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Potentials of sweet potatoes (*Ipomea Batatas*) as a mineral and growth supplement in diets of hybrid catfish (*Heteroclarias*) fingerlings

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Abstract

The experiment was carried out at the Federal University of Technology, Akure, Nigeria from April - September, 2015. Six iso-nitrogenous (35% crude protein) diets were fed to triplicate groups of *Heteroclarias* (2.42±0.16 g) for 56 days in glass aquaria at a stocking rate of 10 fish/tank. Result revealed significant differences ($p < 0.05$) in mineral components and growth performance indices analyzed. Whole fish body had sodium (26.10–38.34 mg/kg), calcium (43.90 – 53.20), potassium (47.80–70.00), magnesium (5.61–6.24), zinc (0.30–0.96), iron (0.79–1.00), copper (0.06–0.13) and phosphorus (135–229), sulphur (1.02–4.91) with the highest recorded in SP4, SP3, SP2, SP1, SP4, SP4, SP5, SP2 and SP2 respectively. Culture water parameters (dissolved oxygen, temperature and pH) were within range values for culturing tropical aquaculture fish species. Result showed that incorporating sweet potatoes meal into hybrid catfish diets improved carcass mineral composition and did not affect water parameters negatively.

Keywords: Sweet potatoes, mineral, supplement, *Heteroclarias*

Introduction

Fish is a good source of protein, fatty acids, vitamins, minerals and essential micronutrients [1]. It is no longer news that fish from the wild is on the decline while aquaculture production supplies nearly 50 percent (63 million tonnes) of fish consumed globally [2]. As such, fish farmers will need additional 50 million tonnes to bridge the demand and supply gap by 2030 [3]. Sweet potatoes (yellow and red variants) are starchy roots widely cultivated in the tropical and sub-tropical regions of the world [4, 5]. Fresh sweet potatoes contain 70-80%, they are low in protein, crude fibre and fat, but are rich sources of energy. The available protein content has high biological value, rich in essential amino acid [6]. It has a highly digestible carbohydrate when cooked and much of the starch is transformed to maltose during heat cooking application. Its tuber is rich in carotene and ascorbic acid (especially yellow varieties) and B-vitamin [7]. It has fair amount of ash and minerals e.g. phosphorus, calcium sodium, chloride and potassium.

The desire of fish farmers is to produce table sized fish within the shortest possible time. Long term success in meeting this goal and having an all-year round supply of fish, depends on the ability of the farmer to control the entire life cycle of the fish [8, 9]. This desire is met by two popular cat fishes of the genera *Clarias* and *Heterobranchus*. *Clarias gariepinus* occupies a unique and prominent position in the commercial fisheries in Nigeria because it is tasty, hardy, has the ability to tolerate poor water quality conditions [10]. In Africa, especially Nigeria; the species mostly cultured are *Clarias gariepinus*, *Heterobranchus* species and their hybrids. *Heteroclarias* is a hybrid of fertilized oocytes collected from *Heterobranchus bidorsalis* females and milt from *Clarias gariepinus* [11]. The resulting fry usually shows improved growth compared to the parental species. This hybrid is reported to exhibit aggressive behaviour and large variations in body weight, this makes them prone to poor survival rates in grow-out ponds [12]. This hybrid fish species exhibits traits such as hardiness, high yield potential, high fecundity, high market value, air breathing characteristics, fast growth rate, disease resistance etc. [13]. For artificial feed to be deemed successful in fish culture, it must meet the requirements for survival and growth of the fish and consequently, contain approximate combinations of nutrients which are effectively and efficiently utilized [14]. Maize holds a very important place in fish nutrition as it is the major and about the cheapest

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energy and carbohydrate source in most farm-made and commercial fish feed. It has been used extensively in fish feeding because of its palatability, high energy value and cheap price ^[15]. Maize has faced stiff competition between man and animal because of its various uses especially in the developing countries coupled with increasing population ^[16]. As a result of this, there is the need for farmers to find a suitable replacement to the use of maize in aqua feed. Previous studies have demonstrated the use of sweet potatoes peels and leaves as supplements fish diets. However, there is a limited work on the use of the sweet potatoes tuber meal in aqua feed. Hence, this study was carried out to determine the mineral composition in the body of *Heteroclaris* fed sweet potato meal supplemented diets.

