Studies on the Inclusion of Graded Levels of Synthetic Methionine to Diets of Clarias Gariepinus Juveniles with Maize and Cassava Root Meals as Energy Sources

Ugwu L.L.C.[1], Arazu V.N.[2], Nwosu M.C.[2], Ibemenuga K.N.[2]
[1]Department of Fisheries and Aquaculture,
Ebonyi State University, P.M.B. 052, Abakaliki, Nigeria.
Llcugwu@Yahoo.Com
[2]Department of Biological Sciences,
Chukwuemeka Odumegwu Ojukwu University,
Uli, Anambra State, Nigeria
Chukellisnwosu@Yahoo.Com

Abstract:-The effects of graded levels of dietary synthetic methionine (SMT), with yellow maize (YM) and cassava root (CVR) meal as energy sources in the diets of Claries gariepinus (mean weight, 24.02 ± 0.28g) were studied for 56 days. Two sets of five (5) experimental diets (D_1, D_2, D_3, D_4 and D_5) were formulated at 38% crude protein and fortified with 1.50, 2.50, 3.50, 4.50, and 5.50% SMT/ 100g of diet respectively. YM or CVR was used as energy source in each of the 5 sets of diets while the controls were devoid of SMT (0.00%/100g). The SMT/YM diets elicited the deposition of significantly (P < 0.05) higher values of crude protein (CP), crude fibre (CF), ash (AS) and nitrogen free extract (NFB) in the fish than the SMT/CVR diets. Additionally, the growth performance of the fish showed that higher values of the weekly mean weight gain (WMWG) and the food conversion ratio (FCR) were obtained with fish fed the SMT/YM diets than with those fed the SMT/CVR diets. Although fishes fed the SMT/YM diets demonstrated better daily rate of growth (DRG) than those fed the SMT/CVR diets, the differences in growth were insignificant (P > 0.05). This result is consistent with the report of other workers which stated that free methionine is poorly utilized by fish and it provides little or no benefit to catfish feeds. The results of this study also imply that YM is a better option as an energy source to enhance growth and nutrient deposition in fish than CVR meal.

Keywords:- Clarias Gariepinus Synthetic Methionine, Yellow Maize, Cassava Root Meal, Energy Source.

I. INTRODUCTION

In most animal feeds, a deficiency in methionine or lysine is corrected by the addition of synthetic free amino acids to the formulation. Andrews et al (1977) reported that free methionine and lysine are poorly utilized by channel catfish (Ictalunts punctatus) and provide little or no benefit to catfish feeds. Thus, amino acid balance must be achieved using combinations of natural proteins sources. The workers used corn gluten meals to enrich the methionine levels of diets containing 24, 30, 36% crude protein and obtained a significant growth response with methionine levels up to 0.60% of diet. The gains obtained from 35% crude protein diet which contained 0.75% methionine (with corn gluten meal) were not significantly different (P > 0.05) from those obtained from 36% crude protein diet which contained 0.59%methionine (without corn gluten meal).

The quality or the amino acid content of protein is the most important factor in optimizing the utilization of dietary proteins (Andrew et al., 1977). If a feed is grossly deficient of any of the ten essential amino acids, poor performance is inevitable despite the gross protein level. Studies have shown that better feed efficiency can be obtained containing 24% protein than a poorly balanced diet containing 36% protein (Andrews and Page, 1974). These authors also stated that since soybean meal (SBM) is usually the major protein source in most channel catfish feeds and SBM is deficient in methionine, this amino acid is usually the first limiting if the feed contains a high level of maize or other grain proteins and a low level of soya bean meal.

