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EFFECTS OF TECHNOLOGICAL TREATMENTS OF DIETARY PALM KERNEL MEAL ON FEED INTAKE, GROWTH AND BODY COMPOSITION OF *Oreochromis niloticus* REARED IN CONCRETE TANKS

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ABSTRACT

An experiment was conducted to determine the effect of treated palm kernel meal in diets on production parameters of Nile tilapia *Oreochromis niloticus* reared in concrete tanks. Fingerlings of Tilapia with an average initial weight 6.22 ± 0.25 g and an average size 7.58 ± 0.21 cm were fed four isonitrogenous diets each containing 30% palm kernel meal treated one-hour or not. So we have NT (untreated), DW (dipped in water), CW (cooked in water) and SW (steamed). These diets were compared with a commercial fish feed, Raanan (RA), all about 32% crude protein. After 8 weeks of experiment the final body weight varied between 29.57 and 43.01 g according to the tested treatments. The best growth rate and food conversion ratio were obtained with diet CW containing palm kernel meal cooked in water with specific growth rate (SGR) of 3.24 %/d and food conversion ratio (FCR) of 1.97 against a SGR of 3.44%/d and a FCR of 1.72 obtained with commercial feed (RA). Moreover, the tested diets do not seem to have any effect on the intestine size but the cooking seems to act on fish liver weight and body composition. The production parameters were improved with the diet containing palm kernel meal cooked in water which seems to be the interest food for *O. niloticus* on growing.
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Contribution/Originality: The authors declare that there is no conflict of interests in relation to this original article. This study is one of very few studies which have investigated on palm kernel meal in diet in order to reduce the cost of fish feed.

1. INTRODUCTION

The food remains the main constraint to fish farming emergence (Liti *et al.*, 2005). Its cost, which exceeds 50% of production cost in fish farming (Gourene *et al.*, 2002) is related to fish meal use as main protein source in compound feed for aquaculture (Hossain *et al.*, 2001). It is important to seek for alternative sources of protein to reduce production cost of fish (Bamba *et al.*, 2014). Vegetable by-products are used more and more in breeding (Soliman *et al.*, 2005). Because of their biochemical composition (amino acid profile, presence of anti-nutritional factors, low digestibility, etc.), by-products of plant origin are likely to affect fish performance (Azaza *et al.*, 2005) by reducing the bioavailability of lipids, proteins and minerals (Ward and Reichert, 1986). According to the inventory of by-products recoverable in fish farming in Togo by PPAAO (2014) palm kernel meal (agro-industrial by-product) is widely available locally and can be incorporated in 30% in feed of *Oreochromis niloticus* fingerlings (Adjanke *et al.*, 2016). It presents deficiencies in amino acids and contains anti-nutritional factors such as tannic acid, phytin phosphorus, phytic acid and oxalate (Akinyeye *et al.*, 2011) which can be eliminated by technological treatments (Kaysi and Melcion, 1992). It would therefore be interesting that suitable technological treatments be applied to palm kernel meal in order to improve its digestibility and to reduce its possible contents in antinutritional factors.

2. MATERIALS AND METHODS

2.1. Experimental Procedure

This study was carried out from January to March 2017 at Aquaculture research and Development unit (REDAQ) based in the agricultural experiment station of the University of Lome in Togo. Four experimental diets, isonitrogenous (32%) and containing 30% palm kernel meal, were prepared using an electric meat grinder (Arshia Model MG300-602) with 3 mm diameter from six ingredients in the same proportions (Table 1). Within these diets, the palm kernel meal was or not treated for one hour. So we have no treatment (NT), dipping in water (DW), cooking in water (CW) and steaming (SW); then dried in sun before including in diet. These diets were compared to a commercial food, Raanan (RA) whose nutritive composition is 32% crude protein; 5.0% lipid; 4.0% fiber; 8.0% ash. The basic nutrient composition of experimental diets is 32.2% crude protein; 9.76% lipid; 9.82% fiber; 4% ash. The different diets approximate and mineral compositions are presented in Tables 1 and 2. The filaments obtained were dried in sun, fragmented into desired size and stored at room temperature until distribution. These feeds were tested on Nile Tilapia fingerlings (6.22 ± 0.25 g and 7.58 ± 0.21 cm) stocked in tanks 7 days before experiment start to acclimatize them to new conditions. Three hundred male mono-sex tilapias were randomly divided into 15 tanks of 600 L volume, filled with 250 liters of water and 20 fishes per tank, forming five treatments with three replicate.

