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Growth performance of milkfish (*Chanos chanos* Forsskal) fed on formulated and non-formulated diets made from locally available ingredients in South Coast region, Kenya

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Abstract
This study was carried out in 12 lab aquariums of 20 litre volume to investigate the effectiveness of four test diets; two formulated and two non-formulated on milkfish growth. The study further investigated the treatment effect on water quality, proximate and chemical characterization of the diets and their digestibility. The intent was to study growth performance of milkfish and the potential of local availability of quality and affordable ingredients. Milkfish juveniles of 6.5 g average weight were stocked at 20 fish per aquaria. All treatments were carried out in triplicate and diets administered at 5% body weight per day for ninety two days. Diet 1 FV consisted of fish meal, rice bran and vitamin and mineral premixes. Diet 2 FW consisted of fish meal and rice bran without vitamin and mineral premix. The non-formulated diets were coconut cake (CC) and maize bran (MB). Feeding the fish on formulated diets resulted in significantly higher mean fish weight gain ($P<0.05$) than that of fish fed on non-formulated diets.

Keywords: Milkfish, diets, premixes, digestibility, proximate composition.

1. Introduction
Fin fish and shell fish production in developing countries occurs primarily in semi-intensive ponds with fertilization and supplemental feeding [1]. The purpose of supplemental feeding is to increase yields. Different fish feed stuffs have been evaluated for supplementation of fresh water fish species. Such supplements include nutritionally complete formulated feeds [2] simple mixtures [3] and single ingredients [4] and [5]. Development towards culture of marine species requires identification of quality affordable ingredients that are locally available for use by the coastal communities practicing mariculture. The main marine species cultured at the Kenyan coast are finfish (milkfish and grey mullets) and shellfish (mud crabs and prawns). They are mostly cultured in brackish waters, with seeds mainly being collected from the ocean open waters and estuaries. Natural food is mainly supplied by regular pond fertilization together with supplementation with low protein diets.

Carbohydrate energy is mainly supplied by cereal brans from agricultural processing farms. The most common include; maize bran, wheat bran and rice bran. Protein mainly comes from natural food, fish offal after processing, gastropods, dead fish, slaughter house wastes and plant protein from soybean, groundnut and cotton seed meals. The efficacy of some of these ingredients and by products has been evaluated for production of Nile tilapia (*Oreochromis niloticus*) [6]. Where better production was observed with high protein feeds as compared to the low protein feeds. However the availability and the potential of these ingredients for fish feed production and performance has not yet been evaluated for semi-intensive production of marine species at the Kenyan coast.

Identification of cost-effective and efficient feeds for boosting aquaculture production has been mentioned as one of the main challenges hindering growth of the industry [7]. Mariculture being a recent development in the region is faced by challenges in finding suitable feed stuffs to use for the cultured species. To identify such feeds, simultaneous evaluation and comparison of the feedstuffs under semi-intensive conditions are necessary. This type of data is lacking for the availability of common cereal brans, agricultural by products and other possible ingredients that can be used for fish feed formulation. The objectives of the present study are to evaluate the potential of fish feed production from locally available by products in the Kenyan coastal region and compare the performance of available ingredients on growth and to assess profitability of the feedstuffs in the production of milkfish.

It is of great importance that the fish feeds are made in such a way that both quality and quantity are achieved in the feeding regimes while a cost effective practice is met in the whole enterprise. This research aimed at evaluating potential for cheap feeds from locally available materials without compromising on quality of the feeds such that the farmers gain from high food conversion ratios achieved. The study provided information on how the locally available agricultural by-products can be combined to formulate high quality feeds to be used in the aquaculture activities within the vicinity of the areas of the farm. In using these locally available agricultural by-products, by-catch and fish waste, value is added to the otherwise unused materials which acts as an avenue of creating jobs for the local people.

This study was aimed to see the effect of formulated diets and non-formulated diets on growth of milkfish fingerlings reared in laboratory tanks with an objective to develop artificial diets that would promote high survival as well as growth of milkfish fry.

2.0 Material and methods

2.1 Study area

This research took place in Kenyan coastal region and within the framework of Kenya Marine and Fisheries Research Institute (KMFRI). The period of investigation was from August 2013 to July 2014.

