected in triplicates from each of the homogenous horizons for separate analysis.

LABORATORY ANALYSIS

(i) Soil moisture

Moisture content of the soil was estimated by gravimetric method (Singer & Mum, 1996). Known weight of the soil sample was collected in Petri dish, dried to constant weight in an oven at a temperature of 105^{0}C and reweighed. Moisture content (%)was computed thus:

Soil moisture content (%) $= \left(\frac{Wb - Wc}{Wb - Wa} \times \frac{100}{1} \right)$

Where Wa = Weight of empty dish
Wb = Weight of dish + wet sample before oven drying
Wc = Weight of dish + dried sample.

ii. Soil particle size analysis and textural class determination

Standard method was adopted in soil particle size analysis using sodium hexametaphosphate as dispersant after treating the sample with hydrogen peroxide to remove the organic matter (Singer & Mum, 1996, Barnabas &Nwaka 2014). Thereafter the soil textural classes were determined using the soil textural triangle.

iii. Soil Chemical (Nutrient) analysis

Soil chemical analysis was carried out in accordance with standard analytical methods by USDA (1971), Udoh&Lekwa (2014). Organic carbon was determined by the acid dichromate digestion method, total nitrogen by micro Kjeldahl digestion and ammonia distillation method. Exchangeable bases (saturated extract) of calcium (Ca) and Magnesium, (Mg) by the EDTA titrimetric method (Cheng and Bray, 1951) and atomic absorption spectrophotometer, while sodium (Na) and Potassium (K) were extracted using the flame photometric method. Total phosphorus (P) was by perchloric acid digestion method (Jackson, 1956). Cation exchange capacity (CEC) was estimated by the centrifugation method using ammonium acetate (NH_4OAc, PH 7.0), Sodium acetate (NaOAc, pH8.2) and potassium acetate (KOAc, pH 7.0). Base saturation (B.S) were then estimated by dividing the sum of the extracted bases by the base exchange capacity.

C. Proximate Composition Analysis of Fish Carcass

After six months of culture, 10 adult fish, with average weight of 250.0 $\pm$ 5.4g were randomly selected from each of the earthen ponds at Umuagwo, Ulakwo and Uboma and processed for carcass analysis at the Fisheries Wet Laboratory, Federal University of Technology Owerri. Samples were analyzed chemically in accordance with the methods of Official Analytical chemists (AOAC, 2005). Nutrients evaluated include crude protein, crude fat, ash, fibre, moisture, free nitrogen extract (NFE) and caloric value.

Moisture content was determined using the oven dry method, ash by muffle furnace method, crude fibre by the reflux method, crude fat by the soxhlet extraction technique and crude protein by the micro Kjeldahl apparatus. The various parameters were estimated as follows:

i. **Carcass Moistures content** (%) = $\frac{Wb - Wc}{Wb - Wa} \times \frac{100}{1}$

Where

Wa = Weight of weighting bottle only
Wb = Weight of weighing bottle + sample before drying
Wc = Weight of weighing bottle + sample after drying

ii. **Ash content (%)**= $\frac{Wc-Wa}{Wb - Wa} \times \frac{100}{1}$

Where
Wa = Weight of empty crucible
Wb = Weight of Crucible + sample before ashing
Wc = Weight of crucible + sample after ashing

iii. **Crude fibre (%)**= $\frac{W_2 - W_1}{\text{Weight of original sample}} \times \frac{100}{1}$

Where W_1 = Weight of empty crucible
W_2 = Weight of crucible and it's contents after incineration

iv. **Crude fat (%)** = $\frac{W_2 - W_1}{\text{Weight of original sample}} \times \frac{100}{1}$

Where W_1 = Weight of empty beaker only
W_2 = Weight of beaker + ether extract.

v. **Crude protein**

The crude protein was obtained by multiplying the % Nitrogen content by a constant factor of 6.25, where the % Nitrogen is estimated thus:

$$\% N = \frac{(T-B) \times \text{Normility} \times \text{atomic mass} \times \text{vol} \times 100}{\text{Weight of original sample}}$$

Where
T = Titre value of sample
N = Normality of Hcl used
Atomic= Factor for atomic mass of Nitrogen
Vol = volume of digest

vi. **Nitrogen free extract (NFE)** was determined by subtracting the sum of (% moisture + % C.P + % crude fat + % crude fibre + % ash) from 100.

