

Replacement of soybean meal in the diets of African catfish fingerlings using Avocado seed meal fortified with DL-Methionine

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Abstract

This study evaluated the effects of the replacement of soybean meal with methionine fortified avocado seed meal on the biochemical, proximate composition and growth performance of African catfish, *Clarias gariepinus*. Five diets were formulated to contain 0%, 25%, 50%, 75%, and 100% of avocado seed meal fortified with (0%, 0.20%, 0.40%, 0.80%, 1%) methionine (Met) respectively, in the replacement for soybean meal. African catfish fingerlings (9g-10.5g) were stocked randomly into 15 glass tanks (75cm X 60cm X 60 cm) at 15 fish per tank, and fed the experimental diets to apparent satiation twice daily for 56 days. Results indicated that the fish fed diet of 25% avocado seed meal fortified with 0.02% Met had the best growth performance in weight gain, feed conversion ratio (FCR) and specific growth rate (SGR), though not significantly ($P>0.05$) different from the values obtained from fish fed diet with 100% soybean meal and 50% of avocado meal fortified with 0.40% Met. Blood profile revealed that avocado meal fortified with Met significantly improved the pack cell volume, without significantly affecting red blood cells, white blood cells and haemoglobin concentrations. Carcass proximate composition expressed that dietary avocado and Met significantly improved the fat and total ash composition while the nitrogen free extract was significantly reduced. Carcass minerals showed that feeding fish with diets of avocado meal with Met significantly increased the Mg, Ca, P and Zn depositions in the fish. In summary, the study established that avocado seed meal fortified with 0.4% DL-methionine can effectively replace up to 50% of soybean meal in the diets of African catfish.

Keywords: Avocado seed meal, Methionine, Soybean replacement, African catfish, Growth performance, Haematology.

Introduction

Fish farming is gaining popularity as a complementary economic activity to declining capture fisheries, for increased fish production and food security, (FAO, 2022). However, commercial fish farming is being limited majorly by the non-availability of cheaper and cost-effective alternative feed sources (Wasilah *et al.*, 2021), as conventional feed ingredients can account for over two-third of the variable cost of fish farming operation (Wasilah *et al.*, 2021, (Sandra *et al.*, 2024). African catfish (*Clarias gariepinus*) is among the commercially important species cultivated in the tropical and sub-tropical countries, because of its inherent fast growth, resistance to diseases and the ability to feed on low trophic levels. Adult African catfish is omnivorous and consumes large quantity of food materials including live algae, detritus, and associated microbes (FAO, 2024). Some non-conventional feed materials like, *Azolla pinnata*, water hyacinth (Nwanna and Falaye, 1997 and Nwanna *et al.* 2008), have been evaluated and showed good potentials as African catfish feed.

Nevertheless, continuous investigations are on-going to determine alternative feed sources, and appropriate nutrient ratio and combinations and fortification with relevant enzymes and amino acids to boost fish production and without compromising immunity and physiological functions (Nwanna *et al.*, 2024). Avocado seed meal has high protein content of 42.5% and can be considered as a cheaper alternative to soybean meal in animal nutrition. In the industries, avocado pulp is used, while the skin and seed are discarded as wastes. However, scientific investigations have revealed that avocado seed meal has good nutritional values and bioactive compounds such as essential fatty acids, high antioxidant activities, high carotenoid concentration

and phenolic compounds (Sneh *et al.* 2022). Rodriguez-carpena *et al.* (2011) and Ejiolor, *et al.* (2018) also reported that avocado seed-meal (ASM) contains appreciable level of polyphenols with antioxidant and antimicrobial power. Similarly, (Melgar *et al.*, 2018, Tremocoldi *et al.*, 2018 and George *et al.*, 2020) expressed that ASM is endowed with lipid, proteins, vitamins, minerals and bioactive compounds such as phenolics and flavonoids, which provides numerous health benefits to animals

With all the nutritional values embedded in ASM as a potential source of protein in animal feeds, there is a dearth of information on its utilization in aquaculture feeds. Therefore, this study investigated the effects of replacement of soybean meal with avocado seed meal in the production of African catfish. As all plant protein ingredients are known to be deficient in methionine, avocado seed meal used in the study was fortified with DL-methionine.

Materials and Methods

Experimental site

The study was conducted at the Teaching and Research farm of the Department of Fisheries and Aquaculture Technology, in The Federal University of Technology Akure, Ondo State.