The tanks are supplied with water from "Togolaise des Eaux" (TdE) which is stored in external tank, then transported through a submersible pump in a water recirculate system. An electric motor pump ensured a constant flow of well-aerated tap water. Water was filtered by setting and a 10% daily exchange of water. Water was totally replaced weekly. Fish are fed manually ad libitum with experimental diets, three times a day (8:00, 12:00 and 16:00) all the days of the week. Every day at 08:00, before feeding, temperature (27-29 °C) and pH (7.61 ± 0.05) were measured with pH meter coupled with a thermal probe (VWR - PH110) and dissolved oxygen (6.19 ± 0.24 mg / L) was measured with an oxymeter (VWR - DO210). Water ammonia (0 - 0.32 mg/L) and nitrite content (0 - 0.13 mg/L) were checked once a week. Fishing control is conducted each week to register production parameters and adjust daily food ration based on breeding biomass. At the beginning of the experiment, the size of all fish was measured using an ichthyometer and a sample of 20 fishes was taken for whole body proximate analysis. At the end of the experiment, 100 g of each test diet and 100 g whole fish homogenized carcasses per treatment were randomly taken three days after the experiment end and kept frozen (-20 °C) for assays. In addition, 6 fish per batch were collected at the end of the test to determine the hepatosomatic index (HSI) and the relative intestine length (LRI) after fish dissection and these organs measured.

2.2. Biochemical Analyzes

Proximate compositions of diets and fish were determined as follows: dry matter after drying at 105 °C for 24 hours in an oven; fat by petroleum ether extraction method; protein content (N x 6.25) by Kjeldahl method after acid digestion; ash by combustion at 550 °C in a muffle furnace for 12 hours according to the methodology described by AOAC-Association of Official Analytical Chemists (2000). Minerals such as Ca, P, Fe, K, Mn, Zn and Mg were also measured in diets and fish.

2.3. Production Parameters Calculated

Parameters shown in Table 3 were calculated to assess the effect of palm kernel meal treated during the test.

2.4. Statistical Analysis

Data were analyzed by one-way analysis of variance (ANOVA I). The LSD Fisher test or test for least significant difference allowed homogeneous groups means discrimination. Differences were considered significant at 5% level. Statistical analyzes were performed using STATISTICA 5.1 program (Stat soft, Inc.).

3. RESULTS

The growth response of O. niloticus fingerlings with the palm kernel meal diets is shown on Table 4. The palatability and acceptability of diets were similar for all treatments with no rejection observed. The survival rates ranged between 88.33 and 100%, the values for treatment RC was low ($P<0.05$) than the others.

Fish final weight, after 56 days of rearing, varied between 29.57 ± 0.96 and 43.01 ± 0.78 g. Fischer's LSD test showed no significant difference ($P>0.05$) between final mean weight of treatment NT (30.87 ± 0.24 g) and DW (29.57 ± 0.96 g). CW and SW had high value but lower compared the control diet ($P<0.05$) as shown in Fig. 1. Daily weight gains varied from 0.42 to 0.66 g/d, with no significant difference ($P>0.05$) between treatment NT and DW and between CW and SW. The two groups (NT, DW) and (CW, SW) were statistically different ($P<0.05$). However, these values were lower than those obtained with commercial feed.

Specific growth rates (SGR) varied from 2.80%/d to 3.44%/d, with no significant difference ($P> 0.05$) between the treatments R0 and R1. This group was statistically different from other diets ($P <0.05$). Food conversion rates (FCR) range from 1.72 to 2.64 for the RA and DW diets respectively. The best growth rates (3.24 and 3.09% / day) and feed conversion (1.97 and 2.18) with the experimental diets were obtained with diets CW and SW containing hydrothermally treated palm kernel meal. The protein efficiency coefficient (PER) varied between 2.96 and 4.18 with a similar trend to that of specific growth rate.

At the end of the experiment, the liver mean weight of fish fed RA and CW diets were different but higher than the other treatments. Hepato-somatic index (HSI) values ranged from 2.88 ± 0.19 for NT to 3.74 ± 0.25 for RA. It was high in fish fed RA and CW diets compared to the other treatments. These two treatments were different ($P <0.05$). HSI values suggest that cooking in water of palm kernel meal would affect the normal development of the liver.

