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Original Article

Evaluation of growth performance and feed utilization of *Oreochromis shiranus* and *Coptodon rendalli* fed diets combining *Moringa oleifera* leaf meal and *Cajanus cajan* meal

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Abstract: This study evaluated the growth performance and feed utilization of *Oreochromis shiranus* and *Coptodon rendalli* fed on diets combining *Moringa oleifera* leaf and *Cajanus cajan*. A factorial experiment (4×2) in a Completely Randomized Design with three replicates was used. *Oreochromis shiranus* and *C. rendalli* (22.20±2.03 g) were randomly selected, assigned to 24 experimental units and reared for 90 days. The fish were fed 32% protein diets formulated as follows: Diet 1- Control (0 g/kg *M. oleifera* leaf and 0 g/kg *C. cajan*), Diet 2 (100 g/kg *M. oleifera* leaf + 150 g/kg *C. cajan*), Diet 3 - (200 g/kg *M. oleifera* leaf + 300 g/kg *C. cajan*), and Diet 4 (300 g/kg *M. oleifera* leaf + 450 g/kg *C. cajan*). The results revealed that there were significant differences in final body weight, body weight gain, and specific growth rate among dietary treatments for both species ($P<0.05$). *Coptodon rendalli* performed better in final body weight, weight gain, and specific growth (60.94±0.54 g, 39.47±0.53 g and 1.13±0.02 %/d, respectively) than *O. shiranus* when fed Diet 2. However, no significant difference was recorded in condition factor (CF) among the dietary treatments for both species ($P>0.05$). *Coptodon rendalli* obtained the best apparent feed conversion ratio (2.75±0.06) and protein efficiency ratio (0.73±0.02) than *O shiranus,* when fed Diet 2. It is therefore concluded that Diet 2 (100g/kg *M. oleifera* leaf + 150g/kg *C. cajan*) recorded the best growth performance and feed utilization for both species and can replace soybean meal as a fish feed ingredient.

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Introduction

The increase in the world's human population in the middle of the 21st century has brought enormous challenges in providing food to livelihoods. Aquaculture and fisheries are key areas for food, nutrition and employment of millions of people (FAO, 2018). However, studies have demonstrated that the future of the aquaculture industry will depend on the sustainable supply of plant proteins for feeds (Hoseini et al., 2017). Soybean meal is widely used as a source of protein for livestock and specifically for herbivorous and omnivorous fish in feed formulation (Hoseini et al., 2018). However, the high cost of this raw material, associated with the competition of this ingredient for human and livestock consumption, has caused problems for fish farmers (Karina et al., 2015). This situation calls for an urgent need to examine other valuable and locally available resources as alternative protein sources for fish feed (Egwui, 2013). Several alternative plants have been investigated for their potential use in replacing soybean-based feed.

Moringa Oleifera leaves and *Cajanus cajan* seed have been identified as contributing to fish nutrition with the possibility of reducing th the possibility to reduce dependence on soybean meal (Karina et al., 2015; Salmon et al., 2017). Additionally, given the availability of these plant ingredients in Mozambique, *M. oleifera* leaves and *C. cajan* seed are considered cheaper than soybean meal. A study by Nouman et al. (2014) showed that *M. oleifera* tolerates adverse conditions, is high yielding and adaptable to different agro ecological zones. Their leaves contain 26.4% crude protein and are rich in vitamins and minerals. Furthermore, *M. oleifera* leaves contain saponins and

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Table 1. Chemical composition (%) of feed ingredients on dry matter basis