2.2 Field Survey

A survey of the locally available ingredients was conducted in the Kwale County which is located in Southern Coast of Kenya and bordering the Republic of Tanzania to the South West. The specific places visited included; major markets, processing factories (coconut, rice, sugar and maize millers), beach hotels, landing beaches, slaughter houses and agricultural areas. The field survey was conducted by administering questionnaires interviews and general observation. Samples intended for further analysis were collected and taken for analysis in KMFRI laboratory.

2.3 Experimental fish and management

Freshly caught milkfish fingerlings were acclimated to laboratory conditions for 3 days before start of the feeding trial. Twelve 20 litre aerated flow through circular tanks filled with marine water were used. Milkfish fingerlings with an initial mean body weight of 6.5 g and mean total length of 7.8 cm were stocked at the rate of 20 fish per tank. The tanks were located inside a wet laboratory with regular 12hr light and 12 hr dark photoperiods. Differences in total length and body weight of these juveniles were analyzed with a non-parametric analysis of variance [8]. No significant differences were found in the initial total length and body weight of the fish stocked in the different experimental units (Kruskal–Wallis; $H = 0.62$, $P = 0.83$).

Fish management activities involved cleaning of the tanks every morning before first feeding and checking for mortality. About two thirds of the water was replaced after each cleaning. The fish were fed twice daily at 10am and 4pm at a feeding rate of 5% body weight. At two weeks interval 5 fish were sampled for individual body weight and total length measurements. Feeding rate adjustments were therefore based on average weight per tank and the number of survivors. All the fish were counted and weighed at the end of the experiment.

2.4 Experimental design and diet formulation

The experiment was conducted in a complete randomized design where four feeding treatments with three replicates each were assigned to the fish. Two isonitrogenous diets (30% CP), were formulated from trash fish and rice bran. One of the formulated diet (FV) was supplemented with commercial vitamin and mineral premixes at 1% and 2.5% inclusion levels respectively. The other feed (FW) did not contain the premixes. The composition of the premix is shown in table 1. Local produced coconut cake (CC) and maize bran (MB) were bought from a processing factory and used as treatment three and four. Dried ingredients were mixed thoroughly, pelletized and the feed dried and stored for feeding the candidate fish.

Table 1: Vitamin and mineral composition of the local premix

Vitamin and mineral composition of the premix			
Vitamins	Content	Minerals	Content (mg)
A	5,000,000 IU	Calcium pantothenate	5000
B1	600 mg	Nicotinic acid	5500
B2	2500 mg	Zinc oxide	70
B6	125 mg	manganese iodide	300
B12	7.5 mg	manganese sulphide	90
C	200 mg	copper sulphate	1.5
D	1,000,000 IU		
E	1,500 IU		
K	1250 mg		

2.5 Proximate analysis of the diets

Sun-dried and ground feed samples purchased locally were taken to the KMFRI Mombasa station laboratory for analysis where they were further ground into finer particles using an electric grinder fitted with a 1 mm *sieve (Thomas-Wiley intermediate mill, 3348-L10 series,* USA) and dried in an oven to a constant weight at 60 °C. Analyses of crude protein, crude fibre, ether extracts, ash and moisture content were done in triplicates, generally following the procedure [9]. Crude protein was quantified by the standard micro-Kjeldahl Nitrogen method, using a sample size of 0.5 g, a Behroset InKje M digestion apparatus and a Behr S 1 steam distillation apparatus (both: Labor-Technik GmbH, Düsseldorf, Germany). The distillate containing ammonia was trapped in 4% boric acid solution prior to titration with 0.1N HCl. Crude protein was estimated by multiplying the nitrogen content with a factor of 6.25. Ether extracts were analyzed using a sample size of 2 g in a soxhlet extractor with petroleum ether (boiling point 40–60 °C). Crude fiber (CF) was determined by boiling 2 g of sample in a standard solution of 3.13% H_2SO_4 for 10 minutes. The remaining sample was rinsed with hot water followed by boiling in 3.13% NaOH for another 10 minutes. Thereafter the remaining sample was rinsed repeatedly with hot water followed by acetone. The residue was oven dried at 60° C for 4 hours, cooled in a desiccator and weighed. The residue was ashed at 550 °C in a muffle furnace overnight. CF was quantified by expressing the loss in weight after ashing as a percentage of the original weight of the sample. Dry matter (DM) was determined by drying 5 grams of sample in an oven for six hours to constant weight at 105 °C. Nitrogen Free Extracts were estimated by difference (DM-CP-EE-CF-Ash). To come up with 28% crude protein diet to be used for the experiment, Pearson's square method of feed formulation was used and the above procedure repeated to get the proximate composition of the prepared feeds.