Fish intestine length at the end of the experiment was similar in all treatments ($P> 0.05$). However, the relative intestine length is low in the treatments RA and CW and high in the others ($P <0.05$). It varied from 4.81 ± 0.21 for RA to 5.13 ± 0.26 for DW. These results seem to confirm the influence of cooking in water on fish weight.

The effects of dietary inclusion of treated palm kernel meal on the body and mineral composition of Oreochromis niloticus carcass are shown in Tables 5 and 6.

Carcass water content is higher in fish fed with foods including palm kernel meal treated with water than others treatments ($P <0.05$). Fish fed diets containing hydrothermally treated palm kernel meal (CW and SW) had higher protein, fewer lipids and ash than those fed with others experimental diets.

Only Ca and P contents in the carcass were significantly affected by dietary treatment. Thus, the hydrothermal treatment allowed an improvement in the carcass composition of Ca and P. For the other minerals, no significant trends were noted between their level in the carcass and the food treatments ($P> 0.05$). The best performances are obtained with diets RA, CW and SW. They are more marked for the diet RA, receiving the commercial feed followed by the CW batch. It contained 30% palm kernel meal cooked in water and provided the most interesting

PER (3.98 ± 0.23), FCR (1.97 ± 0.11), SGR (3.24 ± 0.08) and DWG (0.57 ± 0.02) among local foods. In addition, the fish fed with this diet contained more calcium, phosphorus and protein, less lipids and less ash than other treatments.

4. DISCUSSION

The rate of survival raised during the test between 88 and 100%. The tested diets do not seem affected the survival of fish. In addition, the handling carried out at the time of fishing of control and weighing did not cause mortal stress. Moreover, the low density of loading and the partial replacement of water would have led to this result (Philippart and Ruwet, 1982).

Production parameters analysis showed that growth was effective in all batches. This is related to the presentation of feed in pellet form that reduced food losses by leaching into water and improved significantly the feed conversion rate, protein and energy retention (Pouomogne, 1994; Bamba *et al.*, 2014). Fish fed diets RA, CW and SW presented growth performances relatively more significant than others (NT and DW). This variation of performance could be explained by the nature of the treatments. The hydrothermal treatment of palm kernel meal before its dietary inclusion (CW and SW) would have improved the growth of fish. The daily weight gain (DWG) and the specific growth rate (SGR) are high for fish of these batches. However, the best growth rate with local diets was obtained with diet CW containing palm kernel meal cooked in water. This is related to the best food conversion rate (FCR) obtained with this diet. The diet CW provided the highest PER, FCR and SGR. The weak growth performances observed in fish fed with diets NT, DW and SW (respectively containing palm kernel meal untreated, dipped in water and steamed) could be explained by the presence of non-soluble fibers which can bind to nutrient such as lipids, proteins (Shah *et al.*, 1982) and minerals (Ward and Reichert, 1986) by reducing their bioavailability. This could also be related to the fact that palm kernel meal provided little digestible energy (Francis *et al.*, 2001). However, according to Viola *et al.* (1988) the tilapia would effectively use complex polysaccharides and cellulose (up to some level) to meet its energy needs. Furthermore, the wide variety of anti-nutritional factors found in materials derived from plants limits their use in aquaculture. Thus, the dietary inclusion of palm kernel meal would imply the presence of a range of anti-nutritional factors such as tannic acid, phytin phosphorus, phytic acid and oxalate (Akinyeye *et al.*, 2011) which would reduce growth and feed conversion efficiency (Wee and Shu, 1989). Cooking in water would have led to a better use of the diet CW.

The Hepato-somatic Index (IHS) results recorded during this test are in agreement with those reported by Richter *et al.* (2003) which worked on moringa leaves dietary inclusion on tilapia production. The increase in the liver size observed in fish fed diet CW would come from the quality of this diet ingredient in particular the palm kernel meal cooked in water, which would act on hepatic volume (Richter *et al.*, 2003). None diet tested would act on fish intestine development because, for omnivorous fish like *O. niloticus*, it would not seem to have significant relations between diets and intestine length (Paugy and Leveque, 2006). The differences obtained with fish relative intestine length (RIL) could be explained by the variations in length of fish (Richter *et al.*, 2003). Fish fed diets NT, DW and SW, which show growth delay in height presented high RIL compared to others.

