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Carcass Essential Amino Acids Profile of *Clarias gariepinus* (Burchell, 1822) Fingerlings Fed Different Levels of Maca (*Lepidium meyenii*, Walp.) Root Powder as Feed Additive

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Abstract

This research was carried out to determine the carcass essential amino acids profile of *Clarias gariepinus* fingerlings fed different levels of Maca root powder as feed additive. Five (5) isonitrogenous (40% crude protein) and isocaloric (1,732kcal kg^{-1} gross energy) diets were *formulated,* where Maca root powder in form of feed additive *was included at* 0.0g/100g (TM_0), 0.25g/100g (TM_1), 0.5g/100g (TM_2), 0.75g/100g (TM_3) and 1.0g/100g (TM_4) inclusion levels, *diet without* Maca root powder (TM_0), *served as the control diet. Formulated diets were fed to Clarias gariepinus* fingerlings (n = 300, 10.0±0.00g) *in* fifteen (15) rectangular plastic tanks (n = 20) at a fixed feeding rate of 3% body weight twice daily between the hours of 8:00 - 9:00am and 4:00 - 5:00pm at regular interval and adjusted after every two (2) weeks of sampling *for a period* of twelve (12) weeks. At the end of the research three (3) *Clarias gariepinus* from each treatment were sacrificed with the carcass subjected to essential amino acids analysis. Data collected were analysed using one - way analysis of variance (ANOVA) at P = 0.05. All the nine (9) essential amino acids were found in the final carcass profile of the *Clarias gariepinus*. Carcass histidine value (15.81mg/g) was highest in fish fed diet TM_3 and least (10.02mg/g) in the fish fed the control diet (TM_0), carcass isoleucine value (25.42mg/g) was highest in fish fed diet TM_3 and least (18.20mg/g) in the fish fed control diet (TM_0), while the carcass leucine value (14.17mg/g) was highest in fish fed diet TM_4 and least (11.98mg/g) in the fish fed control diet (TM_0), carcass lysine value (20.13mg/g) was highest in fish fed diet TM_3 and least (14.68mg/g) in the fish fed control diet (TM_0), carcass methionine value (33.07mg/g) was highest in fish fed diet TM_3 and least (26.80mg/g) in the fish fed control diet (TM_0), carcass phenylalanine value (22.24mg/g) was highest in fish fed diet TM_3 and least (17.69mg/g) in the fish fed control diet (TM_0), carcass threonine value (22.23mg/g) was highest in fish fed diet TM_3 and least (15.13mg/g) in the fish fed control diet (TM_0), carcass tryptophan value (25.74mg/g) was highest in fish fed diet TM_3 and least (20.92mg/g) in the fish fed control diet (TM_0) and the carcass valine value (39.77mg/g) was highest in fish fed diet TM_3 and least (32.95mg/g) in the fish fed control diet (TM_0).. The incorporation of Maca root powder as feed additive into the diet of *Clarias gariepinus* fingerlings increases the concentration of the carcass essential amino acids and therefore the *Clarias gariepinus* can be a very important source of the essential amino acids. The incorporation of

Maca root powder as feed additive into the diet of *Clarias gariepinus* fingerlings is recommended for improving the *Clarias gariepinus* carcass essential amino acids profile.
Keywords: Carcass, Essential Amino Acids, *Clarias gariepinus, Lepidium meyenii,* Feed Additive.

