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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

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Abstract
An experiment was conducted to determine the effect of inclusion of palm kernel meal on feed intake, growth and body composition of Nile tilapia *Oreochromis niloticus* reared in concrete tanks. Fingerlings of fish with an average initial weight 5.18 ± 0.06 g were fed five isonitrogenous diets (R0, R1, R2, R3 and R4) containing respectively 0%, 10%, 20%, 30% and 40% of palm kernel meal. These diets were compared with a commercial fish feed (Raanan) all about 32%. After 8 weeks of experiment the final body weight varied between 25.75 g and 38.18 g according to the tested treatments. The best growth rate and food conversion ratio were obtained by feed containing 30% and 40% of palm kernel meal, with respective specific growth rate (SGR) of 3.35%/d and 3.08%/d and food conversion ratio (FCR) of 1.67 and 2.00 against a SGR of 3.58%/d and a FCR of 1.53 obtained with commercial food (RC). This successful test which allowed determining the optimal dietary inclusion of palm kernel meal at 30% in Tilapia on growing feed will be pursued by nutritional improvement tests of this ingredient in order to have a performed feed for Tilapia rearing in Togo.

Keywords: *Oreochromis niloticus*, feed, palm kernel meal, growth performance

1. Introduction
Fish farming is an alternative to fish production deficit in developing countries where population growth corollary food requirements increased including fish [1], which often remains animal protein main source [2]. In Togo, fish production is 25,000 tons per year while needs are estimated at more than 80,000 tons [3]. It is therefore necessary to increase local production through fish farming. Togo fish farming falls within extensive system [4] and its production is marginal (20 tons / year) despite natural potential available for development. This situation is due to food that remains the main constraint to its emergence. Its cost, which exceeds 50% of production cost in fish farming [5], is related to fish meal use as main protein source in compound feed for aquaculture [6]. It is important to seek for alternative and cheap sources of protein to reduce production cost of fish [7, 8]. Other farms competition with fish farming in terms of vegetable proteins poses availability problems. Accessibility to palm kernel meal allows conducting research on its effectiveness in improving fish production. The main benefit of this ingredient is its average crude protein content (16% dry matter) and its permanent availability [4]. Therefore, the purpose of the present investigation was to evaluate the effect of dietary inclusion of palm kernel meal on growth performance, feed utilization and body composition of Nile Tilapia *Oreochromis niloticus*. The results will enable the development of low-cost feed for fish breeding with agricultural by-products available locally in Togo.

2. Materials and methods
2.1 Experimental procedure
This study was carried out from December 2015 to February 2016 at Aquaculture research and Development unit (REDAQ) based in the agricultural experiment station of the University of Lome in Togo. Five experimental diets, R0, R1, R2, R3 and R4, isonitrogenous (32%), including gradual level 0%, 10%, 20%, 30% and 40% of palm kernel meal (Table 1) were prepared using an electric meat grinder (Arshia Model MG300-602) with 3 mm diameter.Corn,

roasted soybeans, palm kernel meal, fish meal, palm oil and mineral-vitamin complex (MVC) were used in this study. These diets were compared to a commercial diet (RC), Raanan with 32% crude protein. These diets were dried in sun, fragmented into desired size and stored at room temperature until distribution. These feeds were tested on Tilapia *Oreochromis niloticus* fingerlings (5.15 ± 0.05 g) stocked in tanks 10 days before experiment start to acclimatize them to new conditions. Three hundred sixty fish were randomly divided into 18 tanks of 600 L volume, filled with 250 liters of water and 20 fish per tank, forming six treatments with three replicate of each treatment.