Dietary lipid level influences feeding level, protein efficiency and growth and promoted saving protein for deposition and growth (De Silva *et al.*, 1991; Skalli *et al.*, 2004; Hixson, 2014). The optimum of dietary lipid requirement for Tilapia growth has been determined in various studies (Hixson, 2014). In our experiment, the best growth performance was observed in fish fed with diet containing palm kernel meal cooked in water equivalent to 11.7% of dietary lipid. The results of this study are consistent with those obtained in other studies (Pie *et al.*, 2004; Lopez *et al.*, 2006).

The reductions in body content of Ca and P were similarly reported by Vielma *et al.* (2000) for rainbow trout, Mbahinzireki *et al.* (2001) for Nile tilapia, fed with vegetable protein sources. Ca and P are the dominant inorganic components in whole fish, and about 90% Ca and 80% P are present in bones (Hertrampf and Piedad-Pascual, 2000).

In tilapia and salmonids, it is well documented that body concentrations of Ca and P are sensitive to an increase in the level of their food content (Skonberg *et al.*, 1997; Mbahinzireki *et al.*, 2001). Indeed, in Nile tilapia, Mbahinzireki *et al.* (2001) found that body concentrations of Ca, P, Mg and Fe dropped proportionally to the increase in plant products in the diet. These authors explained their results in part to the low absorption of these minerals from the food. This can also be attributed to a negative effect of phytic acid contained in plant products, palm kernel meal that forms an insoluble chelate with minerals such as P for which a dietary imbalance reduces the absorption of Ca (Hepher, 1988; Porn-Ngam *et al.*, 1993). Cooking in water had improved the absorption of Ca and P from this food.

5. CONCLUSION

At the end of this study, which aim was to develop efficient diets based on palm kernel meal through different technological treatment, it appears that diets in pellet form were non-toxic to fish. From the result of our investigation on production and nutritional performances, we can conclude that diet CW which contains the palm kernel meal cooked in water as being the most interesting for on-growing tilapia. Others digestive tests on dietary palm kernel meal cooking in water or not on tilapia would make it possible to understand this treatment effect.

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REFERENCES

Adjanke, A., K. Tona, M.C. Ble, I.I. Toko and M. Gbeassor, 2016. Effect of dietary inclusion of palm kernel meal on feed intake, growth and body composition of Nile Tilapia, Oreochromis niloticus reared in concrete tanks in Togo. International Journal of Fisheries and Aquatic Studies, 4(5): 642-646. *View at Google Scholar*

Akinyeye, R.O., E.I. Adeyeye, O. Fasakin and A. Agboola, 2011. Physico-chemical properties and anti-nutritional factors of palm fruit products (Elaeis Guineensis Jacq.) from Ekiti State Nigeria. Electronic Journal of Environmental, Agricultural and Food Chemistry, 10(5): 2190-2198. *View at Google Scholar*

AOAC-Association of Official Analytical Chemists, 2000. Official methods of analysis. Washington, D.C: AOAC.

Azaza, M.S., F. Mensi, A. Abdelmouleh and M.M. Kraïem, 2005. Elaboration of dry foods for the nil tussapia oreochromis niloticus (L., 1758) in breeding in the geothermal waters of Southern Tunisia. Bulletin of the National Institute of Science and Technology Sea of Salammbo, 32: 23-30.

Bamba, Y., N. Ouattara, S. Ouattara, A. Ouattara and G. Gourene, 2014. Effect of diets containing cocoa bean shell and coconut oil cake on the growth of Oreochromis niloticus (LINNE, 1758) in pond. International Journal of Biological and Chemical Sciences, 8(4): 1368-1380. *View at Google Scholar | View at Publisher*

De Silva, S.S., R.M. Guansekera and K.F. Shim, 1991. Interactions of varying dietary protein and lipid levels in young red tilapia: Evidence of protein sparing. Aquaculture, 95(3-4): 305-318. *View at Google Scholar | View at Publisher*

Francis, G., H.P.S. Makkar and K. Becker, 2001. Antinutritional factors present in plant-derived alternate fish feed ingredients and their effects in fish. Aquaculture, 199(3-4): 197-227. *View at Google Scholar | View at Publisher*

Gourene, G., K.B. Kobena and A.F. Vanga, 2002. Study of the profitability of fish farms in the region of Moyen Comoé. Technical Report, Abobo-Adjamé University, Abidjan, Côte d'Ivoire. pp: 1-41.