Collection and preparation of Avocado Seed meal

The fruits of Avocado (*Persia americana*), of Hass cultivar, was obtained from farm settlement in Ile-Oluji, and properly identified in the herbarium of Department of Crops, Soil and Pest Management, Federal University of Technology, Akure, with voucher Number 0436. The fruits were washed, cut and the seed were removed. The seeds were sliced and air dried for 14 days before grinding into fine powder.

Preparation of experimental diets

Feed ingredients used for the experimental diets were purchased from Animal Concept feed mill By pass, Akure,

Ondo State. The ingredients were yellow maize, soybean meal, fishmeal, vegetable oil, vitamin and mineral premixes and starch. Five diets (40% CP) were formulated to contain the avocado seed meal at (0, 25, 50, 75, and 100%) and 0%, 0.20%, 0.40%, 0.80%, and 1% methionine respectively: and labelled as treatments 1-5 (T1 to T5) or diets 1-5. The Avocado seed meal powders and other ingredients were weighed with an electronic weighing balance (Model PB3002), and mixed thoroughly with 1 liter of water per treatment. The dough was pelleted using 2 mm pelletizer, sun dried and packed in polythene bags, and stored at room temperature before use. The gross composition of the experimental diets is presented in Table 1. Samples of diets 1-5 were analyzed for proximate composition according to the method of AOAC (2006).

Experimental System and Fish

African catfish with average weight of 9-10.5g were obtained from a reputable hatchery in Akure, Ondo State. The fish were distributed randomly into glass tanks (75cm X 60cm X 60 cm) at stocking rate of 15 fish per tank. The experimental set up was completely randomized consisting of 5 treatments and 3 replicates. The fish were acclimatized for fourteen days and fed with a commercial diet containing 40% crude protein. The fingerlings were not fed for 24 hours before commencement of the feeding trials to stimulate their appetite and adjust to the experimental diets. During the feeding trial which lasted for 56 days, fish were fed to apparent satiation twice daily at 08:00 – 9:00 and 16:00 - 17:00 hours. Feed was administered gradually to monitor the rate at which the fish picked the feeds.

Growth indices

Biometry was carried out bi-weekly to measure the growth indices. All treatment groups were anaesthetized using clove oil at 95mg/L before the biometrics were taken to avoid handling stress (Adeshina *et al.* 2016). At the end of the feeding trial, (fish were not fed for the last 24 hrs), fish were counted and weighed using digital 10kg electronic balance (Model PB 3002). The weight gain, feed intake, specific growth rate, feed conversion ratio, and protein efficiency ratio were calculated as described by Nwanna and Helen-Tope Jegede (2017). The feed intake of each experimental treatment was calculated and recorded.

- i. Survival rate (SR, %) = $100 \times N_f / N_i$; where N_f and N_i are the number of catfish at the beginning and end of the experiment, respectively, in each treatment
- ii. Weight Gain (Wg) (g) = $W_f - W_i$; where; W_f = Final weight; W_i = Initial weight
- iii. Daily weight gain (DWG) (g) = Mean weight gain / days
- iv. Specific growth rate (SGR) (g/day) = $100 (\ln W_f - \ln W_i) / T$, where W_f and W_i are the final and initial weight, respectively, and T is the number of days in the feeding period
- v. Feed conversion ratio (FCR) = dry feed intake (g) / weight gain (g)
- vi. Protein efficiency ratio (PER) = weight gain (g) / protein intake (g)

Water quality parameters

All aquaria were ensured to possess similar water quality required for optimum growth of the experimental fish. A

total exchange of culture water was carried out once weekly with de-chlorinated borehole water. Water quality parameters such as Temperature, pH, and dissolved oxygen were monitored weekly throughout the study for optimum survival and growth of the experimental animal, using the Hanna multi-parameter model HI9288 (Thailand).

Proximate composition of the experimental fish

Three catfish were randomly collected from each tank and stored at -20° C to estimate the whole-body composition using standard methods (AOAC, 2006). The whole body of the catfish collected from each treatment was oven dried and homogenised. Crude protein was determined using a Kjeldahl analyzer. Crude lipid was extracted using petroleum ether as a solvent. The moisture and ash contents were gravimetrically analyzed using a hot air oven at 105° C for 24 h.