Introduction

Protein and amino acids are the basic organic compounds of cells and the main undertakers of life activities (Wu *et al.*, 2023). The basic units of all proteins are amino acids. Amino acids as the basic building blocks of proteins play an important physiological function such as promoting muscle growth, improving immunity and relieving fatigue (Oriolowo *et al.*, 2020). Protein is made up of twenty (20) amino acids, which include the essential and non - essential amino acids of nutritional importance (Jimoh and Akanbi, 2019). Eleven (11) of these amino acids could be synthesized in sufficient amount in human body and are called non - essential amino acids. These include; alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine and tyrosine. The remaining nine (9), however cannot be synthesized by the body and therefore must be provided through dietary intake (Agwu *et al.*, 2019). They are referred to as essential amino acids. These include; histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine. Oriolowo *et al.* (2020) reported that cysteine and tyrosine may occasionally be referred to as semi - essential amino acids because they are synthesized from methionine and phenylalanine respectively. The lack of ability of the body to possess adequate quantity of these essential amino acids may possibly lead to the deterioration of body muscle protein (Wu *et al.*, 2023). The nutritional worth of any protein food can be estimated by taking into account its essential and non - essential amino acids, collective percentage of individual essential amino acids; energy supplied which is necessary for protein synthesis, amino acid tally and expected protein efficiency ratio (Oriolowo *et al.*, 2020). The value of protein can also be estimated by correlating its amino acids with a notable graded protein applicable to all populations, specifically on the background of the limiting essential amino acids constituents of the food stuff (Jimoh and Akanbi, 2019). Limiting essential amino acid is the tiniest of the amino acid discovered in the protein in relation with standard protein (Wu *et al.*, 2023). This greatly influence the net protein utilization which is the percentage of amino acids converted to protein against the amount of amino acids supplied (Oriolowo *et al.*, 2020). Formulation of cheap and quality *Clarias gariepinus* (Burchell, 1822) feed in this case Maca (*Lepidium meyenii,* Walp.) root powder as feed additive in the diet will improve the carcass essential amino acids profile of the *Clarias gariepinus* used in this research. Premised on the above measures, the carcass essential amino acids profile of *Clarias gariepinus* fingerlings fed different levels of Maca root powder as feed additive was determine.

Statement of the Problem

Fish is a very important animal protein source, specifically in the developing countries due to its high essential amino acids profile and nutritional value of unsaturated fatty acids

(Usman, 2021). Maca is also rich in crude protein, crude lipid, some essential acids (Ali *et al.*, 2024a). Thus, the present study determines the potential of Maca root powder as feed additive in improving the carcass essential amino acids profile with particular reference to *Clarias gariepinus*.

Objective of the Study

The objective of this study was to determine the carcass essential amino acids profile of *Clarias gariepinus* fingerlings fed different levels of Maca root powder as feed additive.

Materials and Methods

Study Area

The research was conducted at the Lay-Joy Fish Farm, Gombe-Yola Road, Billiri local government area (LGA), Gombe State Nigeria. Billiri LGA lies within Lat. 9°50′N; 11°09′E and Long. 9.833°N 11.150°E. It covers an area of 737km² (285 sq. m) and is 50 km away from Gombe, the state capital.

Experimental Fish

Three hundred (300) *Clarias gariepinus* fingerlings with mean initial weight (10.0±0.00g) were stocked at twenty (20) fingerlings per tank in triplicates per treatment after one (1) week of acclimatization.

Experimental Feed

The experimental diets contained fish meal (FM), soybean meal (SBM), yellow maize meal (YMM), groundnut cake meal (GNCM) and Maca root powder. All the ingredients were grounded into a fine powder using a hammer mill and sieved by a 0.25 mm sieve. Fish meal, soybean meal, groundnut cake meal and yellow maize meal were obtained from commercial suppliers in Gombe, the vitamin/mineral premix, fish oil and chromic oxide (Cr_2O_3) were purchased from TTS Integrated Farms Nigeria Limited, Agege - Lagos, while the Maca root powder naturally derived from dry Maca (*Lepidium meyenii*) root was obtained from BonAmour Pharmacy Limited Lagos, Nigeria, imported from Piping Rock Health Products, Ronkonkoma, New - York, USA. Prior to the feed formulation, proximate composition of these ingredients was determined (Table 1).