NFE (%) = 100 – (% M + % C.P + % C.F + % ash + % E E)

vii. **Caloric Value (Energy)**

The caloric value (Kcal) was obtained by multiplying the value of the C.P, EE and NFE by 4,9 and 4 respectively as the sum of the product.

i.e Caloric value (Kcal/100g) = (C.P x 4) + EE x 9) + (CHO or NFE x 4)

STATISTICAL METHOD

Data resulting from the completely randomized trial (CRD) was analyzed with one way analysis of variance (ANOVA) as described by Steel and Torrie (1980), and Njoku*et al* (1998). Significant differences in mean values of parameters were separated using the Duncan's Multiple Range test (Duncan, 1955). This statistical analysis employed the Computer Statistical Package for Social Science (SPSS), version 19, window 8.

RESULTS

SOIL TEXTURAL PROPERTY

Tables 1 -3 show the particle size distribution of the soil profiles developed at Umuagwo (recent alluvium), Ulakwo (coasted plain sands) and Uboma (sand stone and marine shale) respectively. The result shows that while the soil at Umuagwo (table 1) is dominantly sandy, (sand: 94.4-95%, silt: 0.4 – 0.6% and clay 4.9 – 5.2%) in two out of 3 soil horizons, the soil at Ulakwo (table 2) was dominantly sandy loam (sand: 60.5-65.0%, Silt: 15.5-18.0% and clay: 19.5 – 21.5%) in two out of the three soil horizons. The soil at Uboma (table 3) was dominantly clay loam in two of the three horizons (sand: 25.5 -47.8%, silt: 24-26.5%, clay: 28.8-45.0%). The third horizon was clay (sand fraction: 22.0%, silt: 14.0% and clay: 64.0%).

Table 1: Particle size distribution of soil profile developed at Umuagwo, Imo State (recent alluvium)

Soil Particle size %				
Soil depth (Cm)	Sand	Silt	Clay	Soil texture
0 – 20	95.0	0.6	4.9	Sandy
20 – 60	94.	0.4	5.2	Sandy
60 – 150	50.0	34.0	20.0	Sandy Loam

Table 2: Particle size distribution of soil profile developed at Ulakwo Imo state (coastal plain sands)

Soil Particle size (%)				
Soil depth (Cm)	Sand	Silt	Clay	Soil texture
0 – 20	80.7	14.5	4.8	Sandy
20 – 60	65.0	15.5	19.5	Sandy Loam
60 – 150	60.5	18.0	21.5	Sandy Loam

Table 3: Particle size distribution of soil profile developed of Uboma, Imo State (sand stone and marine shales)

Soil particle size (%)				
Soil depth (Cm)	Sand	Silt	Clay	Soil texture
0 – 20	47.8	24.o	28.8	Clay Loam
20 – 60	28.5.	26.5	45.0	Clay loam
60 – 150	22.0	14.0	64.0	Clay

SOIL NUTRIENT (CHEMICAL) COMPOSITION

Tables 4-6 summarize the nutrient status of the three different geomorphological soils at Umuagwo, Ulakwo and uboma.

The result (table 4) shows that the sandy soil at Umuagwo is strongly acidic with pH ranging from 4.0-4.5). The organic carbon content (C.O) was low (0.4 - 0.6%) as well as total nitrogen (0.04 - 0.08%). The soil is generally poor, especially in exchangeable bases (Ca, Mg, K and Na).

Table 5 shows the nutrient profile of the coastal plain soil at Ulakwo. The soil is also strongly acidic, though organic carbon content was medium. Ttotal nitrogen (0.06 – 0.08%) and potassium (0.04-0.06 Me/100g) were also low. Exchangeable Ca, Mg and Na were also low. For the soil at Uboma (table 6), the soil was also strongly acidic (4.5 – 5.0) but medium in organic carbon (0.22 – 0.50%). It was also reasonably high in total nitrogen (0.21 – 0.32%) and exchangeable bases, K (0.06 – 0.18 me/100g). In all the three soil types, base saturation (B.S) and the exchangeable cation exchange capacity (CEC) were generally high and same.

Table 4: Chemical analysis of the recent alluvial soil from soil profile developed at Umuagwo, Imo state

Soil Depth (CM)	PH	O.C (%)	Total Nitrogen (%)	Bray 2.0 (PPM)	Exch.Bases (Me/100g) (Me/100g) Ca	Mg	K	Na	Ea	ECEC	B.S (%)
0-20	4.5	0.6	0.08	8.0	1.40	1.50	0.04	0.005	2.5	5.0	56.0
20-60	4.3	0.5	0.06	10.8	1.35	1.60	0.04	0.05	2.0	4.5	45.0
60-150	4.0	0.4	0.04	15.0	1.45	0.05	0.01	0.003	1.9	2.0	50.0

OC = organic carbon

Table 5: Chemical analysis of the coastal plain soils from the soil profile developed at Ulakwo, Imo state