Ingredients	Crude protein (%)	Dry matter (%)	Ash (%)	Crude fat (%)	Crude fiber (%)	Gross energy (Cal/g)
Soybean meal (roasted)	43.85±0.16	92.70±0.13	5.01±0.07	15.05±0.04	5.08±0.01	4507±11.55
C. cajan seed (roasted)	35.01±0.22	90.66±0.40	6.88±0.14	16.20±0.21	7.77±0.08	2381±21.93
M. oleifera leaf	27.89±0.18	89.81±0.43	8.89±0.89	6.72±0.03	8.89±0.11	2500±13.22
E.sardella (Sundried)	63.50±0.27	92.62±0.84	8.20±0.35	11.86±0.18	0.22±0.01	5019±12.37
Yellow maize	8.82±0.24	92.20±0.08	5.20±0.18	2.34±0.53	1.03±0.10	2297±10.40
Rice bran	9.28±0.34	92.95±0.13	15.76±0.08	6.55±0.08	14.77±0.66	2326±8.74
Wheat bran	14.96±0.28	93.95±0.18	4.34±0.02	3.85±0.91	11.21±0.45	2622±14.89
Casava root	1.2±0.28	91.02±0.40	1.82±0.59	1.42±0.17	3.46±0.33	2335±9.70

Values are the mean ± Standard deviation; n=3

phenols as anti-nutritional factors (Egwui, 2013). On the other hand, *C. cajan* is an important leguminous crop that can be grown under rainfed conditions with the least inputs and is ideally suitable for production on small farms (Walker, 2015). Humans have less preference for *C. cajan* seed for food consumption (Majili et al., 2020). These factors make it inexpensive to be considered as a feed ingredient (Foidl et al., 2001).

Moringa oleifera leaves can replace soybean meal in tilapia diet at 10 to 30% (Bello and Nzeh, 2013; Ganzon-Naret, 2014; Mehdi et al., 2016; El-El-Rahman et al., 2017). In the same way, researchers indicated that *C. cajan* seed can replace soybean meal at 10 to 45% (Ndau and Madalla, 2015). However, the combined effects of both herbal materials as soybean meal alternatives should be determined in *Oreochromis shirannus* and *Coptodon rendalli*. Therefore, the present study aimed to evaluate the effects of combining dietary *M. oleifera* leaf and *C. cajan* seed on growth performance and feed utilization of *O. shiranus* and *C. rendalli.*

Materials and Methods

The study was conducted at Bunda Fish Farm located at Lilongwe University of Agriculture and Natural Resources (LUANAR), in Lilongwe, Malawi (33°50'E, 14°35'S), from 15th August to 15th November 2019 for 90 days.

Feed formulation: The following ingredients were used to formulate different diets: *M. oleifera* leaf, *C. cajan* seed, fish (*Eugraliciprys sardella*) meal, wheat bran, soybean meal, cassava root, yellow maize flour, additives (vitamin and mineral premixes and amino acids). The trial-and-error method was used to formulate the feed. Each treatment contained 32% crude protein. The raw materials were sourced from the Faculty of Agriculture farm of the Catholic University of Mozambique (CUM) and at 25 de Setembro market in Niassa Province of Mozambique.

The *M. oleifera* leaves were dried under shade and processed using a hammer mill to reduce anti-nutritional contents (Nsofor et al., 2012). While *C. cajan* seed was autoclaved at 121°C for one hour and processed using a hammer mill also to reduce anti-nutritional contents (Salmon et al., 2017). The other ingredients were also milled as above to facilitate the production of feed. First, the ground ingredients were analyzed for chemical composition (Table 1) following standard methods (AOAC, 2011).

The ingredients were used to formulate four diets to replace soybean meal with *M. oleifera* leaf and *C. cajan* seed meal at 0, 100, 200, and 300 g/kg, and 0, 150, 300, and 450 g/kg, respectively. These concentrations were selected based on the maximum of 300 g/kg of *M. oleifera* leaves that can replace soybean meal in the dietary for tilapia (Bello and Nzeh, 2013; Ganzon-Naret, 2014; Karina et al., 2015; Mehdi et al., 2016; El-El-Rahman et al., 2017) and maximum of 450 g/kg of *C. cajan* that can replace soybean in the dietary for tilapia (Ndau and Madalla, 2015) without causing any negative effect on the fish performance. The feed were formulated locally and amino acids, minerals + vitamins were added to the experimental trial (Table 2). All dry materials were mixed and stirred homogeneously and then water was

Table 2. Dietary and nutrient compositions of the formulated diets.