2.6 Fish sampling and growth analysis

Fish from tanks were sampled on a biweekly basis. The weights of 5 fish was measured using a weighing bench scale, TCM, TChibo GmbH 221 144, Hamburg model, to the nearest 0.1 g. The average fish weight per tank at the end of the experiment was determined by counting and bulk weighing all milk fish harvested. The fish were removed from the tanks using a scoop net. To reduce stress, the fish were held in plastic sampling basins halfway filled with tank water. Further caution in fish handling was ensured by aerating the water using a 12 Volt aquarium aerator to ensure adequate dissolved oxygen concentrations. To ensure continuous marine water supply to the fish during handling, water was replaced in the basins after each tank handling. The experiment period lasted for 92 days. Fish growth calculations involved computation of mean weight (g) and their standard deviations (± SD) for fish samples from each treatment at each sampling occasion. Graphical plots of mean weights against time were used to visualize growth. At the end of the experiment all fish were harvested and weighed up to the nearest 0.1 g. Specific growth rate (% body weight day^{-1}) was calculated using the formula, *SGR (*lnWTF−lnWTI*)* 100/T* where WTF=average final fish weight (g), WTI=average initial fish weight (g), T=duration of the experiment (days).

Geometric mean body weight (Wg)

Geometric mean body weight was calculated to determine the estimate for the body weight of the fish at the middle of the experiment period.

Wg=e((lnWTF + lnWTI)/2**)**

Metabolic growth (RGRm)

Metabolic growth was calculated to determine the growth achieved by the fish after utilizing the available food to generate energy for metabolism during the experiment period. This formula was used

RGRm=(WTF-WTI) Wg0.8/T

Survival

Survival was estimated by checking the tanks daily for dead fish and recording the number of dead fish and removing them. Survival was calculated by subtracting the number of dead fish from the initial number stocked. Survival percentage = Final number of fish/ initial number x 100

Gross fish yield (GFY)

This is the total biomass of fish at harvesting given by the formula: Final number of fish x final average weight (g).

Net fish yield (NFY)

To obtain NFY, the biomass at stocking was subtracted from the gross fish yield. The final yield was then converted to Kg unit ha^{-1}.

Apparent feed conversion ratio (Apparent FCR)

Feed conversion ratio is the ratio of the quantity of food distributed (g) to the weight gain of fish (g), over the culture period. This was used to judge the efficiency of feed utilization by fish for both diets. It was calculated by dividing the total amount of feed used (dry matter basis) and then dividing by the weight gain of the fish.

2.7 Water quality analysis

Samples for tank water quality were taken biweekly using 250 ml clean bottles. Water samples were taken between 0700 to 0800 hrs from tanks and taken for water quality analysis in the KMFRI laboratory. Temperature (Celsius thermometer), dissolved oxygen (HI 9142 DO Meter Hanna instruments), pH range (HI 9024 Hanna Instruments) and salinity (salinometer HM digital) were measured in situ. Water samples from the tanks were filtered through microfiber glass filter paper (Whatman GF/C 45 mm diameter), using a vacuum pressure air pump. The filtered water was used for the analysis of dissolved nutrients: ammonium-nitrogen (NH_4-N), nitrate nitrogen (NO_3-N), nitrite nitrogen (NO_2-N) and soluble reactive phosphorus (PO_4-P). The filter paper was kept in a test tube containing 10 ml of 90% acetone, ground with a glass rod and preserved in a refrigerator for 24hrs. Later chlorophyll-*a* was determined spectrophotometrically (Milton Roy Spectronic, model 1001 plus) at 750 and 633 nm wavelength following Boyd (2002). The procedures followed were according to standard methods described in American Public Health Association [10] cross-referenced to Boyd and [11]. To avoid contamination, all the glassware was acid washed and rinsed with distilled water before use.