Table 1: Formulation and proximate composition of the experimental diets

Ingrédients %	Diets				
	R0	R1	R2	R3	R4
Fishmeal	47	45.5	43.5	42	40
Corn	39	30.5	22.5	14	6
Palm kernel meal	0	10	20	30	40
Roasted soybeans	10	10	10	10	10
Palm oil	2	2	2	2	2
Vitamin- mineral complex[1]	2	2	2	2	2
Proximate analysis					
Dry matter	91.31	92.67	92.03	92.26	90.80
Crude protein	32.43	32.31	32.28	32.19	32.03
Crude lipid	8.33	9.65	11.75	12.50	13.27
Ash	13.23	15.57	16.73	18.02	18.34
Fiber*	6.80	7.78	8.83	9.82	10.87
Gross Energy (kcal/kg)*	5.40	5.33	5.26	5.20	5.14

RC: Commercial feed, Raanan which composition is as follows: Crude protein = 32%; Lipid = 5.0%; Fiber = 4.0%; Ash = 8.0%.
[1]Composition (ingredient kg^{-1}): Vit. A. 250.000UI; Vit. D3. 50.000 UI; Vit. E. 625UI; Vit.
K3. 50 mg; Vit. B1. 38 mg; Vit. B2. 125 mg; Vit. B3. 750 mg; Vit. B5. 250 mg; Vit. B6. 50 mg; Vit. B9. 25 mg; Vit. B12. 625 mg; Biotin. 1 mg; Ca. 3.69%; P. 0.60%; Na. 2.88%; Fe. 2.800 mg; I. 10 mg; Mn. 1.500 mg; Se.3,75 mg; Zn. 1.250 mg. Antioxidants and antibiotics added; 6 Phytase. 30.000 FYT; Salinomycin. 1.200mg.
R0, R1, R2, R3 and R4: Diets incorporating 0; 10; 20; 30 and 40% of palm kernel meal.
* Calculated from nutritive values tables

The tanks are supplied with water from “Togolaise des Eaux” (TdE) which is stored in external tank for natural evaporation of chlorine, then transported through a submersible pump in a closed circuitsystem. 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. Fish were considered to satiety when they not heedless pellets. Every day at 08:00, before feeding, temperature (25-27 °C) and dissolved oxygen (5.85 ± 0.29 mg/L) were measured with oxymeter coupled with a thermal probe (VWR - DO210) and pH (8.05 ± 0.03) was measured with a pH meter (VWR - PH110).Water ammonia (0 - 0.35 mg/L) and nitrite content (0 - 0.15 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 experiment an initial sample of 20 fish was taken for whole body proximate analysis. At the end of the experiment, 100g of each experimental diet and 100g whole fish homogenized carcasses randomly taken three days after the experiment end and kept frozen (-20 °C) for assays.

2.2 Analysis
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 Association of Official Analytical Chemists [9].

2.3 Production parameters calculated
Parameters shown in Table 2 were calculated to assess palm kernel meal effect during the test.

Table 2: Formulas used in the evaluation of livestock production parameters

Production parameters	Formulas
(DWG) : Daily Weight Gain (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] / (Q x diet protein)
Survival (%)	Survival = 100 x (Nf / Ni)

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

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 and discussion
The growth response of *O. niloticus* fingerlings with the palm kernel meal diets is shown on Table 3. The palatability and acceptability of diets were similar for all treatments with no

rejection observed. The survival rates ranged between 91.67 and 96.67%, the values for treatments R2, R3 and R4 were lower (*P*<0.05) than R0, R1 and RC. These results were similar to those obtained in cages [10] but were much higher than those observed in ponds [11, 12].

Table 3: Effect of dietary inclusion of palm kernel meal on *O. niloticus* fingerlings final weight, specific growth rate (SGR), feed conversion ratio (FCR), protein efficient ratio (PER) and survival rate after 56 days of rearing in concrete tanks.