	Diets[1]			
Soybean meal	Diet 1	Diet 2	Diet 3	Diet 4
M. oleifera meal	59.65	44.65	29.65	14.65
C. cajan seed meal	0.00	5.65	11.65	17.65
Fish meal	0.00	8.65	17.65	26.65
Rice bran	3.65	7.65	11.65	14.65
Yellow maize meal	8.65	4.65	7.65	3.65
Cassava	11.65	11.65	9.65	11.65
Wheat Bran	4.65	4.65	4.65	4.65
Mineral+Vitamin[2]	9.65	10.65	5.65	4.65
Monocalcium phosphate	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50
Lysine%	0.50	0.50	0.50	0.50
Methionine %	0.20	0.20	0.20	0.20
Lime stone	0.20	0.20	0.20	0.20
Analyzed Proximate composition	0.20	0.20	0.20	0.20
Crude Protein %				
Gross Energy Cal/g	32.59	32.78	32.93	32.76
Moisture %	3768.89	3564.85	3346.59	3112.08
Ash %	92.70	92.33	91.86	91.53
Crude Fat %	6.26	6.36	6.86	7.32
Crude Fiber %	10.83	10.65	10.52	10.39
Soybean meal	5.00	5..58	5.92.	6.04

[1]Diets: 1- reference, 2- test diet (100g/kg *M. oleifera* leaf+ 150g/kg *C. cajan*), 3 – test diet (200g/kg *M. oleifera* leaf + 300g/kg *C. cajan*) and 4- test diet (300g/kg *M. oleifera* leaf + 450g/kg *C. cajan*). [2]Mineral+Vitamins: calcium 26%, phosphorous 9 %, salt 4 %, selenium 0.2mg/kg, methionine 100 mg/kg vitamin A 8,000,000 IU, vitamin E 8,000 IU, vitamin D3 3,000,000 IU, vitamin 2,000 MG, pantothenic acid.

added gradually. The mixed ingredients were pressed into pellets of about 1.5 mm using a manual processing machine (Paray et al., 2020).

Experimental fish: The fish fingerlings were obtained from the propagation of broodstocks in Lilongwe University of Agriculture and Natural Resources (LUANAR). Juveniles of 22.20±2.03 g were selected and randomly placed in 24 experimental units. A 4 × 2 factorial experiment in Completely Randomized Design with three replications was used. Species had two levels (*C. rendalli* and *O. shiranus*) while diets had four levels: (1) Control, (2) 100g/kg *M. oleifera* leaf + 150g/kg *C. cajan*, (3) 200g/kg *M. oleifera* leaf + 300 g/kg *C. cajan* and (4) 300 g/kg *M. oleifera* leaf + 450 g/kg *C. cajan*. A total of 24 hapas of 4 m^2 each with stoking density of 5 fish/ m^2 was used. The total number of 480 fish was used (240 *O. shiranus* and 240 *C. rendalli*). Fish were hand-fed twice a day (9:00 AM and 14:00 PM) at 5% body weight (Saravanan et al., 2012). The experiment lasted for 90 days.

Calculation of fish growth performance: Body weight gain, Specific growth rate, condition factor and survival rate were determined using the following formulae (Adineh et al., 2021):

Body weight gain (BWG) (g) = Mean final weight (g) – Mean initial weight (g)

Specific growth rate (SGR) (%/day) = 100 [(LnWf (g) – LnWi (g)]/t (days)

Condition factor (K) = [W(g)/L^3(cm)]*100

Survival rates (SR) (%) = (Final number of fishes/ Initial number of fishes)*100

Where, W is weight in grams and L is standard length in cm.