Fishes require energy for growth, activity and reproduction. Coldwater fishes have shown the ability to utilize carbohydrate as an energy source (Cowey and Sargent, 1972). The hexes component of carbohydrate has shown a major nutritional significance in the energy metabolism of these fishes. Whereas carbohydrates provide the starting point for biochemical synthesis, little may be found in natural diets. Little is present in the body, and fishes can grow on diets devoid of carbohydrates (Cowley and Sergeant, 1979). Maize (Zea mays) particularly the yellow variety is high in calorie carbohydrate, potassium, sodium, chlorine and sulphur (Olomu, 1995). Its proteins are relatively poor in quality. For instance, zein, a fraction of the protein contained in maize is of low biological value as it is deficient in lysine and tryptophan but excessively high in leonine, phenylalanine and tyrosine (aromatic amino acids). Since maize proteins containing fair amounts of methionine and cystine, which are limiting in other foods, maize could be used as a supplement to other foods which are devoid of the sulphur amino acids but rich in lysine and tryptophan (Olomu, 1995). The author also stated that yellow maize has between 500 to 800mg /100g methionine expressed as beta- carotene.

Increased levels of cassava (Manihoi escitlenta) products in practical fish diets have been noted to depress fish growth and feed utilization efficiency (Cowey et al., 1975). This was attributed to the presence of eyanogenic glucosides which can be reduced either by soaking in water or by sun-drying. The utilization of cassava root by common carp (Cyprinus carpio) has been reported by Ufodike and Matty (1983) and these authors stated that cassava root meal can replace some part of maize as an energy source in fish diet. Reports on the agronomic potentials of cassava (Coursey and Hayness, 1970) showed that cassava can meet a considerable part of the energy required in livestock /fish ration especially in Nigeria; where conventional grains are insufficient to meet the needs of man and its animals. Although Nigeria is the world's highest producer of cassava, its demand in the international market as an export commodity and the pressure from livestock feed industry have necessitated the importation of maize into (he country. Tewe and Pessu (1982) nevertheless opined that despite the relative abundance of cassava in Nigeria, it may not be an expedient economic option to introduce its tubers in conventional livestock rations.

Against the background, the effects of the inclusion of the graded levels of synthetic methionine to the diets of Clarias gariepinus (Teugels) juveniles with maize and cassava root meals as energy sources were studied. The essence was to assess the extent to which the enhancement of the methionine level of the two dietary energy sources would affect the growth performance of the fish.

II. MATERIALS AND METHODS

A. Experimental Procedure

Seven hundred and twenty (720) juveniles of Clarias gariepinus (Teugels) (mean weight; 24.02 ± 0.28g) were collected from the African Regional Aquaculture Centre (ARAC), Aluu, Port-Harcourt, Nigeria and conveyed to the Fisheries Research Laboratory of Ebonyi State University, Abakaliki, Nigeria, The fishes were acclimatized for 14 days and fed a maintenance ration of chick starter diet at 3% body weight per day (bw.cT1).Records of fish weight were taken with the aid of a top-loading electronic Mettler balance (Model PT 600).

Two experiments were carried out concurrently in the laboratory to involve Experiment 1, which comprised 360 C. gariepinus juveniles fed with diets fortified with graded levels of synthetic methionine (SMT) and with yellow maize (YM) as the energy source. Experiment 2 comprised another set of 360 C. gariepinus fed with diets fortified with SMT but with cassava root (CVJR) meal as the energy source. For Experiment I, 300 juveniles of the test fish were randomly stocked in 5 sets of aerator fitted glass aquaria (55x30x30cm3) at 20 fish per aquarium and replicated thrice (5x3) to provide 15 experimental treatments. These 5 test diets; D_1 D_2, D_3, D_4 and D_5, formulated at 38% crude protein and fortified with synthetic methionine (SMT) at 1.50, 2.50, 3.50, 4.50 and 5.50%/100g of diet respectively. Sixty (60) juveniles of the experimental fish were stocked in three aquaria and /cd the control diet (Do). The same procedure was adopted in Experiment 2 with respect to fish specimens, aquaria and SMT fortified diets.