2.8 Characterization of Ingredients and digestibility studies

Digestibility studies were conducted to determine the least cost diet formulation and screen for feed stuff potential nutritive value in relation to raw material, quality, processing and storage conditions. Apparent digestibility coefficients (ADC) of the diets were determined at the KMFRI nutritional laboratory in triplicate using fish weighing 30 to 35 g. This was done according to [12]. In each diet 8 g of chromic oxide (Cr_2O_3) an inert marker was mixed with 1 kg feed to give 0.8% concentration of Cr_2O_3. Feaces were collected by internal dissection method of a sample of 5 fish per treatment. Fecal matter was oven dried at 50℃ for 5 hrs and kept in a dry container for composition analysis by acid digestion and spectrophotometric methods. The feed samples were ground and sieved to pass through the 0.5 mm sieve before using them for analysis. Fecal samples from two tank replicates had to be pooled for chemical analysis. The collected feed and ashed feces were oxidized by boiling the samples in a solution of 2.5% sodium molybdate dissolved in 30% water, 30% sulphuric acid and 40% perchloric acid (70%mv). A known weight of 2 mg of chromic oxide was oxidized and used as the standard with feed and ashed fecal samples used as blanks. After oxidation, chromium content was measured in dilute solutions from the color complex formed by the interaction of hexavalent chromium with diphenylcarbazide calorimetry (DPC) at 370 nm. The below equation was used to calculate the apparent digestibility coefficients for the ingredients;

$$\text{ADC nutrient\%} = \frac{\text{1-(Marker in diet)}}{\text{(Marker in feaces)}} \; \frac{\text{(Nutrient in diet) X 100}}{\text{X (Nutrient in feaces)}}$$

3.0 Data analysis and statistical tests

Growth and yield parameters (growth, yield, food conversion ratio, specific growth rate, metabolic growth rate, geometric mean body weight and survival) were analyzed by one way ANOVA. Prior to analysis, the data was checked for normality and percentage data were arcsine transformed. Data were expressed as mean ± S.E. or ± S.D and statistically analyzed by one way ANOVA [13]. Water quality data was analyzed by repeated measures ANOVA with treatment diet as the main factor and time as sub-factor. Digestibility data was analyzed by one way ANOVA. All ANOVA were performed using SPSS (Statistical Package for Social Science) version 18. If the main effect was found significant, the ANOVA was followed by a Tukey ‘s Test at P<0.05 level of significance.

4.0 Results

4.1 Survey of readily available ingredients

Results of the reconnaissance survey of fish feeds ingredients done in Kwale county, South Coast of Kenya, are shown in table 2. The county has three main districts (Msambweni, Lunga lunga and Kinango). During the survey main ingredients were identified, their location, their classification, quality (scale of 1-best and 4-worst), seasonality and perishability. Within each district, different locations were visited, main areas including; markets, processing factories, beach hotels, landing beaches, private homesteads and slaughter houses. Questionnaires were used for data collection. Precisely, from the markets, both agricultural and fish byproducts were available, factories processed mainly coconut and sugar cane. Rice and maize bran was available from millers. Beach hotels had a high percentage of fish as waste and were willing to sell it out. In the landing beaches a number of items were available for instance fish head cuttings, by catch on request, scales and fish offal. Coconut, maize, cowpeas, beans and cotton were available in markets and different homesteads. In the slaughter houses blood meal was available.

Table 2: Results of the ingredients survey in Kwale county (scale of 1-best and 4-worst).

District	Location/village	Ingredients	Class	Quality (1,2,3,4)	Seasonality	Perishability
Msabweni	Tiwi	Fish offal	protein	2	All yr round	High
	Kinondo	bycatch	protein	3	All yr round	High
	Mwabanda	Rice bran	Energy	2	At harvest	Low
	Ngoba	Ricebran/coconut	Energy	1	At harvest	Low
	Town	Blood meal	Protein	2	All yr round	High
Kinango	Town	Fish meal	Protein	2	All yr round	High
Lungalunga	Mwagaro	Seashells	Minerals	2	All yr round	Low
	Majoreni	Bycatch	protein	3	All yr round	High
	Pwongwe	Coconut cake	Energy	3	All yr round	Low
	kikoneni	Maize bran	Energy	3	All yr round	Low
	Lungalunga town	Blood meal	protein	2	All yr round	High
	Vanga	Fish offcuts	protein	2	All yr round	Medium
	Tego	Rice bran	Energy	2	At harvest	Low

4.2 Growth, Survival and yield parameters of milkfish

Growth and yield parameters of milkfish and their combined performances under different treatments are shown in table 3. The ANOVA results showed that there were significant differences (P<0.05) in fish growth among the dietary treatments Fig 1. Fish that were fed on formulated diets exhibited significantly higher (P<0.05) mean weight gain, specific growth rates, geometric mean body weight, metabolic growth, yields and lower food conversion ratio than those fed on CC and MB. Fish that were fed on non-formulated diets had statistically similar (P>0.05) growth performance. Feed conversion ratio differed significantly (P<0.05) among the formulated diets. Coconut cake and MB had statistically different (P<0.05) FCR. FV had significantly different (P<0.05) geometric mean body weight and metabolic growth compared to the other three treatments. There was no significant difference (P>0.05) in survival rates among all the dietary treatments.