Materials and methods

Study Area

The study was carried out at the Federal University of Technology, Akure, Ondo State, South-Western Nigeria. The experimental period was between the months of April and September 2015. The feeding trial took place at the wet laboratory situated on the Fisheries and Aquaculture Technology Teaching and Research farm of the University while the experimental analysis was done at the Central Research laboratory.

Preparation of experimental feed

Sweet potato (*Ipomoea batatas*) tubers were purchased from the local market; Oja-Oba in Akure Metropolis, Ondo State, Nigeria. Tubers were washed thoroughly with water, sliced into flakes, soaked in water for three days to allow fermentation in order to get rid of the anti-nutrients (cyanic, phytic and oxalic acids). After three days, the already fermented tubers were removed from water, washed with clean and fresh water, then sundried for 72 hours at temperatures of 27 – 30 °C. The dried potato flakes were later milled into powder (less than 20 µg) to form sweet potato meal. This was later used in combination with other feed ingredients such as fish meal, soybean meal, yellow maize, vegetable oil, wheat offal (binder) and vitamin premix acquired from Keto Feed Mill, Akure, Ondo State, Nigeria. Six iso-nitrogenous diets of 35% crude protein level was formulated with varying inclusion levels of sweet potatoes replacing yellow maize at 0, 20, 40, 60, 80 and 100% while diets were designated as SP₁, SP₂, SP₃, SP₄, SP₅ and SP₆ (Table 1). Ingredients were thoroughly mixed using wheat offal as a binder by the addition of 250 ml of boiled water (100°C) to aid gelatinization. The homogenous dough obtained was pelleted through die 2mm using Hobart Pelleting Machine, (Model A 200, CA, USA). Pellets were sundried for 120 hours to a moisture content (<10%) and packed in airtight polyethylene bags and refrigerated prior to use.

Eighteen plastic tanks of 50 litres water capacity were used for the study. Tanks were filled to 30 litres level with water supply from the University's Water Station. The tanks were partially drained once in two days to remove faeces and uneaten feeds, while complete draining was done once a week to ensure good water quality. The experimental set up was triplicate.

Fingerlings of experimental *Heteroclaris* (2.42±0.16) g fish species were purchased from IGRO fish farm, Oshogbo, Osun State, South-Western Nigeria. Fish were stocked at a density of 10 *Heteroclaris* per tank and acclimated to laboratory

condition for 7 days. Fish were fed to satiation twice daily between 8:00-9:00 GMT and 16:00-17:00 GMT for 56 days.

Analyses

At the end of the experiment, fish samples were collected from each treatment and taken to the laboratory for proximate according to ^[17]. Minerals compositions were determined after triple acid digestion according to standard procedures described by ^[18] using atomic absorption spectrophotometer (Model 200, Germany).

Statistical analysis

All data generated were subjected to one-way ANOVA to determine any significant relationship between varying inclusion levels of sweet potato meal diet of *Heteroclaris*. Where significant differences were detected among treatments, separation was done using Duncan's Multiple Range post-hoc Test ^[19]. All data were analyzed using the general linear model function of Statistical Package for Social Science (SPSS), version 21.0.