Hematological profile and serum biochemical analysis

At the end of the experiment, 24 h after the last feeding, 3 randomly selected fish from each treatment group were anaesthetized using clove oil at 95mg/L (Adeshina *et al.* 2016) before the blood was taken to avoid handling stress. Blood samples were collected from the caudal vein with a 2-ml sterile hypodermic syringe and carefully transferred into 1.5mL sterile ethylene diamine tetra acetic acid (EDTA) heparinized tubes and after standing for 12 h at 4° C, centrifuged at $850 \times g$ for 15 min at 4°C. The supernatant, which is the serum, was collected and stored at -8° C until enzyme activity assays were performed. Hemoglobin, leucocyte, white blood cells, erythrocyte, and red blood counts were estimated by the Cyanmethemoglobin method according to the methods of (Rusia and Sood, 1992). Erythrocyte indices namely., MCV (Mean cell volume), MCH (Mean cell haemoglobin,) and MCHC (Mean cell haemoglobin concentration) were also calculated according to the standard formula described by Svobodova *et al.* (2006).

Determination of fish carcass minerals

The mineral constituents of the fish were determined using Atomic Absorption Spectrophotometry. Samples were digested following standard laboratory protocol which involved the digestion of oven dried sample using a mixture of concentrated HNO_3 and $HClO_4$ in the ratio of 2:1. 10 cm³ of the mixture were added into a digestion flask containing 2.0 g of the pulverized oven dried fish sample, followed by digestion in a fume hood until a clear solution/digest was obtained and the samples were allowed to cooled and filtered using Whatman No1 filter paper. Minerals elements were determined according to the standard method of AOAC, 2006 using an Atomic Absorption Spectrophotometer (Varian Spectr AA. 20 plus).

Statistical Analysis

Data collected were subjected to one way Analysis of variance as described by Duncan (1955), and Duncan's new multiple range test (P=0.05) Duncan (1955) was used to compare the means. Computer Statistical package for Social Sciences (SPSS) version 23 (IBM), United Kingdom was used to run the analysis.

Results

Proximate composition of experimental diet

The gross feed composition and the results of the proximate composition of the experimental diets are presented in Tables 1 and 2. There were no differences ($P>0.05$) in the moisture content of the diets. Lipid content was the same in diets 1-3, which were significantly higher than in diets 4 and 5. It also decreased with increasing levels of the avocado meal. Ash content was significantly higher in all diets containing the avocado meal than the control diet with 100% soybean meal. The ash contents also increased with increasing levels of the avocado meal. The fibre content was significantly higher in diets 4 and 5 than in diet 1. While there were no differences ($P>0.05$) in protein levels of the diets, diets 4 and 5 had significantly higher nitrogen free extract than in diets 1, 2 and 3, which showed marginal differences amongst each other.

Growth and Nutrient Utilization of *C. gariepinus* fed experimental diets

The growth parameters of the experimental fish are presented in table 3. There were no significant differences in the weight gain of fish fed diets 1-3. However, their weight gain was significantly higher than those of the fish fed diets 4 and 5. Specific growth rate and protein intake followed the same trend. Feed conversion ratio (FCR) was the same in fish fed diets 1-3, which was significantly better than the FCR of fish fed diets 4 and 5. Similarly, protein efficiency ratio (PER) was the same in fish fed diets 1-3, while the PER of fish fed diets 1 and 2 were significantly higher than the PER of fish from other treatments.

Physico-chemical parameters of the experimental tank water

The water quality parameters measured in the culture media is presented in Table 4: Dietary avocado meal did not cause significant variations in the parameters. Therefore, the values of pH, dissolved oxygen and temperature were statistically the same, but within the recommended ranges for good fish culture.

Proximate composition of the experimental fish carcass

Carcass proximate composition of the experimental fish (Table 5) showed no significant differences in the moisture content of the fish. The crude fat of the fish fed diets 4 and 5, were significantly higher than the values from the fish fed diets 1, 2 and 3. Similarly, total ash of fish fed diets 3, 4 and 5 were significantly higher than the values from the fish fed diets 1 and 2. While there were marginal changes in the protein content of the fish, the nitrogen free extract (NFE) decreased significantly with increasing levels of the avocado meal in the diets. Therefore, fish fed diets 1 and 2 had the same NFE, which were significantly higher than the values in the fish fed diets 3, 4 and 5.

Haematological profile of the experimental fish

The result of the haematological profile of the fish (Table 6) showed that pack cell volume increased significantly with increasing levels of the avocado meal in the diets. While the influence of the avocado meal only caused marginal variations in the red blood cells, haemoglobin, white blood cells composition and the mean corpuscular haemoglobin concentration.