Soil Depth (CM)	PH	O.C (%)	Total Nitrogen (%)	Bray 2.0 (PPM)	Exch. Bases (Me/100g) CaMg		K	Na	E,A (Me/100kg	ECEC	B.S (%)
0-20	5.3	2.0	0.08	30.0	1.60	0.55	0.6	0.01	1.50	3.05	63.20
20-60	5.2	1.50	0.06	28.5	1.45	0.34	0.04	0.07	1.75	2.80	55.0
60-150	4.4	1.8	0.06	30.6	0.50	0.30	0.04	0.05	1.60	2.20	52.8

Table 6: Chemical analysis of the soils formed from marine sand stones and shells from the soil profile developed at Uboma, Imo state

Soil Depth (CM)	PH	O.C (%)	Total Nitrogen (%)	Bray 2.0 (ppm)	Exch. Bases (Me/100g) Ca	Mg	K (Me/100kg	Na	E,A (%)	ECEC	B.S
0-20	4.8	1.22	0.32	6.50	1.14	0.75	0.18	0.02	2.1	3.9	45.0
20-60	4.5	1.56	0.45	3.45	1.50	0.60	0.14	0.005	3.0	4.6	35.0
60-150	5.0	2.50	0.21	2.15	0.16	0.05	0.06	0.009	2.8	3.8	18.0

NUTRIENT COMPOSITIONS OF FISH CARCASS

Tables 7-9 present the proximate composition of fish carcass from the three different geomorphological soils of Imo state. Crude protein and fat were (14.2 ± 0.8% and 12.3 ± 1.2%), for the fish from sandy pond (Fig 7), (18.1± 1.0% and 11.1 ± 0.2%) for the sandy loam (Table 8) and (27.6 ± 2.0% and 18.2 ± 0.8%) for fish from the clay loam ponds (Table 9). Mean value of the nutrients varied between the three geomorphological fish ponds. Mean moisture content (85.5 ± 4.0%, 76.10 ± 4.5% and 69.2 ± 5.5%) respectively for the sandy,. Sandy loam and clay loam ponds as well as the caloric value (157.7 ± 5.8 Kcal/100g, 194.3 ± 6.5 Kcal/100g and 362 ± 8.5 Kcal/100g also varied in fish from the different ponds. In all the parameters, the fish reared in clay soils were appreciably higher in nutrients than others. It was also observed that as fat content of the fish carcass increased, the caloric value also increased while moisture content reduced in all the specimens.

Table 7: Carcass composition of pond-raised Tilapia (*O. niloticus*) in sandy soil at Umuagwo (resent alluvium)

	Nutrient Composition (%)						
Sample	C.P (N x 6.25)	Lipid	Fibre	Ash	Moisture	NFE	Caloric value (Kcal/100g
1	15.0	13.0	0.85	85.0	86.5	6.50	82.5
2	12.8	10.5	0.80	80.5	84.8	5.50	80.3
3.	14.8	12.5	0.80	85.0	80.0	6.00	85.0
Mean ($\overline{X}$±SE)	14.2 ±0.8	12.3 ± 1.2	0.77 ± 0.02	0.70 ± 0.03	83.5 ± 5.05	6.00 ± 0.15	82.60 ± 5.5

Note: 1 kilocalorie (Kcal)= the quantity of heat required to charge the temperature of 1 litre of water by 1^{0}C.

Table 8: Carcass composition of pond-raise Tilapia. (O. *niloticus*) in sandy loam soil at Ulakwo (coastal plain sand)

	Nutrient (%)						
Sample	C.P	Lipid	Fibre	Ash	Moisture	NFE	Caloric value (Kcal/100g
1	18.5	12.5	0.75	0.60	75.8	4.5	158.0
2	17.6	10.8	0.75	0.55	80.5	5.0	250.0
3.	18.0	11.0	0.80	0.50	72.0	5.5	195.0
Mean ($\overline{X}$±SE)	18.1 ±1.0	11.1 ± 0.2	0.77 ± 0.05	0.55 ± 0.04	76.10 ± 4.5	5.0 ± 0.5	194.3 ± 6.5

Table 9: Carcass composition of pond raised tilapia (*0.niloticus*) in Clay soils at Uboma (sand stone and marine shale)

Sample	Nutrient (%) C.P	Lipid	Fibre	Ash	Moisture	NFE	Caloric value (Kcal/100g
1	26.8	16.0	0.65	0.56	70.5	5.0	365.0
2	28.5	18.5	0.70	0.65	72.0	4.6	378.0
3.	27.5	20.0	0.75	0.60	65.0	4.5	345.0
Mean ($\overline{X}\pm$SE)	27.6 $\pm$ 2.0	18.2 $\pm$ 0.6	0.70 $\pm$ 0.03	0.60 $\pm$ 0.05	69.2 $\pm$ 5.5	4.7 $\pm$ 0.5	362 $\pm$ 8.5