Results

In all the experimental diets (SP₁ – SP₆), moisture content was between 7.41 and 7.73% with SP₁ having the highest value and SP₆ having the lowest. The protein content was within a uniform range of 34.61-34.69% while the highest and lowest fat contents were obtained in SP₁ and SP₆ but for nitrogen free extract (NFE), the reverse was the case. The highest value for ash was obtained in SP₅ and the lowest in SP₆. Proximate compositions of fish samples were also carried out while culture water was monitored for dissolved oxygen (DO₂), temperature (T) and hydrogen ion concentration (pH). There were significant differences in mineral composition of the fish fed diets (SP₁ – SP₆) i.e. ($p > 0.05$). From the result, SP₄ showed the highest values in sodium, zinc and iron contents; 38.34±0.42, 0.96±0.04 and 1.00±0.69 respectively. For magnesium the highest value was observed in SP₁ which is the control. Treatment 2 (SP₂) had the highest values in phosphorus and potassium as 229.0±0.00 and 70.50±0.53 respectively while their lowest occurred in SP₄ with 135.0±0.62 and 45.50±0.47. Copper was highest in SP₅ (0.13±0.02) and calcium in SP₃ with 53.20±0.16, sulphur in SP₆ with 34.40±0.60. Chlorine was completely absent except in SP₆.

Discussion

The study showed an increase in the mineral compositions of *Heteroclaris* fed sweet potatoes meal supplemented diets. There was a general increase in sodium, zinc and iron contents in *Heteroclaris* fed sweet potatoes meal supplemented diets, with the highest composition recorded in fish fed diet (SP₄). The recommended compositions by ^[20] were (0.1 – 0.3% for sodium, 50 – 100 mg / kg for zinc and 30 - 100 mg / kg for iron). Sodium, in its ionic form (Na⁺) is responsible for the maintenance of extra-cellular equilibrium and gastric digestion ^[21]. Absorption of dissolved zinc occurs in the gills and it serves as a co-factor in different enzymatic systems involved in the utilization of almost all the nutrients. In this study, zinc composition in *Heteroclaris* was a little lower than the recommendations of ^[22] of 15 – 30 mg/kg and this could be made up by supplementation. Zinc deficiency in fish leads to dwarfism, cataract and reduced growth ^[21]. The result obtained for iron concentration in this study is in agreement with what was reported by ^[23] that iron

requirement in fish ranges between 30 – 150 mg/kg. Iron is important for the synthesis of haemoglobin and its deficiency results in microcytic hypochromic anaemia, with a decrease in haematocrit ^[24]. Therefore, it can be inferred from this study that to obtain a maximum increase in sodium, zinc and iron levels based on ^[20] recommendation, 60% sweet potato meal and 40% yellow maize could be incorporated into the diets of *Heteroclaris* while the deficit could be made up using additives. In this study, the level of potassium in was highest in *Heteroclaris* fed sweet potatoes supplemented diets at 40% (diet SP₃) supplementation level. According to ^[21] quantitative requirements for most fresh water fish species is between 0.3 and 1.2% and the result obtained in this study was far above this assertion. The above mentioned mineral content obtained in this study was in line with the recommendations by ^[20] in fish diets. Potassium ion is responsible for the maintenance of intracellular fluid and its deficiency leads to anorexia, tetanus and convulsions which can result in massive mortalities ^[25]. From this study, it can be affirmed that maximum increase in potassium can best be achieved when *Heteroclaris* diet is supplemented with 20% sweet potato meal and 80% yellow maize. In this study, calcium one of the macro nutrients was highest in *Heteroclaris* fed diet (SP₃) showing a high calcium content of about 53% when compared with the control. This corroborates the assertions of ^[26] that the dominant quantity of calcium is domicile in the skeleton (30%) and scales (80%) of bony fish. Furthermore, he reported that when fishes are famished, these structures provide a pool of calcium for reabsorption into the body system for normal metabolic activities. Calcium is responsible for blood clotting and other physiological processes including metabolism, nerve and muscle function and osmoregulation ^[1]. Phosphorous, a major mineral like calcium was found to be highest in sweet potato meal supplemented diet at 20% level. Higher concentration of phosphorous is also found in the bones and scales of fish and is responsible for metabolic functions ^[26]. This study recorded a higher proportion of phosphorus in *Heteroclaris* body above the recommended requirement of 0.2 – 0.8% as reported by ^[21]. Phosphorus deficiency leads to a decrease in skeletal and body growth, excess lipid deposition and increase in gluconeogenesis enzymes ^[21]. Copper (though a trace mineral is of great importance in the productivity of culture waters) was dominant in *Heteroclaris* fed treatment five (SP₅) compared to other diets, control inclusive. Copper is an important component of a number of metallo-enzymes responsible for a wide variety of metabolic processes ^[1]. Copper facilitates the absorption of other trace elements such as iron and zinc. Although, the quantity of copper obtained in this study is below the recommendation of ^[24] of 3 – 5 mg/kg, this could be supplemented with the synthetic sources. The deficiency of copper in fish includes reduction in growth, cataract and sensitivity to infection (Guillaume *et al*, 2001). This study revealed a significant difference ($p < 0.05$) in the sulphur contents of *Heteroclaris* fed the control diet (3.39 ± 0.46 mg / kg) and test diets, especially SP₆ (34.40 ± 0.60 mg / kg). Although, sulphur is a trace element it is required in the synthesis of cysteine, a non-essential amino acid which is one of the building blocks of protein ^[1]. From this study, total supplementation of yellow maize (100% sweet potato meal) is recommended for maximum increase in the sulphur content of *Heteroclaris*.