Hepher, B., 1988. Nutrition of pond fishes. New York, USA: Cambridge Univ. Press. pp: 388.

Hertrampf, J.W. and F. Piedad-Pascual, 2000. Handbook on ingredients for aquaculture feeds. The Netherland: Kluwer Academic Publishers. pp: 573.

Hixson, S.M., 2014. Fish nutrition and current issues in aquaculture: The balance in providing safe and nutritious seafood, in an environmentally sustainable manner. Journal of Aquaculture Research Development, 5(3): 1-10. *View at Google Scholar* | *View at Publisher*

Hossain, M.A., U. Focken and K. Becker, 2001. Effect of soaking and soaking followed by autoclaving of Sesbania seeds on growth and feed utilisation in common carp, cyprinus carpio L. Aquaculture, 203(1-2): 133 - 148. *View at Google Scholar* | *View at Publisher*

Kaysi, Y.J.P. and J.P. Melcion, 1992. Traitements technologiques des protéagineux pour le monogastrique: Exemples d'application à la graine de féverole. INRA Productions Animales, 5(1): 3-17. *View at Google Scholar*

Liti, D., L. Cherop, J. Munguti and L. Chhorn, 2005. Growth and economic performance of Nile tilapia (Oreochromis Niloticus L.) fed on two formulated diets and two locally available feeds in fertilized ponds. Aquaculture Research, 36(8): 746–752. *View at Google Scholar* | *View at Publisher*

Lopez, L.M., A.L. Torres, E. Durazo, M. Drawbridge and D.P. Bureau, 2006. Effects of lipid on growth and feed utilization of while seabass (Atractoscion Nobilis) fingerlings. Aquaculture, 253(1-4): 557-563. *View at Google Scholar* | *View at Publisher*

Mbahinzireki, G.B., K. Dabrowski, K.J. Lee, D. El-Saidy and E.R. Wisner, 2001. Growth, feed utilization and body composition of tilapia (Oreochromis sp.) fed with cottonseed meal-based diets in a recirculating system. Aquaculture Nutrition, 7(3): 189- 200. *View at Google Scholar* | *View at Publisher*

Paugy, D. and C. Leveque, 2006. Fish in African Inland waters: Diversity, ecology, human use. IRD Editions. pp: 564.

Philippart, J.C. and J.C. Ruwet, 1982. Ecology and distribution of tilapias. In: The biology and culture of tilapias (Pullin et Lowe Mc Connell, Eds.). ICLARM Conférence Proceedings, 7, Manila, Philippines. pp: 15-59.

Pie, Z., S. Xie, W. Lei, X. Zhu and Y. Yang, 2004. Comparative study on the effect of dietary lipid level on growth and feed utilization for Gibel carp (Carassius Auratus Gibelo) and Chinese long snout catfish (Leiocassius Logirostris Gunther). Aquaculture Nutrition, 10(4): 209-216. *View at Google Scholar* | *View at Publisher*

Porn-Ngam, N., S. Satoh, T. Takeuchi and T. Watanabe, 1993. Mineral nutrition in Fish-XXIX. effect of the ratio of phosphorus to calcium on zinc availability to rainbow trout in high phosphorus diet. Nippon Suisan Gakkaishi, 59(12): 2065-2070. *View at Google Scholar* | *View at Publisher*

Pouomogne, V., 1994. Evaluation of the potential of some by-products of the agro-food industry and food intake modalities. Thesis of Doctor of ENSAR, Rennes. pp: 267.

PPAAO, 2014. Study on aquaculture feed input in Togo. CONTRAT N°036 /2013/CI/ MAEP-PPAAO-TOGO/ SPM: 67.