Dietary ingredients (Table I) were thoroughly mixed, precooked and pelletized with a locally fabricated pelletizer and oven dried, the formulated diets packed in small cellophane bags, labeled according to treatment, and stored in a pest-free cupboard within the laboratory. Feeding offish was carried out thrice daily at four hourly intervals (Sam I2noon and 6pm) at 5% bw.d"1 for 56 days (8 weeks). The filtration systems of the aquaria helped in the elimination of faeces and other residues. Water temperature readings (27 ± 0.06 C) and p"1 values (6.60 ± 0.14) were recorded with maximum and minimum thermometer and a p meter (Model Ph-J-2Qlt) respectively. Control weighing was carried out every 7 days and feed administered adjusted in accordance with the body weight of fish.

B. Analytical Procedure

The proximate composition of both the experimental diets (Tables 2 and 3) and fish (Table 5) were analysed by methods described by Windham (1996). Crude protein was determined by microkjeldahl method, fat by soxhlet extraction method and ash by combusting in muffle furnace at 600 C for 12h. The digestible carbohydrate content was computed by obtaining the difference between % fibre + % ash + % crude protein + % crude fat and 100%. The amino acid concentrations of samples (Table 4) were determined by acid hydrolysis and high performance liquid chromatography (HPLC) method as described by Ogunji and Wirth (2001).

Determination of Growlli Parameters: The weekly mean weight gain (WMWG) was computed following Ishwata (1969) method:

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$$\text{WMWG} = \frac{\text{Final MW} - \text{initial MW}}{\text{Total number of weeks}}$$

Where

MW=mean weight.

The food conversion ratio (FRC) was calculated from the relationship between food intake and wet weight gain, thus:

$$\text{FRC} = \frac{\text{Dry weight of diet fed to fish (g)}}{\text{Live weight gain (g)}}$$

The daily rate of growth (DRG) was calculated from the relationship between the mean increase in weight per day and the body weight offish thus:

$$\text{DRG} = \frac{\text{Mean increase in weight}}{\text{Body weight of fish}}$$

Statistical Analysis: AH the data obtained were subjected to analysis of variance (Steel and Torrie, 1990) to determine, statistical significance ($P < 0.05$). The Duncans (1955) Multiple Range Test method was employed to partition the difference.

III. RESULTS

Table 1 shows the gross composition of the diets fortified with synthetic methionine (SMT) with either yellow maize (YM) or cassava root meal (CVR) as the energy source (D_1-D_5) and the control (D_0). The proximate compositions of the diets (D_1-D_5) with YM as energy source are shown in Table 2; while Table 3 shows the proximate compositions of the diets when CVR was used as the energy source. The selected amino acids composition of the diets (D_1-D_5)with either YM or CVR as the energy source is shown in Table 4; while Table 5 shows the weekly proximate compositions of C. gariepinus juveniles fed the SMT fortified diets. The weekly mean weight gains (WMWG) of the test fish arc shown in Table 6; while Table 7 shows the feed conversion ratio (FCR) of the fish between days 7and 56 of the study period. The daily rate of growth (DRG) of the fish is shown in Table 8.

From the results of the proximate compositions of the test diets (Table 2 and 3), it was evident that the SMT fortified diets with YM as the energy source (Table 2) had significantly ($P < 0.05$) higher values of crude protein (CP), nitrogen free extract (NFE) and total digestible nutrients (TDN) than the SMTdiets with CVR as the energy source (Table 3). This disparity in nutrient values was also shown by the profiles of the selected amino acids of the SMT/CVR diets (Table 4). The mean values of the proximate compositions of the fish fed the SMT/YM and the SMT/CVR diets (Table 5) indicated mat the SMT/YM diets elicited the deposition of significantly ($P < 0.05$) higher values of crude protein (CP), ether extract (EE), crude fibre (CF), ash (AS), and nitrogen free extract (NFE) SMT/CVR diets. However, no definite pattern of variations in the proximate compositions of the fish was established as the SMT levels in the diets increased from 1.5%/100g in the diet (D,-D5) (Table 5).