Determination of feed utilization parameters: Total amount of feed given to the fish during the study period were recorded and the apparent feed conversion ratio and the protein efficiency ratio were calculated using the following formula (Hoseini et al., 2022):

Apparent Feed Conversion Ratio (AFCR) = Total feed given (g)/weight gain (g)

Apparent Protein Efficiency Ratio (APER) = Weight

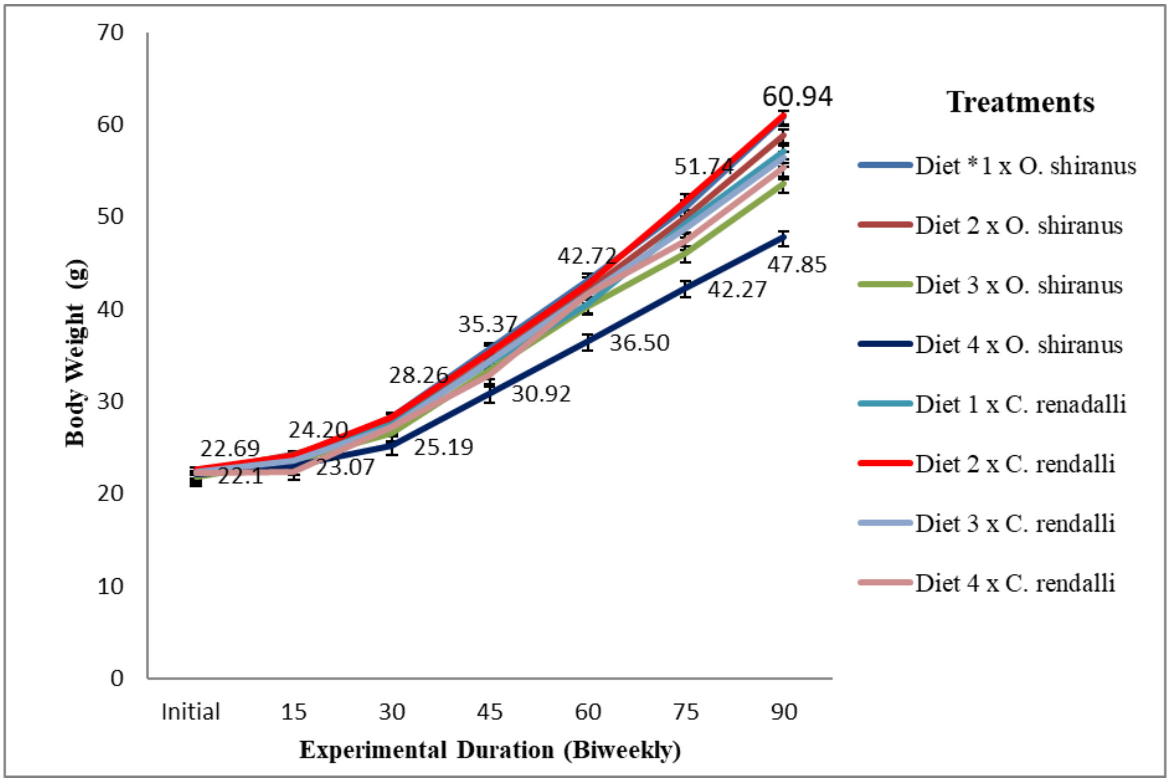

Figure 1. Biweekly increase in weight of *O. shiranus* and *C. rendalli* fed diets combining *M. oleifera* leaf and *C. cajan* meal. *Diets: 1- control, 2- (100 g/kg *M. oleifera* leaf + 150 g/kg *C. cajan*), 3 – (200 g/kg *M. oleifera* leaf + 300 g/kg *C. cajan*) and 4- (300 g/kg *M. oleifera* leaf + 450 g/kg *C. cajan*). Data are presented as mean ± SD (n =3).

gain (g)/Protein intake (g)

Water quality parameters: Water quality parameters such as temperature, pH and dissolved oxygen concentration (DO) were measured at 20 cm below the water surface twice a day (morning 06: 00 h and afternoon 14:00 h). While ammonia (NH_4), nitrate (NO_3), nitrites (NO_2) and phosphate (PO_4) were monitored biweekly using APHA method.