Table 3: Performance of milkfish fed on different dietary treatments; FV: formulation with vitamins and minerals premix, FW: formulation without vitamins and mineral premix, CC: coconut cake, MB: maize bran. The mean values followed by the different superscript letter within treatment indicate significant difference at (P<0.05). If the effects were significant, ANOVA was followed by Tukey test. *P<0.05

Growth parameters	Means tukey test Treatments			
20 fish per tank	FV	FW	CC	MB
Stocking weight (g)	6.8^{a}	6.4^{a}	6.2^{a}	6.5^{a}
Harvest weight (g)	34.3^{b}	34.3^{b}	31.3^{a}	31.1^{a}
Weight gain (g)	27.5^{b}	27.9^{b}	25^{a}	24.5^{a}
Specific growth rate (%bwd^{-1})	1.4^{b}	1.43^{b}	1.27^{a}	1.22^{a}
Feed conversion ratio	1.22^{ab}	1.51^{bc}	1.26^{ab}	2.2^{c}
Geometric mean body weight (g)	16.3^{b}	14.5^{a}	13.8^{a}	14^{a}
Metabolic growth (gbw/d/kg^0.8)	30.9^{b}	25.9^{a}	28.6^{a}	27.4^{a}
Survival (%)	80^{a}	85^{a}	75^{a}	81^{a}
Gross yield (Kgha^{-1} 92d^{-1})	5506^{a}	5845^{a}	4701^{a}	5099^{a}
Net yield (Kgha^{-1} 92d^{-1})	3940^{a}	4555^{a}	3454^{a}	3796^{a}

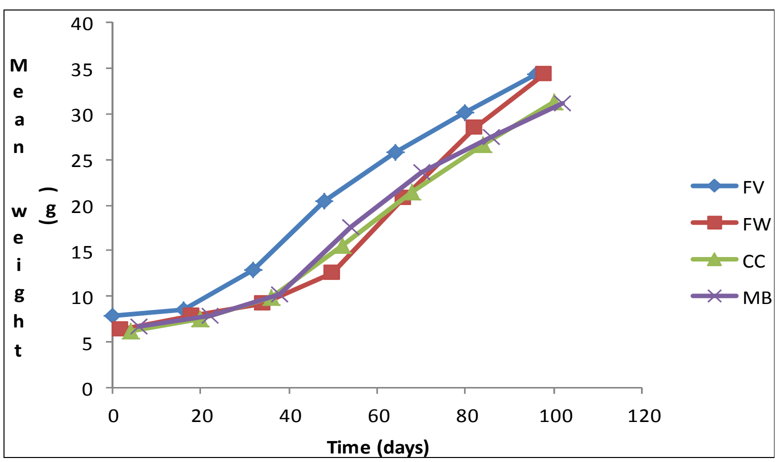

Fig 1: Growth curves for milkfish (*Chanos chanos*) under different dietary treatments (FV formulation with vitamins and mineral premix; FW formulation without vitamin and mineral premix; CC coconut cake; MB maize bran)

4.3 Water quality parameters

Mean values of water quality parameters and outcomes of ANOVA are presented in Table 4. Among the four treatments, there were no significant differences in temperature, salinity, PH, TAN, nitrates, nitrites and chlorophyll-a. Significant differences at (P<0.05) were seen in the dissolved oxygen and phosphate concentrations. Dissolved oxygen was high in FV treatment and low in the CC treatment while phosphates were high in the CC treatment. There was no significant effect on the day period when dissolved oxygen, temperature and pH were sampled. For the same parameters there was significant interaction effect between the treatment and sampling time.