Similarly, no definite pattern, of increase or decrease in the values of the weekly mean weight gain (WMVVG) of the fish was established as the study period progressed from day 7 to day 56 (Table 6). Nonetheless, the values of the WMWG of the fish fed the SMT/YM diets were higher than those recorded for fishes fed the SMT/CVR diets in all the treatments. WMWG values of fishes fed the SMT/YM diets were higher than those fed the SMT/CVR diets in the magnitude of 5% (Table 6). Additionally, no definite pattern of increase or decrease was obtained in the values of the WMWG of the fish as the levels of SMT in YM or CVR diets increased from 1.5%/100g. Generally, the values of the WMWG of the fish fed the SMT/YM and the SMT/CVR diets varied significantly ($P < 0.05$) as the dietary levels of SMT increased from 1.5%/100g to 5.5%/100g (Table 6).

The food conversion ratio (FCR) of the fish showed similar trend of variation in values when the SMT/YM and the SMT/CVR diets are compared. Whereas the FCR values of the fish fed the SMT/CVR diets were higher than those for the SMT/YM diets, irrespective of the period under consideration (day 7 to day 56) (Table 7), inconsistent changes in the FCR values were recorded between days 7and 56 as the dietary SMT levels increased from 1.5%/100g to 5.5%/100g. Generally, the values of the FCR of the fish fed the SMT/YM and the SMT/CVR diets also varied significantly ($P < 0.05$) as the dietary levels of SMT increased (Table 7). The daily rate of growth (DRG) of the fish deviated somewhat from the trend exhibited by the WMWG and the FCR values of the fish. DRG values of the fish increased from 1.5%/100g to 5.5%/100g; although such increases were insignificant ($P > 0.05$)(Table 8). Furthermore, DRG values decreased as the study period progressed from day 7 to day 56, irrespective of the dietary SMT treatment. Comparatively, however, the DRG values of the fish fed the SMT/YM diets were minimally higher than those recorded for the SMT/CVR diets (Table 8).

IV. DISCUSSION

The physiological effects of incorporating various levels of synthetic methionine (SMT) in the diets of C.gariepinus juveniles with yellow maize as the energy source indicated that dietary SMT apparently contributed to a better enhancement of nutrient composition and certain growth parameters of the fish than when cassava root meal was used as the energy source. The significantly ($P < 0.05$) higher values of CP, EE, CF, AS and NFE in fishes feed the SMT/YM diets (Table 2) than in those fed the SMT/CVR diets (Table 3) attested to this claim. This state of the affairs was further corroborated by the profiles of some selected ammo acids of the SMT/YM and the SMT/CVR diets used for the study (Table 4).

Since maize proteins are deficient in lysine and tryptophan but contain fair amounts of methionine and cosine (Olomu, 1995), the presence of yellow maize in the SMT/YM diets might have enhanced the potential of the diet to effect better nutrient deposition and growth (DRG) than the SMT/CVR diets. The inclusion of graded levels of SMT in the SMT/YM and SMT/CVR diets was aimed at improving the quality of SMT in the diets and observing the trend of nutrient deposition and growth in the fish. The implication of our present results is that yellow maize as an energy source in catfish diets that are fortified with SMT, effected comparatively better growth and nutrient deposition in the fish than diets with cassava root meal as an energy source.

Research has shown that increased levels of cassava (Manihot esculenta) products in practical fish diets depress growth and feed utilization efficiency in fish (Cowey et al,, 1975). This was attributed to the presence of cyanogenic glucosides in cassava, which must be reduced either by soaking in water or by sun-drying. Although cassava root meal (CVR) can meet a considerable part of the energy requirement offish, its utility to facilitate the deposition of the requisite nutrients in the fish and effect growth cannot be compared with that of yellow maize (YM).

From our present results, it was evident that despite the uniform inclusion of SMT in the SMT/YM and the SMT/CVR diets at 1.50-5.50% /100g, the C. gariepinus juveniles fed the SMT/YM diets had belter proximate composition (Table 5), better WMWG (Table 6), better FCR (Table 7) and better DRG (Table 8) than those fed the SMT/CVR diets. This implies that in a choice of between YM and CVR as energy sources for the diets of C. gariepinus juveniles, YM is a better option to enhanced growth and nutrient deposition in the fish, Additionally, the inclusion of graded levels of synthetic methionine in C. gariepinus diets with either CVR or YM as energy source apparently did not effect any tremendous increase in the daily rate of growth of the fish ('fable 8). This result is consistent with the report of Andrews et al. (I977) which stated that free methionine and lysine arc poorly utilized by channel catfish (Ictalurus punctatus) and provide little or no benefit to catfish feeds. These workers contended that amino acid balance in fish feeds must be achieved through combinations of natural proteins.