Mineral contents of the experimental fish carcass

The result of the mineral deposition in the fish fed methionine fortified avocado seed meal is presented in table

7. Dietary avocado and Met significantly increased the deposition of Mg, Ca, P and Mn in the carcass tissues of the experimental fish.

Discussion

The study investigated the effect of total replacement of soybean meal with avocado seed meal on the production of African catfish. DL-methionine was added to avocado seed meal because plant protein feeds are often limiting in methionine. Proximate composition of the experimental diets showed variations as a result of the dietary composition. This is expected because nutrient composition of diets is a function of the ingredient combination (Nwanna and Ikuesan, 2024). The significant increase in ash contents of all the diets containing avocado seed meal over the control diet could be ascribed to the influence of the avocado meals and which also caused variations in the carcass minerals. Similarly, the more the avocado meal in the diets, the higher the fibre content and nitrogen free extract of the diets. This is in agreement with the report of Nwanna and Ikuesan (2024) which indicated that dietary ash, fibre and nitrogen free extract increased with increasing levels of avocado leaf meal in the diets fed to African catfish.

Improvement in the growth performance of the fish fed 25% avocado meal with 0.02g methionine (Met) over the fish fed 100% of soybean meal is in line with (Wasilah, et al., 2020), on *Osphronemus gouramy* and the work of Chinh et al. (2024) on *Oreochromis niloticus*. Nwanna et al, (2012) and Trenton et al. (2024) also reported that supplementation of Met to plant protein feeds balances the amino acids in the feed and supports growth of animals. In the present study, 25% of the avocado meal plus 0.02% of Met gave the best growth performance while from another study, Deni et al., (2024) reported 20% of avocado seed meal as the best in the production of Nile tilapia.

The physicochemical parameters, pH, dissolved oxygen and temperature of water observed in this study were statistically the same and within the acceptable ranges for good fish culture (Abdelhamid, 2010). As the avocado meal did not affect the water quality in this study, Deni et al., (2024) also reported that feeding avocado meal to Nile tilapia did not cause remarkable changes in the culture water systems.

Increases in the carcass fat and total ash of the fish fed avocado meal and Met over the carcass of fish fed 100% soybean meal

as recorded in the present study, could be attributed to changes

Table 1: Gross Composition of test diets (g/100g dm) fed *C. gariepinus* fingerlings.

INGREDIENTS	D1 0%	D2 25%	D3 50 %	D4 75%	D5 100%
	ASM	ASM	ASM	ASM	ASM
Fish meal (45%)	25.8	25.8	25.8	25.8	25.8
Soybean meal (45%)	25.0	18.76	12.50	6.25	0.00
Alvocado seed meal	0.00	6.61	13.24	19.86	26.48
gnc (48%)	25.0	25.0	25.0	25.0	25.0
Yellow maize (10%)	16.60	16.03	15.46	14.69	14.12
Methonine	0.00	0.20	0.40	0.80	1.00
Lysine	0.20	0.20	0.20	0.20	0.20
Cellulose	1.00	1.00	1.00	1.00	1.00
Fish oil	6.00	6.00	6.00	6.00	6.00
vitamin and mineral premix	0.40	0.40	0.40	0.40	0.40

Table 2: Proximate Composition (g/100g DM) of experimental diet

Parameters (%)	D1 0%	D2 25%	D3 50%	D4 75%	D5 100%
	ASM	ASM	ASM	ASM	ASM
Moisture	7.15±0.30 ^a	7.22±0.30 ^a	7.45±0.01 ^b	7.86±0.05 ^c	7.13±0.11 ^d
Crude fat	15.25 ±0.26 ^a	15.51±0.61 ^a	14.68±1.0 ^a	11.52±0.30 ^b	9.88 ± 0.05 ^c
Total ash	5.17±0.02 ^d	5.83±0.27 ^c	5.84±0.58 ^c	6.54±0.02 ^b	7.85±0.1 ^a
Fibre	2.67±0.25 ^{cd}	2.73±0.30 ^c	3.13±0.32 ^c	4.03±0.6 ^b	4.80±0.5 ^a
Crude protein	40.02±0.38 ^a	40.02±0.13 ^a	40.02±0.22 ^a	39.99 ± 0.11 ^a	39.99 ± 0.11 ^a
Nitrogen free extract	29.7±0.8 ^b	28.67±0.8 ^b	29.83±1.4 ^b	32.04±0.32 ^a	32.27± 0.3 ^a