Data analysis: Data were analyzed using Statistical analysis system (SISVAR) V.13 and Excel was used to plot graphs. Shapiro-Wilk and Levene's tests were used to check for normality and equality of variance. Therefore, analysis of variance (Two-Way ANOVA) was performed to test for significant variation in different parameters among the treatment combinations at 0.05 alpha level. Turkey`s test was used to separate differences among individual treatments.

Results

Growth performance: The results presented in Table 3 indicated that for weight gain, final body weight and specific growth rate (SGR) presented significant difference of diets and species as well as the interaction between factors ($P<0.05$). Contrarily, for condition factor (CF), the isolated effect of diet, as well as the interaction between the factors, were not significantly different ($P>0.05$). Means of final body weight, weight gain and SGR as a function of the effect of diets and species are presented in Table 3.

The results of final body weight and body weight gain, indicated that for species *C. rendalli*, Diet 1 (control), Diet 3 (200g/kg *M. oleifera* leaf + 300 g/kg *C. cajan*) and Diet 4 (300 g/kg *M. oleifera* leaf + 450 g/kg *C. cajan*) were not significantly different. However, there were significantly different in Diet 2 (100 g/kg *M. oleifera* leaf + 150 g/kg *C. cajan*). For *O. shiranus*, the final body weight and body weight gain were not significantly different in Diets 1 and 2 but significant differences were observed in Diets 3 and 4. The species *C. rendalli* had better performance than *O. Shiranus* when fed Diet 2 (100 g/kg *M. oleifera* leaf+ 150 g/kg *C. cajan*), resulting in an average of 60.94±0.54 g and 39.47±53 g for final body

Table 3. Means (± SE) of initial body weight, final body weight, weight gain, sgr and cf as a function of the effect of diets and species.

Diets[1]	Initial Weight (g)		Final weight (g)		Weight gain (g)		SGR		CF	
	C. rendalli	*O. shiranus*	*C. rendalli*	*O. shiranus*	*C. rendalli*	*O. shiranus*	*C. rendalli*	*O. shiranus*	*C. rendalli*	*O. shiranus*
Diet 1	22.28±0.16	22.36± 0.16	57.16±0.54 aA	60.88±0.54 aB	34.86±0.53 aA	38.08±0.53aB	1.07±0.02 aA	1.10±0.02 aA	1.81±0.05 aA	1.66±0.05aB
Diet 2	22.69±0.16	22.33±0.16	60.94±0.54bA	58.9±0.54aB	39.47±0.53 bA	36.50±0.53aB	1.13±0.02aA	1.09±0.02abA	1.83±0.05 aA	1.68±0.05aB
Diet 3	22.36±0.16	21.86±0.16	56.48±0.54 aA	53.55±0.54 bB	34.90±0.53 aA	31.48±0.53bB	1.05 ± 0.02 aA	1.00±0.02 bA	1.84±0.05 aA	1.69±0.05aB
Diet 4	22.21±0.16	22.10±0.16	55.34±0.54 aA	47.8±0.54 cB	33.81±0.53 aA	27.59±0.53cB	1.06 ± 0.02 aA	0.89±0.02 cB	1.88±0.05aA	1.71±0.05aB
P-value										
Diets	0.790n.s		0.000**		0.000**		0.000**		0.744ns	
Species	0.060n.s		0.000**		0.000**		0.005**		0.001**	
Diets x Species	0.286n.s		0.000**		0.000**		0.007**		0.998ns	

[1]Pairs of means followed by the same lowercase letter in the vertical direction are not significantly different at 0.05 level (*P*>0.05) and, pairs of means followed by the same uppercase letter in the horizontal direction, do not present statistical differences between them by the test of Tukey (*P*<0.05). [1]Diets: 1 - Control (0 g/kg *M. oleifera* leaf + 0 g/kg *C. cajan*), 2 - (100 g/kg *M. oleifera* leaf + 150g/kg *C. cajan*), 3 - (200 g/kg *M. oleifera* leaf + 300 g/kg *C. cajan*) and 4 - (300 g/kg *M. oleifera* leaf + 450 g/kg *C. cajan*). Data are presented as mean±SE (n = 3).