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Table 1: Gross Composition (% dry matter) of Synthetic Methionine fortified diets fed to Clarias gariepinus juveniles for 56 days

Nutrients (%)	**Synthetic Methionine Fortified Diets**					
	D_0	D_1	D_2	D_3	D_4	D_5
	Control 0.00% SMT1/100G	1.50% SMT1/100G	2.50% SMT1/100G	3.50% SMT1/100G	4.50% SMT1/100G	5.50% SMT1/100G
Yellow maize or cassava root meal	20.32	20.14	20.08	19.98	19.90	19.72
Groundnut cake	45.74	44.66	43.84	43.06	42.30	41.64
Fish meal	13.72	13.64	13.56	13.48	13.40	13.32
Blood meal	9.12	8.96	8.92	8.88	8.80	8.72
Oyster shell	0.05	0.05	0.05	0.05	0.05	.0.05
Brewer’s waste	5.00	5.00	5.00	5.00	5.00	5.00
Palm oil	5.00	5.00	5.00	5.00	5.00	5.00
Ad-vit[2]	0.60	0.60	0.60	0.60	0.60	0.60
SMT (%/100g)	-	1.50	2.50	3.50	4.50	5.50
Total	100.00	100.00	100.00	100.00	100.00	100.00

[1]Synthetic Methionine, [2]Pfizer Livestock Feeds Production Supplying The Following Vitamins And Minerals Per Gram Of Diet: A, 19823 IU; D_3 1965 IU; B_{12}, 10g Ton^{-1}; Raboflavin, 41mg; Niacin, 246mg; Pantothenic Acid, 98mg; Folic Acid, 19mg; Manganese, 241mg; Zinc, 100mg; Iodine, 20mg; Oxytetracycline Hydrochlorine, 20gm Ton^{-1}

Table 2: Proximate Compositions of Synthetic Methionine Fortified Diets for Clarias Gariepinus Juveniles With Yellow Maize As Energy Source.

Nutrients (%)	**Synthetic Methionine Fortified Diets**					
	D_0	D_1	D_2	D_3	D_4	D_5
	Control 0.00% SMT1/100G	1.50% SMT1/100G	2.50% SMT1/100G	3.50% SMT1/100G	4.50% SMT1/100G	5.50% SMT1/100G
Dry	89.25	88.56	90.63	88.84	87.75	91.37
Crude protein	36.56	30.38	33.60	36.48	41.64	42.38
Ether extract	10.86	10.28	10.64	10.61	12.35	13.77
Ash	10.42	13.60	13.64	10.60	9.66	9.55
Crude fibre	8.20	7.19	7.02	6.98	6.14	6.94
NFE	33.96	38.15	33.70	32.25	28.82	26.56
ME[3] (Kj/Kg)	12.72	12.92	12.95	12.54	12.50	12.49
TDN[4]	80.72	80.48	80.72	80.88	81.28	81.37
SE[5]	75.74	75.44	75.73	75.52	74.37	72.84
ME: protein ration (Kj/mg)	8.30	9.06	9.10	7.52	7.48	7.82

[1]Synthetic methionine [2]Nitrogen free extract, [3]Metabolizable energy, [4]Total digestible nutrient [5]Starch equivalent

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Table 3: Proximate Compositions of Synthetic Methionine Fortified Diets for Clarias Gariepinus Juveniles with Cassava Root Meal as Energy Source