Chlorine was not present in *Heteroclaris* fed the control and test diets except treatment six (SP₆) that showed some traces

of chlorine (0.001). Chlorine ion is of vital importance in gastric digestion ^[21] and it is often in combination with sodium ion forming sodium chloride. It has been reported that the aquatic environment is generally rich in sodium and chlorine ions, as such; a “dietary” has not been demonstrated ^[22]. The study also revealed that treatment four (SP₄) consistently increased in most of the mineral elements but SP₆ can be seen to have the optimum values when both were compared. Therefore, total replacement of yellow maize with sweet potato meal would give an optimum increase in the mineral composition of *Heteroclaris*. The mineral requirements of fish as given by ^[20] when compared to the results obtained in this study revealed that incorporating sweet potato tuber meal into fish diets could boost body mineral composition of fish.

The result of the proximate analysis of sweet potato meal shows that the crude protein, fibre, moisture and ash are similar to the report of ^[27]. The proximate compositions of the diets used in this experiment were within the acceptable range. Protein requirement for tropical catfish is estimated to be between 35 and 40% ^[28] and the crude protein content of the diet was within this range i.e. 34.60 - 34.69%. ^[1] deduced that fibre contents level in fish diets is not desirable when more than 12%, as increased fibre content leads to decreased quality of nutrients in diet resulting to low digestibility in fish. The analyzed crude fibre content for all the diets were within the required limit for fish i.e. 5.91-6.51%. The observed lipid values for the analyzed diets were in line with that of ^[29] who reported that 10-20% of lipid in most fresh water fish diets gives optimal growth without producing an excessively fatty carcass. The result of the proximate composition of experimental diets was in line with the report of ^[30] that incorporated sweet potatoes in the diet of poultry. The culture water quality parameters (temperature 26.6-26.9 °C, pH 6.96-6.98 and dissolved oxygen 6.53-6.67 mg / l) were within a tolerant limit for the culture of tropical fishes *Heteroclaris* inclusive. Optimum levels of these parameters are required for optimum growth, survival and health of the fish. Dissolved oxygen value below 4 mg / l begins to stress fishes and pH of less than 4 leads to mortality in fish due to its corrosive effect and such acidic water reduces the appetites of fish which in turn reduces their growth rate. At pH of 9, water becomes unproductive because carbon dioxide becomes unavailable in such water and at pH 11, fish dies ^[31]. The water quality parameters for the study were within the acceptable range. Good growth, health and production of commercial fish and other aquatic animals primarily depend on adequate supply of nutrients, both in terms of quantity and quality, irrespective of the culture system in which they are grown. In aquaculture, complete feeds with the required nutrients in appropriate proportions should be made available to the animal for optimal growth. Generally, there is a poor understanding of dietary mineral requirement in fish due to the challenges of devising mineral deficient diets and need to deplete tissue mineral stores ^[1].