weight and body weight gain respectively (Table 3). The SGR results showed that *C. rendalli* differed significantly from *O. shiranus* when fed Diet 3 (200g/kg M. oleifera leaf + 300 g/kg *C. cajan*) and Diet 4 (300 g/kg *M. oleifera* leaf + 450 g/kg *C. cajan*). Therefore, *C. rendalli* presented the highest SGR with 1.13±0.02 when fed Diet 2. For Condition factor (CF), the results indicated that the species *C. rendalli* and *O. shiranus* significantly differed among different treatment diets. Contrary, diets and the interaction between factors did not present differences (Table 3).

The survival rate of *O. shiranus* and *C. rendalli* fed diets combining *M. oleifera* leaf and *C. cajan* were 100% in 6 treatments except for 2 treatments, namely Diet 4 fed to *O. shiranus* and the same Diet 4 fed to *C. rendalli* that were 95 and 98.35%, respectively.

The biweekly growth of *C. rendalli* and *O. shiranus* indicated an exponential increase in weight with an increase in time (Fig. 1). The *C. rendalli*, presented a higher average of 60.94±0.54 (g) when supplemented with Died 2. While the *O. shiranus* specie showed weak growth in all experimental phases with the lowest final average weight of 47.85±0.54 (g) when supplemented with Diet 4.

Feed utilization: The results presented in Table 4 showed that for AFCR and APER, the isolated effect of diet and species and the interaction between factors were significantly different (*P*<0.05). Means (±SE) of AFCR and APER as a function of the effect of diets and species are presented in Table 4. The AFCR showed that C. *rendalli* had no significant difference from all diets (*P*<0.05) with a mean of 2.82±0.06. For *O. shiranus*, the AFCR had no significant differences in Diets 1, 2 and 3, with a mean of 2.85±0.06. However, *O shiranus* had significant differences in Diet 4 with a mean of 3.19±0.06 Kg of feed to produce 1 kg of fish. The two species performed well when fed Diets 1, 2 and 3 but *C. rendalli* performed better than *O. shiranus* when fed Diets 2 and 3 with the mean of 2.75 ±0.06 and 2.78±0.06, respectively (Table 4). The APER results indicated significant differences among treatment diets and species (*P*<0.05), as well as evidencing the existence of significant interaction between the factors (Table 4). The results from APER showed that *C. rendalli* and *O. shiranus* differed significantly when supplemented Diets 2 and 4. For *C. rendalli*, all diets did not differ significantly from each other. For the *O. shiranus*, Diets 1, 2 and 3 did not differ significantly except for Diet 4. The best performance was obtained by *C. rendalli* compared to *O. shiranus* with an average of 0.73±0.02 when fed to Diet 2 (Table 4).

Water quality parameters: The results of water quality parameters, did not show significant differences in diets and species (*P*>0.05) nor the interaction between factors for all the analyzed variables. The means (±SE) of water quality parameters (Temperature, Dissolved oxygen and pH)

Table 4. Means (±SE) of AFCR and APER as a function of the effect of diets and species.