Nutrients (%)	**Synthetic Methionine Fortified Diets**					
	D_0	D_1	D_2	D_3	D_4	D_5
	Control 0.00% SMT1/100G	1.50% SMT1/100G	2.50% SMT1/100G	3.50% SMT1/100G	4.50% SMT1/100G	5.50% SMT1/100G
Dry	89.24	84.13	86.10	84.41	83.36	86.80
Crude protein	36.55	28.86	31.92	36.66	39.56	40.26
Ether extract	10.87	9.77	10.11	10.08	11.73	13.08
Ash	10.45	12.92	12.96	10.07	9.18	9.07
Crude fibre	8.24	6.83	6.67	6.63	5.83	6.59
NFE	33.98	36.11	32.02	30.64	27.38	25.23
ME^3 (Kj/Kg)	12.70	12.27	12.30	11.91	11.88	11.87
TDN^4	80.73	76.46	76.68	76.84	77.22	77.30
SE^5	75.75	71.67	71.94	71.74	70.65	69.20
ME: protein ration (Kj/mg)	8.34	8.61	8.65	7.14	7.11	7.43.

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Table 4: Selected Amino Acids Composition (% Dry Matter) Of Experimental Diets Fed to Clarias Gariepinus Juveniles for 56 Days

Name of amino acid	Synthetic Methionine Fortified Diets					
	Control D_0 0.00% SMT1/100G	D_1 1.50% SMT1/100G	D_2 2.50% SMT1/100G	D_3 3.50% SMT1/100G	D_4 4.50% SMT1/100G	D_5 5.50% SMT1/100G
Aspartic acid[4]	2.54(2.51)	1.95(1.76)	2.04(1.91)	2.93(2.18)	3.16(2.73)	4.17(4.06)
Glutamic acid[4]	3.69(3.58)	3.52(3.21)	3.68(3.23)	3.91(3.63)	3.44(3.16)	4.64(4.32)
Serine[4]	0.68(0.53)	1.11(1.08)	1.21(1.10)	1.28(1.09)	1.56(1.24)	0.58(0.44)
Histidine[4]	1.63(1.46)	0.36(0.27)	0.56(0.45)	0.46(0.23)	1.73(1.37)	0.76(0.52)
Glycine[5]	0.82(1.46)	0.88(0.73)	0.94(0.82)	0.94(0.81)	1.02(0.96)	0.93(0.83)
Threonine[4]	0.68(0.62)	0.96(0.84)	0.97(0.86)	1.01(0.92)	0.64(0.48)	0.78(0.68)
Arginine[4]	0.94(0.86)	1.06(0.88)	1.19(1.06)	1.27(1.16)	1.53(1.35)	1.62(1.33)
carnosine4	0.41(0.38)	0.02(0.01)	0.04(0.02)	0.04(0.02)	0.07(0.04)	0.13(0.08)
taurine4	0.12(0.10)	0.01(0.01)	0.02(0.01)	0.01(0.01)	0.03(0.02)	0.02(0.02)
Alamine[4]	1.92(1.76)	0.06(0.03)	1.13(1.05)	1.62(1.25)	1.76(1.63)	1.71(1.46)
Tyrosine[4]	1.54(1.44)	0.06(0.04)	1.11(0.96)	1.21(1.12)	1.39(1.09)	1.48(1.19)
Valine[1]	0.11(0.09)	0.02(0.02)	0.03(0.01)	0.04(0.03)	0.07(0.05)	0.08(0.04)
Phenylalanine[4]	1.69(1.43)	1.07(1.03)	1.17(1.05)	1.21(1.12)	1.29(1.12)	1.64(1.38)
Isoleucine[4]	1.27(1.16)	0.76(0.64)	0.06(0.03)	1.02(0.96)	1.18(1.05)	1.33(1.14)
Leucine[4]	0.75(0.66)	1.01(0.98)	1.03(1.01)	0.07(1.01)	0.76(0.51)	0.75(0.59)
Ornitine[5]	2.09(1.98)	1.52(1.13)	1.62(1.41)	1.76(1.47)	2.01(0.98)	2.22(2.09)
Lysine[4]	0.02(0.01)	0.01(0.01)	0.02(0.01)	0.02(0.01)	0.03(0.02)	0.04(0.02)

[1]Analysis was carried out using HPLC; 5mg of samples were hydrolyzed at 110ºC for 24h. [3]All values of each amino acid at different levels of SMT fortification in a row are significantly different ($p<0.05$); [4]Essential amino acids; [5]Non-essential amino acids. *Values in parenthesis represent the amino acids composition of experimental diets with cassava root meal as the energy source.