Conclusion

Poor nutrition can affect the well-being of the animal, thus, predisposing it to susceptible and opportunistic infections by various disease-causing agents. It can be inferred from the result that total replacement of maize with sweet potato did not give the highest mineral content in all cases. However, this can be complemented with the synthetic sources of these nutrients to make up for the limitations. The result of this

study showed that potassium, phosphorus and Sulphur were best at 20% supplementation level, calcium at 40%, sodium, zinc and iron at 60%, copper at 80% and chlorine at 100% supplementation level. A total replacement (100%) of maize with sweet potato is recommended as sweet potatoes tuber meal will reduce cost of fish feed, but an insight into its growth performance potential would be necessary to corroborate this suggestion. *Heteroclaris* production should

be encouraged by educating the local fish farmers on the economic benefits of the species. Incorporating sweet potatoes meal into the diets of *Heteroclaris* fingerlings had no deleterious effect on the water quality of culture water as they were within the range required for the culture of tropical fishes. The cultivation of sweet potatoes should also be encouraged in order to reduce competition between man and animals for conventional feed stuffs such as maize.

Table 1: Gross Composition of Experimental Diet (g / 100g).

Ingredients	SP ₁ (control)	SP ₂	SP ₃	SP ₄	SP ₅	SP ₆
Yellow Maize	36.74	29.39	22.04	14.70	7.35	0.00
Sweet potato	0.00	7.35	14.70	22.04	29.39	36.74
Fishmeal	26.63	26.63	26.63	26.63	26.63	26.63
Soyabean meal	26.63	26.63	26.63	26.63	26.63	26.63
Vit./mineral premix	3.00	3.00	3.00	3.00	3.00	3.00
Veg. oil	4.00	4.00	4.00	4.00	4.00	4.00
Wheat offal (binder)	3.00	3.00	3.00	3.00	3.00	3.00

Where; SP₁: Control diet, 0% sweet potato and 100% maize supplement;

SP₂: 20% sweet potato and 80% maize supplement;

SP₃: 40% sweet potato and 60% maize supplement;

SP₄: 60% sweet potato and 40% maize supplement;

SP₅: 80% sweet potato and 20% maize supplement; and

SP₆: 100% sweet potato and 0% maize supplement.

Table 2: Composition (%) of Experimental Diets (dry matter)

Parameters	SP ₁ (control)	SP ₂	SP ₃	SP ₄	SP ₅	SP ₆
Crude protein	34.69	34.63	34.67	34.65	34.61	34.60
Ash	14.89	15.01	14.85	14.81	15.08	14.67
Fat	6.71	6.64	6.61	6.58	6.55	6.51
Crude fibre	6.51	6.48	6.49	5.95	5.91	6.22
Moisture	7.73	7.48	7.67	7.58	7.42	7.41
NFE	29.47	29.76	29.71	30.43	30.43	30.59

Table 3: Mineral compositions of *Heteroclaris* fed sweet potato diet (mg/kg) (Mean±SE).