Diets[1]	AFCR[2]		APER[3]	
	C. rendallii	*O. shiranus*	*C. rendalli*	*O. shiranus*
Diet 1	2.87±0.06aA	2.78±0.06aA	0.66±0.02aA	0.67±0.02aA
Diet 2	2.75±0.06aA	2.84±0.06aA	0.73±0.02aA	0.66±0.02aB
Diet 3	2.78±0.06aA	2.92±0.06aA	0.67±0.02aA	0.65±0.02aA
Diet 4	2.88±0.06aA	3.18±0.06bB	0.65.3±0.02aA	0.54±0.02bB
P-value: *P* = 0.05				
Diets	0.005**		0.007**	
Species	0.022**		0.002**	
Diets x Species	0.039**		0.008**	

Pairs of means followed by the same lowercase letter in the vertical direction, do not present statistical differences between them by the Tukey test ($P<0.05$) and, pairs of means followed by the same uppercase letter in the horizontal direction, do not present statistical differences between them by Tukey test ($P<0.05$). [1]Diets: 1 control, 2 - (100 g/kg *M. oleifera* leaf + 150 g/kg *C. cajan*), 3 – (200 g/kg *M. oleifera* leaf + 300 g/kg *C. cajan*) and 4- (300 g/kg *M. oleifera* leaf + 450 g/kg *C. cajan*). [2]AFCR- apparent feed conversion ratio, and [3] APER - apparent protein efficiency ratio. Data are presented as mean ± SE (n =3)

were recorded with 19.91±0.09 AM, 27.03±0.23 PM; 4.64±0.04 AM 5.28±0.03 PM; 7.39±0.01AM and 7.60±0.01 PM, respectively. Additionally, the recorded results of ammonia (NH_4), nitrate (NO_3), nitrite (NO_2) and phosphorous (PO_4) with the mean (±SE) of 0.05±0.01, 5.56±0.13, 0.016±0.01 and 0.03±0.02, respectively.

Discussions

In aquaculture, a proper diet with optimum nutrition have been recognized as a main factor in promoting a satisfactory growth performance (Adewumi, 2018). The results indicated that *C. rendalli* had better performance in almost all the growth parameters, compared to *O. shiranus* when supplemented with Diet 2 (100 g/kg *M. oleifera* leaf+ 150 g/kg *Cajanus cajan*). From there, an increment on the level of inclusion of above 100 g/kg of *M. oleifera* leaf has decreased growth parameters. A similar result was reported by Richter et al. (2003) and Hussain et al. (2017) who found that there was a decrease in the growth performance at a level of inclusion of moringa leaf above 100 g/kg. The explanation for this may be attributed to what was reported by Han et al. (2000), who justified a decrease in growth performance as a result of the presence of anti-nutritional factors such as saponins and phytate in the *Moringa* leaves. According to Chen et al. (2011), high levels of saponin in the feedstuff significantly depressed the feed intake and growth responses. The same scenario was observed by Bello and Nzeh (2013) when studying the effects of varying levels of *M. oleifera* leaf meal diet on the growth performance of *Clarias gariepinus*. They found the better performance of nutrients utilization and survival parameters at 100 g/kg of inclusion without any negative effects on the growth and feed efficiency. Previous studies observed that the specific growth of Nile tilapia fed 15% of soaked *C. cajanus*, had a specific growth rate of 0.75±0.05% day^{-1} (Ndau and Madalla, 2015). In the current experiment, the specific growth overcomes for both *C. rendalli* and *O. shiranus.*

When comparing the two fish species, the results indicated that *C. rendalli* had a positive response on growth performance parameters when fed by *M. oleifera* + *C. cajanus* combined diet than *O. shiranus*. This could have been because different fish species have different preferences for feed and their digestibility. Accordingly, *C. rendalli* is a largely non-selective feeder and it eats a wide range of territorial plants when compared to *O. shiranus* (Chikafumbwa et al., 1991). Despite the low growth performance observed in *O. shirannus*, the *M. oleifera* + *C. cajan* based diets provided good health conditions for both *C. rendalli* and *O. shiranus*. The condition factor (general well-being of fish) was increasing as the level of inclusion of *Moringa* and *Cajanus* were increasing. This may be attributed to the fact that *M. oleifera* leaves are rich in vitamins and minerals which can increase as we increase the inclusion in the diet (Nouman et al., 2014). The study indicates that the highest CF was achieved in D4 when fed to *C. rendalli* with a mean of 1.88±0.05 and the lowest in Diet 1 when fed to *O. shiranus* with a mean of 1.66±0.05. Those figures are greater than 1 that indicated that the fish were in good condition (Abobi, 2015). A condition factor of less than 1 indicates that fish are in bad health condition (Rajkumar, 2006).