Five (5) isonitrogenous and isocaloric diets were prepared, each diet with crude protein (CP) content at 40% CP as calculated according to Pearson's square method and gross energy content at 1,732kcal kg^{-1} respectively for the feeding the experimental *Clarias gariepinus* as recommended by Ali (2022) was prepared, where the Maca root powder in form of feed additive *was incorporated into at* 0.0g/100g (TM_0)), 0.25g/100g (TM_1), 0.5g/100g (TM_2,) 0.75g/100g (TM_3) and 1.0g/100g TM_4) inclusion levels, *diet without* Maca root powder *(TM_0), served as the control diet (Table 2). Diets were subjected to proximate analysis as described by AOAC (2005) as presented in Table 3.*

Table 1: Proximate and Energy Composition of Ingredients used for the Experimental Diets

Ingredients	CP%	CL%	CF%	Ash%	NFE%	Moisture%	GE
Fish meal	71.23	7.83	ND	9.22	3.81	7.91	1195
Soybean meal	43.90	3.10	7.30	5.10	33.90	6.70	1003
GNC meal	43.50	5.17	6.01	5.97	31.00	8.35	2432
Yellow maize	8.95	3.35	10.38	4.07	64.86	8,39	807

Source: Ali *et al.* (2024b).

Keys: CP - Crude protein, CL - Crude lipid, CF - Crude fibre, NFE - Nitrogen free extracts, GE - Gross energy, GNC - Groundnut cake, ND - Not detected.

Experimental Design

The *Clarias gariepinus* fingerlings were cultured in fifteen (15) rectangular plastic tanks (flow - through system) with a water holding capacity of one thousand litres (1,000L) each in a complete randomized design (CRD). Each tank was washed thoroughly with salt, filled to just a little over 1/3 (350 litres) capacity and stocked with twenty (20) fingerlings of *Clarias gariepinus* with mean initial weight (10.0±0.00g). The *Clarias gariepinus* fingerlings were fed the experimental diet at 3% body weight two (2) times daily between the hours of 8:00 - 9:00am and 4:00 - 5:00pm for a period of twelve (12) weeks. The quantity of Feed was adjusted accordingly after every two (2) weeks of sampling for growth performance and survival rate (mean body weight and mortality). Water temperature, pH, dissolved oxygen, and ammonia were measured at the beginning of the experiment after which they were measured weekly throughout the period of the experiment. Water temperature, dissolved oxygen and pH were measured using Horiba U-22 XD multi - parameter water quality checker while ammonia was measured using freshwater aquaculture test kit (Model AQ-2, Code 3633-03, Lamotte U. S. A). At the end of the experiment, three (3) fish from each treatment were sacrificed and the carcass subjected to essential amino acids analysis.

Determination of Essential Amino Acids

The carcass essential amino acids profile of *Clarias gariepinus* fingerlings fed different levels of Maca root powder as feed additive was determined as previously described by AOAC (2005) and also the method of Saad and Alim (2015). With slight modification. About 0.5g of each sample was digested into 5ml of 6 N HCl for about 24 hours and then filtered. 200µg of the filtrate was evaporated and dried in a 140°C oven for 1 hour. 1ml of diluting buffer (0.15 M sodium hydrogen carbonate, pH 8.6 with NaOH) was added to each sample and then mixed by vortex. The resulting solutions were incubated at 70°C in a water bath for 15 min. The reaction was stopped by placing the vials in an ice bath for 5 min. A total of 400µL of the dilution buffer [mixture of 50 ml of acetonitrile, 25 ml of ethanol, and 25ml of 9mM sodium dihydrogen phosphate; 4% dimethylformamide; and 0.15% triethylamine (pH 6.55 with phosphoric acid)] was added, followed by thorough mixing and centrifugation (5 min, 5000 rpm). 20µL of the clear supernatants were then injected into the HPLC. Dabsyl derivatives of free essential amino acids were separated on an Agilent 1100 HPLC system, using a reversed - phase Spherisorb ODS 2 column (25.0 cm × 0.46 cm; 5 µm particle size). Detection was achieved with a UV detector set at 254nm. Free essential amino acids quantification was accomplished by the absorbance recorded in the chromatograms relative to external standards. Under the assay conditions described, a linear relationship between the concentration of amino acids and the absorbance at 254 nm was obtained in the tested range. Finally, samples were injected into the amino acid analyser model (SYKAM 57130) and the profiles of each sample were determined.