Richter, N., P. Siddhuraju and K. Becker, 2003. Evaluation of nutritional quality of moringa (Moringa Oleifera Lam.) leaves as an alternative protein source for Nile Tilapia (Oreochromis Niloticus L.). Aquaculture, 217(1-4): 599-611. *View at Google Scholar* | *View at Publisher*

Shah, N., M.T. Atallah, P.R. Mahoney and P.L. Pellet, 1982. Effect of dietary fiber components on fecal nitrogen excretion and protein utilization in growing rats. Journal of Nutrition, 112(4): 658-666. *View at Google Scholar* | *View at Publisher*

Skalli, A., M.C. Hidalgo, E. Abellan, M. Arizcun and G. Cardenete, 2004. Effect of the dietary protein/lipid ratio on growth and nutrient utilization in common dentex (Dentex Dentex L.) at different growth stage. Aquaculture, 235(1-4): 1-11. *View at Google Scholar* | *View at Publisher*

Skonberg, D.I., L. Yogev, R.W. Hardy and F.M. Dong, 1997. Metabolic response to dietary phosphorus intake in rainbow trout oncorhynchus mykiss. Aquaculture, 157(1-2): 11-24. *View at Google Scholar* | *View at Publisher*

Soliman, A.K., A.I. Mohamed, A.A.R. Abou and A.M. Badawy, 2005. Partial and complete replacement of clover leaf (Trifolium alexandrinum) meal protein by cabbage leaf (Brassica oleracea) meal protein in Nile tilapia diets together with economic evaluation. Cahiers Options Méditerranéennes, 63: 143-149. *View at Google Scholar*

Vielma, J., T. Mäkinen, P. Ekholm and J. Koskela, 2000. Influence of dietary soy and phytase levels on performance and body composition of large rainbow trout (Oncorhynchus Mykiss) and algal availability of phosphorus load. Aquaculture, 183(3-4): 349-362. *View at Google Scholar* | *View at Publisher*

Viola, S., S. Mokady, D. Behar and U. Cogan, 1988. Effects of polyunsaturated fatty acids in feeds of tilapia and carp. 1. Body composition and fatty acid profiles at different environmental temperatures. Aquaculture, 75(1-2): 127-137. *View at Google Scholar* | *View at Publisher*

Ward, A.T. and R.D. Reichert, 1986. Comparison of effect of cell wall and hull fibre canola and soybean on the bioavailability for rats of minerals, protein and lipid. Journal of Nutrition, 116(2): 233-241. *View at Google Scholar* | *View at Publisher*

Wee, K.L. and S.W. Shu, 1989. The nutritive value of boiled full fat soybean in pelleted feed for Nile tilapia. Aquaculture, 81(3-4): 303-314. *View at Google Scholar* | *View at Publisher*

Table-1. Formulation and proximate composition of the experimental diets.

Parameters %	**Diets**			
	NT	**DW**	**CW**	**SW**
Fishmeal	42	42	42	42
Corn	14	14	14	14
Palm kernel meal*	30	30	30	30
Roasted soybeans	10	10	10	10
Palm oil	2	2	2	2
Vitamin- mineral complex	2	2	2	2
Proximate analysis				
Dry matter	96.93	96.30	96.51	93.34
Crude protein	32.19	32.12	31.88	32.02
Lipid	12.50	12.37	11.71	12.02
Fiber	9.82	9.88	8.91	9.58
Ash	18.02	18.24	17.96	17.88

RA: Commercial feed, Raanan which composition is as follows (%): Dry matter = 93.45; Crude protein = 32.04; Lipid = 5.68; Fiber = 4.35; Ash = 8.58.

Table-2. Mineral composition of the experimental diets (based on dry matter).

Diets		**g/kg**				**mg/kg**	
	Ca	**P**	**Mg**	**K**	**Fe**	**Zn**	**Mn**
RA	24,9 ± 3,3	18,2 ± 2,7	6,8 ± 2,9	8,2 ± 0,6	702 ± 58,1	243 ± 14,2	77 ± 2,8
NT	50,8 ± 4,7	13,8 ± 0,5	7,1 ± 3,1	9,0 ± 0,6	871 ± 41,3	291 ± 18,8	81 ± 6,7
DW	46,1 ± 2,7	13,8 ± 2,7	7,9 ± 4,0	11,3 ± 0,7	793 ± 35,7	283 ± 28,1	78 ± 6,3
CW	37,3 ± 2,7	16,6 ± 0,4	6,2 ± 2,3	6,9 ± 0,3	680 ± 54,2	227 ± 37,5	75 ± 4,5
SW	37,6 ± 2,7	14,7 ± 2,7	6,4 ± 2,6	7,4 ± 0,6	796 ± 46,8	236 ± 15,9	76 ± 3,1