Parameter	Diet					
	RC	R0	R1	R2	R3	R4
Initial body weight (g)	5.13 ± 0.03ª	5.17 ± 0.03ª	5.18 ± 0.06 ª	5.13 ± 0.08ª	5.12 ± 0.03ª	5.17 ± 0.06ª
Final body weight (g)	38.18 ± 0.79ª	26.45 ± 1.30ᶜ	25.77 ± 0.97ᶜ	26.05 ± 1.84ᶜ	33.47 ± 0.71 ᵇ	28.97 ± 1.43ᶜ
Daily weight gain (g/d)	0.59 ± 0.01ª	0.38 ± 0.02ᶜ	0.37 ± 0.02ᶜ	0.37 ± 0.03ᶜ	0.51 ± 0.01ᵇ	0.43 ± 0.03ᶜ
SGR (%/d)	3.58 ± 0.05ª	2.91 ± 0.08ᵇ	2.86 ± 0.06ᵇ	2.90 ± 0.11ᵇ	3.35 ± 0.03 ª	3.08 ± 0.11ᵇ
FCR	1.53 ± 0.01ª	2.04 ± 0.11ᵇ	2.03 ± 0.09ᵇ	2.05 ± 0.09ᵇ	1.67 ± 0.05 ª	2.00 ± 0.10ᵇ
PER	2.04 ± 0.02ª	1.53 ± 0.09ᶜ	1.54 ± 0,07ᶜ	1.52 ± 0.07ᶜ	1.87 ± 0.06 ᵇ	1.57 ± 0.08ᶜ
Survival (%)	95.00 ± 0.00ª	93.33 ± 2.89ᵇ	96.67 ± 2.89ª	91.67 ± 2.89ᶜ	91.67 ± 2.89ᶜ	91.67 ± 2.89ᶜ

RC: Commercial feed, Raanan. R0, R1, R2, R3 and R4: diets including 0; 10; 20; 30 and 40% of palm kernel meal. Mean in a row with different superscripts significantly differ (*p*<0.05).

Fish final weight, after 56 days of rearing, varied between 25.77 ± 0.97 and 38.18 ± 0.79 g. Fischer's LSD test showed a significant difference (*P*<0.05) between final mean weight of treatment R3 (33.47 ± 0.71 g) and the other experimental diets (R0, R1, R4) but was lower compared the control diet (*P*<0.05) as shown in Figure 1. Daily weight gains varied from 0.37 to 0.59 g/d. These results were consistent with those (0.4 to 0.6 g/d) obtained in tanks [13] with diets made from local byproducts. However, these values were greater than those obtained in tanks (0.06 to 0.12 g/d) [14] and pond (0.1 g/d) [12] with diets containing different levels of Azolla.

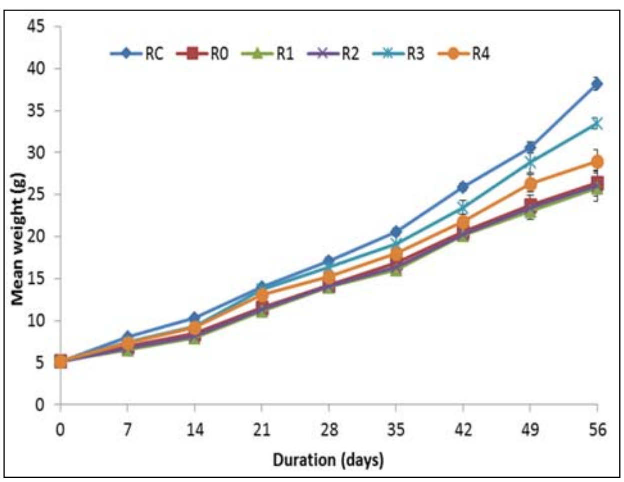

Fig 1: Mean growth of *O. niloticus* fingerlings fed with experimental diets containing increasing level of palm kernel meal.

RC: Commercial feed, Raanan. R0, R1, R2, R3 and R4: diets incorporating 0; 10; 20; 30 and 40% of palm kernel meal.