Means on the same row and different superscript are significantly (P <0.05) different

Table 3: Growth performance and nutrient utilization of African catfish fed the experimental diets

Parameters	D1 0%	D2 25%	D350%	D475%	D5 100%
	ASM	ASM	ASM	ASM	ASM
Initial weight(g)	10.3± 0.13 ^a	10.2±0.92 ^a	10.2±.038 ^a	10.2± .13 ^a	10.1± .04 ^a
Final weight (g)	51.78 ± 3.16 ^a	52.7± 3.7 ^a	47.8±2.05 ^{ab}	40.9± 1.7 ^c	29.1± .57 ^c
Weight gain (g)	41.5 ± 3.29 ^a	42.5± 3.75 ^a	37.6± 2.07 ^{ab}	30.6±1.7 ^c	19.1±1.7 ^d
Specific growth (g/day/fish)	1.25± 0.05 ^a	1.26±0.05 ^a	1.19±0.4 ^a	1.02±0.12 ^b	0.84±20 ^c
Protein intake (g)	28.60±1.19 ^a	28.58±1.52 ^a	28.12±0.22 ^a	24.35±0.8 ^b	19.23 ±0.16 ^c
Feed conversion ratio	1.59± 0.05 ^d	1.56±0.11 ^d	1.73±0.05 ^{cd}	1.94±0.08 ^a	2.4±0.04 ^a
Protein efficiency ratio	1.45±0.05 ^a	1.48±0.07 ^a	1.33±0.8 ^{ab}	1.25±0.08 ^{bc}	1.00±0.01 ^d

D: Diet Means on the same row and different superscript are significantly (P<0.05) different.

Table 4: Physico-chemical properties of the experimental tank water.

PARAMETER	D1 0%	D2 25%	D3 50%	D4 75%	D5100%
	ASM	ASM	ASM	ASM	ASM
pH	7.68±0.08 ^a	7.53±0.05 ^a	7.51±0.04 ^a	7.51±0.06 ^a	7.53±0.08 ^a
DO (mg/l)	4.50±0.03 ^a	4.52±0.06 ^a	4.54±0.04 ^a	4.57±0.02 ^a	4.59±0.05 ^a
TEMP.(°C)	28.61±0.20 ^a	28.67±0.23 ^a	28.64±0.25 ^a	28.65±0.20 ^a	28.67±0.24 ^a

DO: Dissolved Oxygen; TEMP: Temperature; pH: Potential Hydrogen ion concentration:

Means on the same row and different superscript are significantly (P <0.05) different.

Table 5: Proximate composition of experimental fish carcass

Parameters (%)	D10%	D2 25%	D3 50%	D4 75%	D5 100%
	ASM	ASM	ASM	ASM	ASM
Moisture	7.44±.015 ^a	7.42±.02646 ^a	7.26±.069 ^b	7.25±.03 ^a	7.24±.03 ^a
Crude fat	13.5200±.68 ^c	14.17±.010 ^{cd}	14.92 ±.71 ^c	15.89 ±.25 ^b	16.87 ±.03 ^a
Total ash	6.01±00 ^d	6.21±.25 ^d	6.73±15 ^c	7.12±15 ^b	7.63±15 ^a
Crude protein	64.05±.005 ^a	64.04±.026 ^a	63.95±030 ^a	63.83 ±.010 ^a	63.49±.32 ^b
Nitrogen free extract	8.56 ±.68 ^a	8.30±.29 ^a	7.11±.55 ^b	5.91 ±.33 ^b	4.75 ±.14 ^b

Means on the same row and different superscript are significantly (P <0.05) different