Table 2: Ingredient Percentage Composition (g/100g) of Experimental Diets with Different Levels of Maca Root Powder as Feed Additive

Ingredients (%)	TM_0	TM_1	TM_2	TM_3	TM_4
Fish meal	20.00	20.00	20.00	20.00	20.00
Soybean meal	21.50	21.25	21.00	21.00	21.00
GNC meal	23.00	23.00	23.00	23.00	23.00
Yellow maize	30.00	30.00	30.00	29.75	29.50
Maca root powder	**0.00**	**0.25**	**0.50**	**0.75**	**1.00**
Fish Oil	1.00	1.00	1.00	1.00	1.00
Vegetable oil	1.00	1.00	1.00	1.00	1.00
Starch	1.00	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
*Vitamin/premix	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Cr_2O_3	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00

Source: Ali *et al.* (2024b).

Keys: TM_0 - Maca root powder (0.0g/100g), TM_1 - Maca root powder (0.25g/100g), TM_2 - Maca root powder (0.5g/100g), TM_3 - Maca root powder (0.75g/100g), TM_4 - Maca root powder (1.0g/100g)

*Vitamin and mineral mixture (product of HEPOMIX): 12.000.000 IU Vitamin A; 2.000.000 IU Vitamin D3; 10g Vitamin E; 2g Vitamin K3; 1g Vitamin B1; 5g Vitamin B2; 1.5 g Vitamin B6; 10g Vitamin B12; 30g Nicotinic acid; 10g Pantothenic acid; 1g Folic acid; 50g Biotin; 250g Choline chloride 50%; 30g Iron; 10g copper; 50g Zinc; 60g Manganese; 1g Iodine; 0.1g Selenium and Cobalt 0.1g.

Table 3: Proximate and Gross Energy Composition of Experimental Diets with Different Levels of Maca Root Powder as Feed Additive

Proximate composition (%)	TM_0	TM_1	TM_2	TM_3	TM_3
Crude protein (%)	40.01	40.05	40.08	40.21	40.11
Crude lipid (%)	5.80	5.86	5.88	5.96	5.91
Crude fibre (%)	2.81	2.86	2.89	2.92	2.90
Moisture (%)	5.47	5.79	5.30	5.15	5.19
Ash (%)	13.11	12.87	12.94	12.69	13.01
Nitrogen - free extract (%)	32.80	32.57	32.91	33.07	32.88
Gross energy (Kcal/kg)	3,330	3,310	3,201	3,180	3,197

Source: Ali *et al.* (2024b).

Keys: TM_0 - Maca root powder (0.0g/100g), TM_1 - Maca root powder (0.25g/100g), TM_2 - Maca root powder (0.5g/100g), TM_3 - Maca root powder (0.75g/100g), TM_4 - Maca root powder (1.0g/100g).

Data Analysis

The data obtained were subjected to one - way analysis of variance (ANOVA) using the GraphPad Instant package for windows 2016 of statistical analysis system (SAS, 2016). Mean separation was done (at P = 0.05) using Fisher's least significance difference (LSD) to separate the means in cases of significant difference.