COMPARISON OF THE PROXIMATE COMPOSITION OF FISH CARCASS FROM EARTHEN PONDS OF DIFFERENT SOIL TEXTURAL PROPERTY

Nutrient composition of *Clariasgariepinus* raised in soils of different textural classes was compared in table 10. The result showed that whereas fish nutrients varied between the three different ponds, crude protein (27.6 $\pm$ 2.0%), crude fat (18.2 $\pm$ 2.0% and the caloric value (362.0 $\pm$ 8.5 Kcal/100g) observed in the tissue of fish raised in the clay soil were significantly higher ($P < 0.05$) than those of other ponds.

DISCUSSION

The result shows that soils rich in clay have good reserves of total nitrogen and available phosphorus compared to sandy and sandy loam soils. This may be attributed to the differences in their parent materials. According to Ohiri and Ano (1992), sandy soils have multi nutritional problems due to the quartz sand as the parent material while clay loam soils with sandstones and marine shales as parent materials are usually high in available phosphorus, total nitrogen and potassium. Novikov (1983) explains that aquatic plants and animals need nitrogen compound in the form of nitrate ions (NO^-_3) and ammonium ion (NH_4^+) to form protein and other important molecules like DNA and Vitamins in the body tissue. Mineral compounds of phosphorus (P) extracted from the underlying soil occur in water (fish pond) as orthophosphate ($P0^{3-}_4$) ions and utilized by aquatic plants (algae and fungi) and considered as a limiting factor for primary production and fish yield in ponds (De Vere, 1996). Those polyphosphates and nitrogenous compounds derived from soil phosphorus and total nitrogen undergo series of continuous conversions in aquatic ecosystem to form nucleotides (nucleic acid) which are present in living cells of fish as deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) (Njoku 2014). Nitrogen found in soil, through the process of nitrification (nitrogen fixation) is converted to mineral (organic) compounds of nitrogen by aquatic plants (blue-green algae and some fungi). They occur in water as ions of ammonia (NH_4^+), and nitrate (NH_3^-). Green plants take up the inorganic forms of Nitrogen (NH_3 and $N0_3$) during assimilation and reduce them to ammonia and finally to aspartic and glutamic acids as precursors in protein formation in fish. The foregoing seem to explain the positive relationship which exists between soils of high inorganic nutrient (total nitrogen, available phosphorus and exchangeable bases), and nutrient status of fish carcass from the difference earthen ponds. Another pertinent observation is that as the fat content of the fish increased, the moisture content declined. This is in agreement with the observations of Novikov (1983) that the greater the quantity of fat in fish flesh, the smaller the quantity of water and vice versa. Similarly, it was observed that the higher the lipid (fat) content of the fish the higher the caloric value of the fish. Novikov (1983) is of the view that fish fat which is rich in phosphorus, particularly adenosine tri-phosphate has high energy equivalents than other nutrient parameters in fish, adding that in the course of assimilation, 1gram of protein releases 4.1 calories of heat, carbohydrate 4.1 and fat as much as 9.3 calories per gram.

Table 10: comparison of proximate composition of fish carcass raised in earthen ponds with soils of different textural properties

Soil/Pond Location	Nutrient Parameter of fish ($\bar{X}$ ± SE)						
	C.P (%)	FAT (%)	Ash (%)	Moisture (%)	Fibre (%)	NFE (%)	Caloric Value (Kcal/100g)
Umuagwo (Sandy soil)	14.72 ± 0.8[a]	12.3 ± 1.2[a]	0.77 ± 0.02[a]	83.5 ± 4.0[a]	0.81 ± 0.01[a]	4.9 ± 0.1[a]	181.7 ± 5.8[a]
Ulakwo (Sandy loam)	18.1 ± 1.0[b]	11.1 ± 0.2[a]	0.55 ± 0.04[b]	76.10 ± 4.5[b]	0.77 ± 0.05[a]	5.0 ± 0.5[a]	194.3 ± 6.5[a]
Uboma (Clay Loam-Clay)	27.6 ± 2.0[c]	18.2 ± 0.8[b]	0.60 ± 0.03	60.2 ± 5.5[bc]	0.70 ± 0.03[b]	4.7 ± 0.5[a]	363 ± 8.5[c]

abc: mean values in the same column with different super scripts are significantly different at F = 0.05

SE = Standard Erro

CONCLUSION

It would seem that clay soil, which is rich in inorganic nutrients is positively related to the dietary quality of cultured *Oreochromisniloticus* in earthen ponds. This is an important consideration in site selection of fish ponds.

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