Table 4: Treatment effect and sampling time on different water quality parameters based on one-way ANOVA. The mean values followed by the different superscript letter within factor indicate significant difference at (P<0.05). If the effects were significant, ANOVA was followed by Tukey test. *P<0.05;**P<0.01; ***P<0.001

Water quality parameters	Means Tukey test						
	Treatments				Day Period		Interaction
Parameters	FV	FW	CC	MB	Morning	Afternoon	Treatment X DAY
Dissolved Oxygen(mgl^{-1})	7.3^{c}	6.7^{b}	4.5^{a}	6.3^{b}	6.4^{ab}	6.5^{ab}	***
Temperature (C)	24^{a}	24.2^{a}	24.6^{a}	24.4^{a}	24.5^{a}	24.2^{a}	***
PH	7.2^{a}	7.3^{a}	7.2^{a}	7.1^{a}	7.2^{a}	7.3^{a}	***
Salinity (ppt)	32.3^{a}	34.2^{a}	33.1^{a}	35.4^{a}			
TAN (mgL^{-1})	0.127^{a}	0.183^{a}	0.186^{a}	0.158^{a}			
NO_2N (mgL^{-1})	0.138^{a}	0.169^{a}	0.155^{a}	0.193^{a}			
NO_3N (mgL^{-1})	0.072^{a}	0.058^{a}	0.026^{a}	0.017^{a}			
Chloropylla (µgL^{-1})	107^{a}	115.4^{a}	112.8^{a}	114.5^{a}			
Phosphates (mgL^{-1})	0.122^{a}	0.273^{ab}	0.168^{a}	0.277^{ab}			

4.4 Proximate analysis of test diets

Results of proximate composition of the diets are shown in table 5. Fecal matter was also analyzed for proximate composition to be able to calculate for the nutrient digestibility of the different treatments. FV had the highest protein content (300 g/kg^{-1}) with FW and CC having (295 g/kg^{-1}) and (227 g/kg^{-1}) respectively. FV and FW had the highest amount of crude fat (72 g/kg^{-1}). CC had the highest amount of crude fibre (125 g/kg^{-1}) and dry matter (904 g/kg^{-1}). FV had the highest amount of ash content (132 g/kg^{-1}). Nitrogen free extracts (NFE) were highest in MB diet (579 g/kg^{-1}). Rice bran and maize bran in this diet were included at 33.25% to allow for the premix.

Table 5: Chemical characterization and composition of the diets used

% Composition of the artificial diets				
Ingredient	**FV**	**FW**	**CC**	**MB**
Trash fish meal	30	30		
Rice bran	33.25	35		
Maize bran	33.25	35		
Vitamin mix	1.0	-		
Mineral mix	2.5	-		
Cr_2O_3	0.8	0.8	0.8	0.8
Total	100	100		
Proximate composition of the diet (% on wet weight basis)				
Crude protein	30	29.5	22.7	11.7
Crude fat	7.2	7.2	5.8	3.9
Crude fibre	5.1	4.9	12.5	12.2
Dry matter	87.4	88.2	90.4	89.8
Ash	13.2	11.8	7.4	4.1
NFE	31.9	34.8	42.4	57.9
Proximate composition of fecal material (% on wet weight basis)				
Crude protein	3.0	2.8	2.0	1.5
Crude fat	0.2	0.2	0.2	0.1
Crude fibre	0.7	0.6	0.7	0.9
Dry matter	8.5	7.8	8.9	9.0
Ash	0.2	0.3	0.4	0.3

4.5 Digestibility of the diets

Results of the digestibility studies are shown in table 6. The Apparent digestibility coefficient (ADC) values varied significantly between the formulated diets (FV, FW) and non-formulated diets (CC, MB). Coconut cake diet had the least digestibility coefficient among the nutrients which was significantly different at P<0.05 except for crude fats which was did not differ significantly in all the treatments P>0.05.