Previous studies conducted by Odedeyi and Ayegbusi (2018) found condition factors ranging from 1.07 to 1.08 when fishes were fed diets containing 150 and 300 g/kg *M. oleifera* leaf and justified this because of good utilization of the nutrients in the diet. The results in the present study are above these figures when soya bean is replaced at 25, 50 and 75% with a combined *M. oleifera* leaf and *C. cajan*. This could be because of combining *M. oleifera* leaf with *C. cajanus* is less harmful than soya bean (Bello and Nzeh, 2013). The authors argued that the anti-nutritional factors such as polyphenols, amylase and protease inhibitors, which are a known problem in most legumes, are less problematic in *C. cajanus* than in soybean. The results of the present study, clearly show that the combined *M. oleifera* leaf and *C. cajanus* can replace soya bean meal without affecting the fish health condition with a 100% survival rate up to 200 g/kg *M. oleifera* leaf + 300 g/kg *C. cajan* incorporated in the diets.

Feed utilization of *O. shirannus* and *C. rendalli* fed on combined *M. oleifera* and *C. cajan* revealed that once introduced the *M. oleifera* leaf and *C. cajanus* to Diets 2 and 3, the AFCR remained the same as the control for both fish species. However, with an increment in the levels of combined *M. oleifera* and *C. cajanus* in the diets, the AFCR increased and inversely the APER decreased. The same trend was observed by Richter et al. (2003) who concluded that a higher level of *M. oleifera* in diets suppress growth performance. The increase in AFCR was attributed to anti-nutrients such as phenol, tannins, phytates and saponins (Richter et al., 2003). Anti-nutritional factors such as phytic acid can interfere with the nutritional value of feed, therefore, reducing mineral absorption, protein digestibility and resulting in toxicity and health problems when present in high concentrations in feedstuff (Samtiya et al., 2020). Although the decrease in feed utilization for the two species with high doses of *Moringa* + *C. cajanus* in the feed, *C. rendalli* showed to use the feed compared to *O. shiranus* efficiently. This may be due to the poor digestibility and palatability of plant-based diets for *O. shiranus* (Skelto, 2001). Although the two species are omnivorous, *C. rendalli* is more of a plant feeder than *O. shiranus* (Koekemoer and Steyn, 2014). However, the feed conversion rate found by Ndau and Madalla (2015) was 2.77±0.79 and 2.70±0.56 in Correa et al. (2020). These results are in the same range as observed in the present study indicating that *C. cajan* can replace the soya bean meal.

The results of water quality parameters indicated no significant effects on *C. rendalli* and *O. shiranus* and had no significant differences across treatments and the levels were within the recommended concentration. The mean (±SE) of water quality parameters (Temperature, Dissolved oxygen and pH) ranged from 19.91±0.09 AM, 27.03±0.23 PM; 4.64±0.04 AM 5.28±0.03 PM; 7.39±0.01AM and 7.60±0.01 PM, respectively. Additionally, ammonium (NH_4), nitrate (NO_3^-), nitrite (NO_2^-) and phosphorous (PO_4^{3-}) ranged from mean (±SE) of 0.05±0.01, 5.56±0.13, 0.016±0.01 and 0.03±0.02, respectively. The water quality parameters recorded during the experiment were within the recommended ranges as provided in Bhatnagar, (2013); Jaganmohan and Kumari, (2018).

Conclusion

It is concluded that the partial replacement of soya bean meal by the combination of *M. oleifera* leaves + *C. cajan* at levels of 100g/kg *M. oleifera* leaf + 150g/kg *C. cajan* improves growth performance, feed utilization and general health condition of fish. Furthermore, the *C. rendalli* species performed better when fed the diets in question than *O. shiranus.*

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