Parameters	SP ₁ (control)	SP ₂	SP ₃	SP ₄	SP ₅	SP ₆
Na	26.10±0.46 ^a	29.10±0.17 ^b	37.50±0.29 ^c	38.34±0.42 ^f	32.50±0.29 ^c	35.40±0.32 ^d
Ca	51.80±0.52 ^d	46.90±0.65 ^b	53.20±0.16 ^c	49.70±0.23 ^c	43.90±0.04 ^a	49.00±0.22 ^c
K	58.70±0.75 ^c	70.50±0.53 ^c	70.00±0.12 ^c	45.50±0.47 ^a	47.80±0.53 ^b	60.70±0.00 ^d
Mg	6.24±0.46 ^a	5.86±0.23 ^a	5.76±0.52 ^a	6.21±0.61 ^a	5.61±0.48 ^a	6.17±0.53 ^a
Zn	0.30±0.01 ^a	0.38±0.06 ^b	0.38±0.00 ^b	0.96±0.04 ^d	0.40±0.02 ^b	0.75±0.04 ^c
Fe	0.99±0.12 ^a	0.91±0.20 ^a	0.84±0.02 ^a	1.00±0.09 ^a	0.79±0.09 ^a	0.75±0.04 ^a
Cu	0.07±0.01 ^a	0.06±0.02 ^a	0.08±0.01 ^a	0.07±0.01 ^a	0.13±0.02 ^b	0.09±0.01 ^{ab}
P	205.00±0.79 ^d	229.00±1.58 ^f	215.00±1.85 ^c	135.00±0.62 ^a	155.00±0.62 ^b	195.00±0.54 ^c
S	3.39±0.46 ^b	4.91±0.53 ^c	1.06±0.28 ^a	1.02±0.48 ^a	2.43±0.75 ^b	3.44±0.60 ^d
Cl	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.00±0.00 ^a	0.001±0.01 ^b

Means with the same superscripts in the same row are not significantly different ($P < 0.05$)

Table 4: Parameters of Culture Water (Mean±SE)

Parameters	SP ₁ (control)	SP ₂	SP ₃	SP ₄	SP ₅	SP ₆
Dissolved Oxygen (mg/l)	6.53±0.08 ^a	6.67±0.03 ^a	6.57±0.03 ^a	6.57±0.03 ^a	6.63±0.13 ^a	6.57±0.03 ^a
Temperature (°C)	26.8±0.03 ^b	26.6±0.03 ^a	26.8±0.03 ^b	26.8±0.10 ^b	26.8±0.03 ^b	26.9±0.03 ^b
pH	6.96±0.00 ^a	6.97±0.00 ^{ab}	6.97±0.00 ^{ab}	6.98±0.00 ^b	6.98±0.00 ^b	6.97±0.01 ^{ab}

Means with the same superscripts in the same row are not significantly different ($P < 0.05$)

References

- De Silva SS, Anderson TA. Fish nutrition in aquaculture. Chapman and Hall Aquaculture Series 1, St. Edmundsbury Press. London.1995, 319.
- FAO. The State of World Fisheries and Aquaculture. Food and Agricultural Organization. Rome, Italy, 2012, 209.
- FAO. The State of World Fisheries and Aquaculture. Food and Agricultural Organization. Rome, Italy. 2014, 230.
- Bouwkamp C. Sweet potato products: A natural resource for the tropics. CRC Press, Inc. Boca Raton, Florida, USA. 1985, 271.
- Bourke RM, Vlassak V. Estimates of food crop production in Papua New Guinea, Anu Canberra, 2004.
- Asuquo BO, Anuibunwa FO. Evaluation of nutritional potentials of four common forages for rabbit feeding. Proc. Of the 8th Ann. Farming Systems Research and Ext. Workshop in Southern Nigeria. 1993, 49-53.
- Wariboko C, Ogidi IA. Evaluation of the performance of