Specific growth rates (SGR) from 2.86%/d to 3.58%/d with no significant difference (*p*>0.05) between treatment RC and R3 and between R0, R1, R2 and R4. The two groups (RC, R3) and (R0, R1, R2, R4) were statistically different (*P*<0.05). The best growth rate (3.35%/d) with experimental diets was obtained with diet R3 containing 30% of palm kernel meal. This improved growth of fish fed with diet R3 is related to the better feed conversion ratio (FCR) (1.67 ± 0.05) with this diet. The feed conversion ratio obtained in our experiment can be explained in part by the presentation of feed in pellet form that reduced food losses by leaching into water. According to [8], feed intake in pelleted form improved significantly the feed conversion rate, protein and energy retention. Our results are consistent with those reported by several authors for diets containing more than 25% of non-conventional sources of protein for tilapia feed [10, 13, 15, 16]. The protein efficiency ratio (PER) varied between 1.52 and 2.04 with similar trend to that of growth rate. Experimental diet R3 (containing 30% of palm kernel meal) provided the highest PER and SGR. The weak growth performances observed in fish fed with diets R0, R1 and R2 (respectively containing 0, 10% and 20% of palm kernel meal) could be explained by the presence of fibers which can bind to nutrient such as lipids, proteins [17] and minerals [18] by reducing their bioavailability. This could also be related to the fact that palm kernel meal provided little digestible energy [19]. 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 implies a range of anti-nutritional factors presence which would reduce growth and feed conversion efficiency [20]. Increasing dietary lipid level influences feeding level, protein efficiency and growth and promoted saving protein for deposition and growth [21-23]. The optimum of dietary lipid requirement for Tilapia growth has been determined in various studies [23]. In our experience, the best growth performance was observed in fish fed with diet containing 30% of palm kernel meal incorporation equivalent to 12.5% of dietary lipid. The results of this study are consistent with those obtained in other studies [24-26]

The effects of dietary inclusion of palm kernel meal on whole-body proximate composition of Nile Tilapia, *Oreochromis niloticus* are shown in Table 4. Carcass water content increased proportionally with palm kernel meal level in diet up to 30% and then dropped to 40% dietary inclusion. Similarly, increasing palm kernel meal level in fish diet lead to increase carcass protein content reaching a maximum at 30% of incorporation. Fish fed with the diet containing 30% of palm kernel meal (R3) had higher protein and fewer lipids than those fed with the others experimental diets.

Table 4: Carcass composition of fingerlings of *Oreochromis niloticus* after 56 days of feeding experimental diets

Parameter		Diet					
	Initial	RC	R0	R1	R2	R3	R4
Moisture	76.47	72.52 ± 1.18^{d}	73.42 ± 1.03^{c}	73.34 ± 0.48^{c}	74.94 ± 0.81^{b}	75.48 ± 0.57^{a}	73.09 ± 1.03^{c}
Crude protein	12.04	16.05 ± 0.51^{c}	16.33 ± 0.34^{c}	16.51 ± 0.88^{c}	17.94 ± 0.56^{b}	18.21 ± 0.29^{a}	17.84 ± 0.43^{b}
Total fat	3.24	5.54 ± 0.37^{c}	5.48 ± 0.64^{c}	5.70 ± 0.81^{c}	4.46 ± 0.32^{b}	3.59 ± 0.26^{a}	5.11 ± 0.53^{c}
Ash	2.89	4.04 ± 0.64^{b}	4.01 ± 0.96^{b}	3.79 ± 0.88^{a}	3.68 ± 0.58^{a}	3.55 ± 0.41^{a}	3.49 ± 0.96^{a}

RC: Commercial feed, Raanan. R0, R1, R2, R3 and R4: diets including 0; 10; 20; 30 and 40% of palm kernel meal. Mean in a row with different superscripts significantly differ (p<0.05).

Body lipid level decreased as moisture content increased up to 30% of palm kernel inclusion in fish diet. Similar tendency was noted for ash content. The lowest values of ash content were recorded in fish fed with diets containing palm kernel meal (R1, R2, R3 and R4). Body ash content decreased with palm kernel meal dietary inclusion.

4. Conclusion
From the result of our investigation we can conclude that palm kernel meal can be include in the diet of *O. niloticus* up to 30%. But the diet could be significantly improved by technologically processed (soaking, cooking, etc.) of this ingredient to reduce fiber and anti-nutritional factors effects on growth performance of this species.

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