Results

In this research, all the nine (9) essential amino acids were found in the final carcass profile of the *Clarias gariepinus*. The results of the carcass essential amino acids profile of *Clarias gariepinus* fingerlings fed different levels of Maca root powder as feed additive is presented in Table 4. Carcass histidine values range from 10.02mg/g⁻15.81mg/g, the highest histidine value, 15.81mg/g was recorded from fish fed diet TM_3, while the least histidine value, 10.02mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass histidine values. Carcass isoleucine values range from 18.20mg/g⁻25.42mg/g, the highest isoleucine value, 25.42mg/g was recorded from fish fed diet TM_3, while the least isoleucine value, 18.20mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass isoleucine values. Carcass leucine values range from 11.98mg/g⁻14.17mg/g, the highest leucine value, 14.17mg/g was recorded from fish fed diet TM_4, while the least leucine value, 11.98mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass leucine values. Carcass lysine values range from 14.68mg/g⁻20.13mg/g, the highest lysine value, 20.13mg/g was recorded from fish fed diet TM_3, while the least lysine value, 14.68mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass lysine values. Carcass methionine values range from 26.80mg/g ⁻ 33.07mg/g, the highest methionine value, 33.07mg/g was recorded from fish fed diet TM_3, while the least methionine value, 26.80mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass methionine values. Carcass phenylalanine values range from 17.69mg/g ⁻ 22.24mg/g, the highest phenylalanine value, 22.24mg/g was recorded from fish fed diet TM_3, while the least phenylalanine value, 17.69mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass phenylalanine values. Carcass threonine values range from 15.13mg/g ⁻ 22.23mg/g, the highest threonine value, 22.23mg/g was recorded from fish fed diet TM_3, while the least threonine value, 15.13mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass threonine values. Carcass tryptophan values range from 20.92mg/g ⁻ 25.74mg/g, the highest tryptophan value, 25.74mg/g was recorded from fish fed diet TM_3, while the least tryptophan value, 20.92mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass tryptophan values. Carcass valine values range from 32.95mg/g ⁻ 39.77mg/g, the highest valine value, 39.77mg/g was recorded from fish fed diet TM_3, while the least valine value, 32.95mg/g was recorded from the fish fed control diet (TM_0). There was a significant difference ($p<0.05$) among the fish fed diets with Maca root powder and the control diet (TM_0) carcass valine values.

Table 4: Carcass Essential Amino Acids Profile of *Clarias gariepinus* Fingerlings Fed Different Levels of Maca Root Powder as Feed Additive

Amino acid (mg/g)	TM_0	TM_1	TM_2	TM_3	TM_4
Histidine	10.02^a	10.99^b	11.02^b	15.81^d	11.88^c
Isoleucine	18.20^a	19.91^b	20.32^b	25.42^d	22.10^c
Leucine	11.98^a	12.86^b	13.10^c	12.43^b	14.17^d
Lysine	14.68^a	15.02^b	15.98^b	20.13^c	16.38^b
Methionine	26.80^a	27.13^b	28.00^b	33.07^c	28.64^b
Phenylamine	17.69^a	18.92^b	19.84^c	22.24^d	20.03^c
Threonine	15.13^a	16.86^b	17.64^c	22.23^d	18.10^c
Tryptophan	20.92^a	21.84^b	22.03^b	25.74^c	22.73^b
Valine	32.95^a	33.96^b	34.89^b	39.77^d	35.62^c

Mean values in each row with similar superscripts are not significantly different ($p>0.05$).
Keys: TM_0 - Maca root powder (0.0g/100g), TM_1 - Maca root powder (0.25g/100g), TM_2 - Maca root powder (0.5g/100g), TM_3 - Maca root powder (0.75g/100g), TM_4 - Maca root powder (1.0g/100g).