RA: Commercial feed, Raanan. NT, DW, CW and SW: Diets including palm kernel meal respectively untreated, dipped in water, cooked in water and steamed. Values are expressed as mean ± SD

Table-3. Formulas used in the evaluation of livestock production parameters

Production parameters	**Formulas**
(DWG) : Daily Weight Gai□ (g/d)	DWG = (Wf – Wi)/ test duration (days)
(SGR) : Specific Growth Rate (%/j)	SGR = 100□(LnWf – LnWi) / test duration (days)
(FCR) : Food Conversion Ratio	FCR = D / [(Bf + Bd) – Bi]
(PER) : Protein Efficiency Ratio	PER = [(Bf + Bd) – Bi] / (D x diet protein)
(HSI) : Hepato Somatic Index (%)	HSI = 100 x Liver weight / Fish weight
(RIL) : Relative Intestine Length	RIL = Intestine length (cm) / Fish length
Survival (%)	Survival = 100 x (Nf / Ni)

Nf, Ni: Final fish number, Initial fish number; D: cumulative quantity of food distributed (g); Bi, Bd and Bf: initial, dead and final biomass (g); Wi, Wf: initial, final weight (g)

Table-4. Effects of dietary inclusion of treated palm kernel meal on *O. niloticus* fingerlings final weight, specific growth rate (SGR), feed conversion ratio (FCR), protein efficient ratio (PER), hepato-somatic index (HSI), relative intestine length (RIL) and survival after 56 days of rearing in concrete tanks.

Parameter	Diets				
	RA	NT	DW	CW	SW
Initial body weight (g)	6.25 ± 0.25^{a}	6.31 ± 0.49^{a}	6.18 ± 0.22^{a}	6.25 ± 0.19^{a}	6.13 ± 0.17^{a}
Final body weight (g)	43.01 ± 0.78^{a}	30.87 ± 0.24^{d}	29.57 ± 0.96^{d}	38.35 ± 0.56^{b}	34.64 ± 0.64^{c}
Daily weight gain (g/d)	0.66 ± 0.01^{a}	0.44 ± 0.01^{c}	0.42 ± 0.02^{c}	0.57 ± 0.02^{b}	0.51 ± 0.01^{b}
SGR (%/d)	3.44 ± 0.10^{a}	2.84 ± 0.12^{d}	2.80 ± 0.07^{d}	3.24 ± 0.08^{b}	3.09 ± 0.07^{c}
FCR	1.72 ± 0.10^{d}	2.56 ± 0.21^{a}	2.64 ± 0.11^{a}	1.97 ± 0.11^{c}	2.18 ± 0.14^{b}
PER	4.18 ± 0.26^{a}	3.07 ± 0.23^{d}	2.96 ± 0.12^{d}	3.98 ± 0.23^{b}	3.59 ± 0.23^{c}
HSI	3.74 ± 0.25^{a}	2.88 ± 0.19^{d}	2.95 ± 0.29^{d}	3.42 ± 0.22^{b}	3.11 ± 0.15^{c}
RIL	4.81 ± 0.21^{b}	5.07 ± 0.15^{a}	5.13 ± 0.26^{a}	4.88 ± 0.24^{b}	5.05 ± 0.26^{a}
Survival (%)	88.33 ± 11.55^{b}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	100.00 ± 0.00^{a}	98.33 ± 1.63^{a}

RA: Commercial feed, Raanan. NT, DW, CW and SW: Diets including palm kernel meal respectively untreated, dipped in water, cooked in water and steamed. Mean in a row with different superscripts significantly differ ($p<0.05$).

Table-5. Carcass composition of fingerlings of *Oreochromis niloticus* after 56 days of feeding experimental diets.

Parameter %		Diets				
	Initial	RA	NT	DW	CW	SW
Moisture	76.33 ± 0.3^{a}	72.61 ± 1.2^{d}	72.93 ± 0.6^{d}	75.69 ± 0.8^{b}	74.83 ± 1.2^{c}	74.29 ± 0.8^{c}
Crude protein	14.28 ± 0.1^{e}	18.69 ± 0.6^{a}	17.43 ± 0.5^{d}	17.10 ± 0.4^{d}	18.38 ± 0.6^{b}	18.02 ± 0.3^{c}
Total fat	3.40 ± 0.0^{c}	3.88 ± 0.4^{b}	4.12 ± 0.3^{a}	4.27 ± 0.4^{a}	3.49 ± 0.3^{c}	3.62 ± 0.2^{bc}
Ash	2.97 ± 0.4^{d}	3.44 ± 0.1^{b}	3.73 ± 0.1^{a}	3.80 ± 0.2^{a}	3.26 ± 0.4^{c}	3.42 ± 0.1^{b}

RA: Commercial feed, Raanan. NT, DW, CW and SW: Diets including palm kernel meal respectively untreated, dipped in water, cooked in water and steamed. Mean in a row with different superscripts significantly differ ($p<0.05$).