- improved sweet potato (*Ipomoea batatas* L. LAM) varieties in Bayelsa State, Nigeria. African Journal of Environmental Science and Technology. 20014, 6-15.
8. Ezenwaji O. Methods for Assessment of Fish in Freshwater. IBP Handbook No. 3, Blackwell Scientific Publication, Oxford, 1989, 136.
9. Ekelemu JK, Ekokotu PA. Principle and Practice of Fish seed production: Issues in Animal Science (ed. S.I. Omeje). Ray kenedy Scientific Publishers, Enugu, 1999, 182-196.
10. Idodo-Umeh G. Freshwater Fishes of Nigeria (Taxonomy, Ecological Notes, Diets and utilization) Idodo Umeh Publishers Ltd. Benin City. 2003, 232.
11. Ponzoni RW, Nguyen NH. Proceedings of a Workshop on the Development of a Genetic Improvement Program for African catfish *Clarias gariepinus*. World Fish Center Conference Proceedings Number 1889. The World Fish Center, Penang, Malaysia. 2008, 130.
12. Oguguah NM, Nwadukwe F, Atama CI, Chidobem JI, Eyo JE. Growth performance of hybrid catfish (H. bidorsalis (♀) x C. gariepinus (♂)) at various stocking densities in varied culture tanks. Animal Research International. 2011; 8(3):1419-1430.
13. Fagbenro OA, Fasasi OS, Jegede T, Olawusi-Peters OO. 60 years of Tilapia Aquaculture in Nigeria. ECONOMICS and COUNTRY – REGIONAL REPORTS of the Ninth International symposium on Tilapia culture (ISTA 9), Shanghai, China. 2011, 331-450.
14. Ajah PO. Fish Breeding and Hatchery Management. Jerry Commercial Productions, Calabar-Lagos, 2000, 141-149.
15. Woolfe AJ. Sweet Potato: An Untapped Food Resource, Cambridge University Press. UK, 1992.
16. FAO. Development of traditional food crops in developing countries. Report of a joint consultation Geneva, 1986.
17. AOAC. Official methods of analysis of the association of official's analytical chemists, 16th edition. Association of official analytical chemists, Arlington, Virginia, USA, 2003.
18. AOAC. Official methods of analysis, 17th edition Association of Official Analytical Chemists. Washington, D.C, 2005.
19. Dytham C. Choosing and using statistics: A Biologist's guide. Blackwell Science Ltd., London, UK. 1999, 147.
20. ADCP. Aquaculture Development and Coordination Programme. Fish feeds and feeding in developing countries-an interim report on the ADCP feed development programme, Roma. PNUD/FAO, ADCP/ REP/83/18, 1983, 97.
21. Guillaume J, Kaushik S, Bergot P, Metailler R. Nutrition and feeding of Fish and crustaceans. Praxis Publishing Ltd., Chichester, Springer-Praxis books in Aquaculture and Fisheries. UK, 2001, 408.
22. NRC. National Research Council. Nutrient requirements of Fish. National Academy Press. Washington. DC, 1993.
23. NRC. National Research Council. Nutrient requirements of warm water fishes and shellfishes, re vised edition. National Academy Press, Washington, DC, 1983
24. Lall SP. The minerals. In: Halver, JE (ed.). Fish Nutrition, 2nd edition. Academic Press, San Diego. 1989, 219-257.
25. Wilson RP, El Naggat G. Potassium requirement of fingerling channel catfish, *Ictalurus punctatus*. Aquaculture. 1992; 108:169-175.
26. Lovell RT. Nutrition and Feeding of Fish. Van Nostrand Reinhold Publishers, New York, USA, 1989.
27. Abd El-Hakim FN, Lashin MM, Al-Azab A, Fahim MA. Effect of dietary replacement of yellow corn energy with culled sweet potato (as non-traditional energy source) on growth performance, nutrients utilization and carcass traits of growing Nile Tilapia (*Oreochromis niloticus*) Egypt J Aquat. Biol. & Fish. 2010; 14(2):1-17.
28. Boonyaratpalin M. Catfish feed. National inland Fisheries Institute. Extension paper No. 528 (in Thai). Department of Fisheries, Bangkok, Thailand, 1988.
29. Cowey CB, Sargent JR. Nutrition. In: Fish Physiology, Hoar, W.S., D.J. Randall and J.R. Brett (Eds.). Academic Press, London, 1979, 1-69.
30. Ravindran V, Blair R. Feed resources for poultry production in Asia and the Pacific Region. Energy sources. World's Poultry Science Journal. 1991; 47:214-231.
31. Adesulu EA. Pisciculture in Nigeria essential production information. External Communication Ltd. Lagos, Nigeria. 2001, 12-20.