Table 6: Apparent digestibility coefficient % of the experimental diets

Nutrients	Means Tukey test: Diets			
	FV	FW	CC	MB
Dry matter	97.44^{b}	87.55^{ab}	80.47^{a}	92.19^{ab}
Crude protein	87.61^{ab}	85.51^{ab}	82.52^{a}	90.01^{ab}
Crude fats	96.56^{a}	95.34^{a}	94.87^{a}	97.6^{a}
Crude fibre	88.21^{b}	82.87^{a}	80.52^{a}	94.38^{b}
Crude Ash	97.93^{b}	95.81^{b}	82.71^{a}	93.92^{b}

5.0 Discussion

5.1 Growth, Survival and yield parameters of milkfish

Yield parameters of milkfish varied in the different treatments and there was also a significant effect on growth. The growth curves in figure 1 show an exponential and a linear phase of growth. In the exponential growth phase the treatment growth curves overlapped and demonstrated first growth as a result of efficient utilization of dietary proteins. Feeding the fish on the formulated diets resulted in significantly higher mean fish weight gain than that of fish fed on coconut cake (CC) and maize bran (MB). However, fish that fed on diets formulated with or without vitamins and mineral premix had similar mean weights. We therefore deduced that supplementation of the formulated diets with vitamins and mineral premix did not significantly improve growth of milkfish but could have promoted the well-being of the fish. This observation is of importance to small scale farmers are encouraged to formulate simple diets for milkfish production in ponds where there is primary production of natural foods for vitamins and mineral supplementation. In *O.niloticus* ponds, studies by [6] showed that exclusion of premixes lead to 20% reduction in feed cost. In the same study data on economic performance indicated positive returns. Economic analyses were not done for the present study considering the short culture period leaving the fish no time to reach market size. However, the growth of fish fed on CC and MB was similar, implying that MB was also effective in production of milkfish but for good results it needs to be combined with a protein supplement. It was observed that since coconut cake is readily available in the coastal region it could be a suitable substitute for maize bran.

5.2 Water quality parameters

Water quality management is of imperative importance in aquaculture. It is usually strongly influenced by culture species combinations, quality and quantity of nutrient inputs and culture system used [14]. In the present study water temperature, salinity and pH were within the suitable range for tropical fish culture [15]. Dissolved oxygen was also within range in other treatments but significantly low in the CC treatment which could be as a result of the fat content in the diet and time taken before the feed is eaten by the fish. Total ammonia nitrogen (TAN) ranged between 0.12-0.18 mg/l in all the treatments which was far below the toxicity level of (21mg/l) recorded by [16]. The source of ammonia was probably from decomposing uneaten feed and fish excreta. The low levels of nutrients (nitrates, nitrites, phosphates and chlorophyll-a) could have been attributed by the high exchange rate of water in the culture tanks.

5.3 Proximate analysis of test diets

Results from proximate analysis in the present study demonstrated that the test diets (FV, FW, CC and MB) differed both in nutritional quality and efficiency. Low levels of fibre in the test diets showed an increase in fish growth irrespective of the level of dietary protein suggesting that the test feeds were utilized primarily as energy substrates. High fiber levels in fish diets have been reported to reduce growth and dietary protein utilization in a number of species [17, 18]. The high crude protein level in the formulated diets (FV and FW) contributed to high weight gain as compared to the CC and MB diets.

5.4 Digestibility of the diets
Determination of digestibility of fish feed ingredient is the first priority when evaluating its inclusion in a feed [19]. Apparent digestibility coefficients for dry matter, crude protein, crude fats, crude fibre and crude ash were determined using 0.8% chromic oxide as an external indicator [20]. In this study the digestibility results are in agreement with findings of other research done previously even though different methodologies were used. [21] reported an apparent digestibility coefficient protein value of 87% for fish meal and in his study he used intestinal dissection for collection of faeces. In this study the apparent digestibility coefficient for protein varied between 82% and 90% for all the test diets. Coconut cake had low apparent digestibility coefficient which might have been due high concentration of fiber. Condition of the candidate fish being young could have probably showed a decrease in digestibility due to presence of anti-nutritional factors in the test diets.

6. Conclusions and recommendations
The findings of this study demonstrated that formulated feed supplements were suitable in production of milkfish while the locally available coconut cake can be used as a replacement for maize bran. The study also exhibited that supplementation with vitamin and mineral premixes with intent of growth promotion may not be necessary but could be important for health and disease control. Water quality did not vary much but in practical milkfish pond culture farmers should be encouraged to monitor water quality to avoid unnecessary mortalities. Cheap, easily digestible and quality locally available supplementary feeds used in the study like fish meal and rice bran combinations, coconut cake and fish meal combinations are recommended to promote faster growth with minimal environmental impacts. Extension of this study by rearing the fish for more days could perhaps show some distinct differences in growth between the fish fed on formulated diets and those fed on the other test diets. Use of sea cages where the fish is exposed to natural conditions to test the diets could also be explored.

7. Acknowledgements
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