Table 6: Haematological profile of the experimental fish

Parameters	D1		D2		D3	D4	D5
	0% ASM	25% ASM	50% ASM	75% ASM	100% ASM		
Packed cell Volume	27.70±7.71 ^d	28.25 ± 4.3 ^c	29.50 ±7.06 ^b	29.83 2.64 ^b	32.75 ± 2.67 ^a		
Red blood cell count (x10⁶/l)	1.96 ± .16 ^a	1.80 ± 0.4 ^a	1.89 ± 2.34 ^a	1.87 ± 0.10 ^a	1.89 ± 0.31 ^a		
Heamoglobin concentration (dl)	9.4 ± 2.56 ^a	9.25 ± 1.44 ^a	9.89 ± 2.34 ^a	9.71 ± 0.69 ^a	10.83 ± 1.03 ^a		
White blood cell count (X10⁹/L)	1.61 ± 0.69 ^a	1.46±0.75 ^a	1.86± 1.00 ^a	1.57 ±.40 ^a	1.63±0.74 ^a		
Mean corpuscular volume (Fl)	143.78 ±38 ^c	158.37 ±33 ^b	144.22 ±29 ^c	160.55 ± 20 ^b	185.41 ± 12 ^a		
Mean corpuscular haemoglobin (Pg)	47..90 ± 10 ^c	52.78±12 ^b	47.91 ± 9.7 ^c	52.26 ± 6.3 ^b	62.03 ± 3.7 ^a		
Mean corpuscular haemoglobin concentration (%)	33.32 ± 0.0 ^a	33.32 ±0.01 ^a	33.75 ±0.09 ^a	32.61±1.60 ^a	33.04 ± 0.6 ^a		

Means on the same row and different superscript are significantly (P <0.05) different.

Table 7. Mineral contents of the experimental fish carcass (mg/g)

Parameters	D1 0%	D2 25%	D3 50%	D4 75%	D5 100%
	ASM	ASM	ASM	ASM	ASM
Mg	18.7 ^c	21.9 ^b	26.0 ^a	20.6 ^b	20.1 ^b
Ca	25.8 ^c	30.9 ^a	31.7 ^a	27.2 ^b	27.7 ^b
P	7.24 ^b	9.96 ^a	9.13 ^a	9.44 ^a	9.12 ^a
Mn	0.09 ^b	0.11 ^a	0.11 ^a	0.09 ^b	0.92 ^b
Zn	0.77 ^c	1.13 ^a	1.05 ^a	0.84 ^b	0.88 ^b

Means on the same row and different superscript are significantly (P <0.05) different.

in nutrient synthesis and deposition rate in the muscles (Abdel-Tawwab *et al.*, 2020). Lei *et al.* (2023) and Yang *et al.* (2024) also asserted that methionine influenced fat metabolism in juvenile black seabream *Acanthopagrus schlegelii*. Carcass nitrogen free extract (NFE) decreased significantly with increasing levels of the avocado seed meal in the diets. This is in contrast with the report of Nwanna and Ikuesan (2024) which highlighted that dietary iron oxide nanoparticles of Alovera leaf meal did not significantly affect the carcass NFE of African catfish.

Significant improvement in the pack cell volume by the dietary avocado meal over the fish fed 100% soybean meal is in support of the work of Udo *et al.* (2024) on Nile tilapia. In the present study, there were no significant differences in the red blood cells, haemoglobin and white blood cells of the fish fed the control diet and those fed avocado meal with Met. This is in consonance with the reports of Udo *et al.* (2024) which showed no significant differences in similar parameters after feeding Nile tilapia with 20% avocado seed meal. Similarly, Geoge *et al.* (2020) reported that avocado seed meal did not have deleterious effects on the blood profile of broiler chicks. Adewole *et al.* (2024) also reported that avocado seed meal of up to 8% in the diet did not have negative impact on the blood parameters of chicken.

Information from the present study revealed that dietary avocado meal with Met increased significantly the Mg, Ca, P and Zn deposition in the fish. This is consistent with the findings of Lei *et al.* (2023) and Yang *et al.* (2024), which highlighted nutritional composition of feed, as a factor, that influences the nutrient composition of fish product. This improvement in the carcass minerals composition could be ascribed to high ash and minerals composition in the avocado seed meal. Ifesan and Olorunsola (2015) also reported high minerals composition in avocado seed meal. According to Justina *et al.* (2016), these minerals in avocado seeds, probably, makes it a choice feed for animals to balance their micronutrient deficiencies.

Conclusion

Replacement of soybean meal with avocado seed meal fortified with DL-Methionine, improved total ash and dietary fibre, carcass minerals deposition and supported fish growth performance and blood profile. Replacement of soybean meal at 25% avocado meal and 0.02% DL-methionine gave the best growth performance. However, and statistically, the study established that avocado seed meal fortified with 0.4% DL-methionine can replace up to 50% of soybean meal in the diets of African catfish. Further studies are required to determine the best processing method that might produce better growth performance in the fish.

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