Discussion

The building blocks of protein are amino acids. Essential amino acids are the most important group of amino acids as they are vital for body tissue regeneration and they can be dietary acquired through fish consumption (Swastawati *et al.*, 2023). The carcass histidine values; 10.02mg/g–15.81mg/g, recorded from this study are lower than the values, 9.67mg/g – 32.34mg/g reported by Anderson (2020) for *Clarias gariepinus* fingerlings fed diets containing black soldier fly (*Hermetia illucens*) larvae meal. However, these variations in the chemical composition of the amino acids might be as a result of differences in feed, age, sex, environment and season. Oriolowo *et al.* (2020) stated that histidine helps in the production of histamine, which takes part in allergic and inflammatory reactions. It plays a very important role in maintaining the osmoregulatory process and is related to energy production or is used in other metabolic pathways during certain emergencies or harsh conditions. Umar *et al.* (2016) reported that histidine also helps in the removal of heavy metals from the body. The carcass isoleucine values, 18.20mg/g–25.42mg/g, recorded from this study are comparable with the values, 21.20mg/g – 28.72mg/g, reported by Umar *et al.* (2018) for masculinized *Clarias gariepinus*. Isoleucine plays a vital role in blood formation and energy metabolism ((Agwu *et al.*, 2019; Anderson, 2020). The carcass leucine values, 11.98mg/g – 14.17mg/g, recorded from this study are comparable with the values, 8.250mg/g–18.53mg/g reported by Umar *et al.* (2016) for *Clarias gariepinus* fed commercial feed. Leucine increases the production of growth hormone, which is credited with bone, muscles and skin regeneration (Anderson, 2020). The carcass lysine values, 14.68mg/g – 20.13mg/g, recorded from this study are lower than the values, 14.21mg/g – 29.92mg/g reported by Anderson (2020) for *Clarias gariepinus.* However, these variations may be attributed to differences in feed, age, sex, environment and season. Lysine is needed in the synthesis of carnitine, which converts fatty acids into energy and also plays an important role in the production of hormones, antibodies and enzymes. A deficiency in lysine could lead to niacin deficiency which causes a health condition known as pellagra (Oriolowo *et al.*, 2020). The carcass methionine values, 26.80mg/g–33.07mg/g, recorded from this study are lower than the values, 35.72mg/g – 43.09mg/g reported by Umar *et al.* (2018) for *Clarias gariepinus.* However, these variations may be attributed to differences in feed, age, sex, environment and season. Methionine aids in the production of sulphur, which is necessary for normal metabolism and it is also essential for the synthesis of haemoglobin and glutathione that fights against free radicals (Oriolowo *et al.*, 2020). The carcass phenylalanine values, 17.69mg/g – 22.24mg/g, recorded from this study are comparable with the values, 16.97mg/g–24.34mg/g reported by Umar *et al.* (2016) for *Clarias gariepinus.* The dietary intake of phenylalanine helps in the prevention of mood swings, lethargy, sluggishness, feeling of anxiety and low morale (Oriolowo *et al.*, 2020). Umar *et al.* (2016) reported that phenylalanine is needed for normal functioning of the central nervous system (CNS). The carcass threonine values, 15.13mg/g – 22.23mg/g, recorded from this study are comparable with the values, 14.44mg/g – 23.11mg/g reported by Umar *et al.* (2018) for *Clarias gariepinus.* Threonine is an important ingredient in the formation of bones, cartilages, hairs, teeth and nail (Oriolowo *et al.,* 2020). The carcass tryptophan values, 20.92mg/g ⁻ 25.74mg/g, recorded from this study are comparable with the values, 20.72mg/g ⁻ 28.84mg/g reported by Umar *et al.* (2016) for *Clarias gariepinus.* Tryptophan plays a key role in the brain as a precursor of the neurotransmitter, serotonin, which has a major effect on the feeding behaviour of animals, it also works as a relaxant, alleviate insomnia, prevent migraine, reduce anxiety and promote proper immune function (Oriolowo *et al.*, 2020). The carcass valine values, 32.95mg/g ⁻ 39.77mg/g, recorded from this study are higher than the values, 9.91mg/g ⁻ 19.64mg/g reported by Anderson (2020) for *Clarias gariepinus.* However, these variations may be attributed to differences in feed, environment and season. Valine plays a key role in growth, nervous and digestive systems (Swastawati *et al.*, 2023).

Conclusion

Findings from this study suggested that the inclusion of Maca root powder as feed additive into the diet of *Clarias gariepinus* fingerlings increases the concentration of the carcass essential amino acids and therefore the *Clarias gariepinus* can be a very important source of the essential amino acids. The present study indicated that the carcass essential amino acids profile of the *Clarias gariepinus* fingerlings fed diets incorporated with different levels of Maca root powder as feed additive and the control diet had all the nine (9) essential amino acids.

Recommendations

- The incorporation of Maca root powder as feed additive into the diet of *Clarias gariepinus* fingerlings is recommended for improving the *Clarias gariepinus* carcass essential amino acids profile.
- Further research should be carried out on other plant - based feed additives on their efficiency in improving the carcass essential amino acids profile of *Clarias gariepinus.*

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