Table-6. Carcass mineral composition (based on dry matter) of *Oreochromis niloticus* after 56 days of feeding experimental diets.

Diets	g/kg				mg/kg		
	Ca	P	Mg	K	Fe	Zn	Mn
RA	20.3 ± 0.1a	14,2 ± 0.2a	6.9 ± 1.5	8.7 ± 0.6	659.6 ± 91.3	107.6 ± 8.8	8.1 ± 0.6
NT	10.2 ± 2.2b	8.7 ± 0.1b	6.6 ± 1.7	7.9 ± 0.6	639.7 ± 85.7	91.7 ± 8.1	6.8 ± 0.1
DW	12.2 ± 2.6b	10.9 ± 0.1b	6.7 ± 1.3	9.6 ± 0.7	630.2 ± 78.8	84.3 ± 8.2	6.9 ± 0.6
CW	19.8 ± 2.7a	13.8 ± 0.5a	6.4 ± 1.1	7.2 ± 0.3	613.0 ± 46.8	119.1 ± 4.2	6.7 ± 0.6

RA: Commercial feed, Raanan. NT, DW, CW and SW: Diets including palm kernel meal respectively untreated, dipped in water, cooked in water and steamed. Mean in a row with different superscripts significantly differ ($p<0.05$).

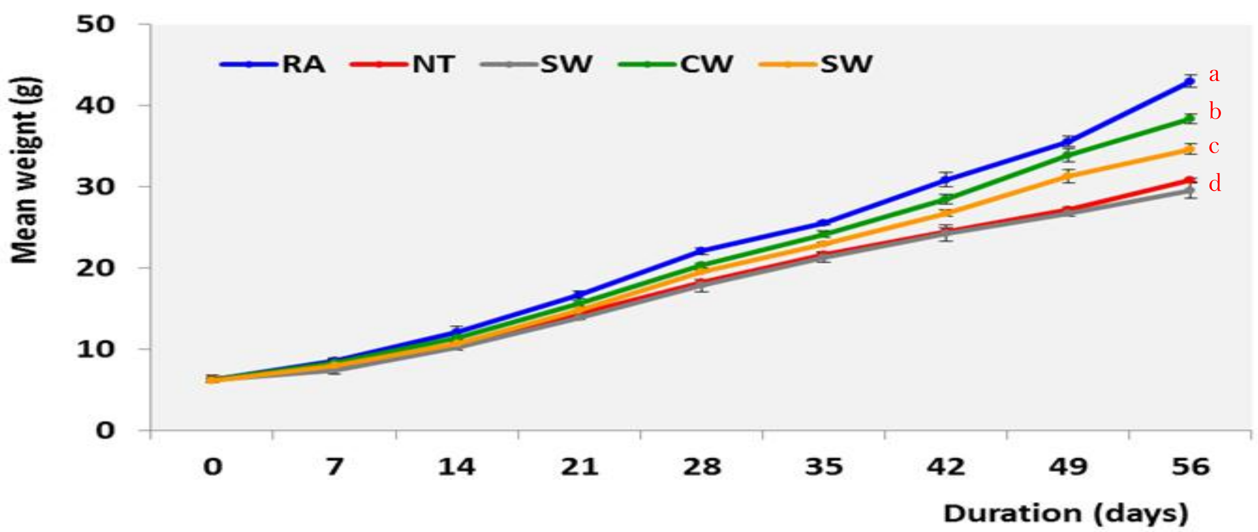

Fig-1. Mean growth of *O. niloticus* fingerlings fed with experimental diets containing palm kernel meal, whether or not treated.
RA: Commercial feed, Raanan. NT, DW, CW and SW: Diets including palm kernel meal respectively untreated, dipped in water, cooked in water and steamed.