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Table 5: Weekly Proximate Composition of Clarias Gariepinus Juvelines Fed With Synthetic Methionine Fortified For 65 Days

Diet	Synthetic methionine (%/100)	**Weekly Proximate Composition**											
		Mean value											
		Moisture		Crude protein		Ether extract		Crude fibre		Ash		NFE[1]	
		YM[2]	CVR[3]	YM	CVR	YM	CVR	YM	CVR	YM	CVR	YM	CVR
D_0 control	0.00	70.93	67.38	19.61	18.63	1.62	1.54	0.64	0.61	3.03	2.88	4.07	8.96
D_1	1.50	70.54	67.01	19.21	18.32	1.70	1.62	0.68	0.65	3.62	3.44	4.18	8.96
D_2	2.50	71.58	68.02	19.23	18.27	1.62	1.53	0.66	0.63	3.29	3.13	3.63	8.42
D_3	3.50	70.18	66.67	18.19	17.97	1.78	1.69	0.62	0.59	3.21	3.05	5.29	10.03
D_4	4.50	70.58	67.05	19.15	18.19	1.65	1.57	0.58	0.55	3.14	2.98	4.90	9.66
D_5	5.50	70.88	67.34	18.71	17.77	1.53	1.45	0.62	0.59	3.1	2.97	5.13	9.88

[1]Ntrogen free extracts, [2]Yellow maize (as energy) source), [3]cassava root meal (as energy source)

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Table 6: Weekly Mean Weight Gain (WMWG) of Clarias Gariepinus Juveniles Fed Synthetic Methionine Fortified Diets For 56 Days

Period (days)	Control D_0		**Synthetic Methionine Fortified Diets** D_1 (1.50%/SMT/100g)		D_2 (2.50%/SMT/100g)		D_3 (3.50%/SMT/100g)		D_4 (4.50%/SMT/100g)		D_5 (5.50%/SMT/100g)	
	YM^{2}	CVR^{3}	YM	CVR	YM	CVR	YM	CVR	YM	CVR	YM	CVR
7	0.45 ± 0.02^{a}	0.43 ± 0.02^{a}	0.12 ± 0.01^{b}	0.11 ± 0.01^{b}	0.29 ± 0.01^{c}	0.28 ± 0.01^{c}	0.12 ± 0.01^{b}	0.11 ± 0.01^{b}	0.23 ± 0.01^{cd}	0.22 ± 0.01^{d}	0.21 ± 0.01^{d}	0.20 ± 0.01^{d}
14	0.71 ± 0.03^{a}	0.67 ± 0.03^{a}	0.80 ± 0.03^{b}	0.76 ± 0.03^{ab}	0.73 ± 0.03^{b}	0.69 ± 0.02^{c}	0.57 ± 0.02^{d}	0.54 ± 0.02^{d}	1.58 ± 0.06^{e}	1.50 ± 0.06^{f}	1.50 ± 0.06^{f}	1.43 ± 0.05^{g}
21	1.62 ± 0.06^{a}	1.54 ± 0.06^{b}	0.92 ± 0.04^{c}	0.87 ± 0.06^{c}	1.98 ± 0.06^{d}	1.88 ± 0.05^{e}	2.06 ± 0.06^{f}	1.96 ± 0.05^{d}	2.03 ± 0.07^{f}	1.93 ± 0.06^{d}	1.93 ± 0.06^{d}	1.83 ± 0.05^{e}
28	-0.92 ± 0.02^{a}	-0.87 ± 0.02^{a}	0.35 ± 0.02^{b}	0.33 ± 0.02^{b}	-0.66 ± 0.02^{c}	0.63 ± 0.03^{c}	-0.27 ± 0.02^{d}	-0.26 ± 0.01^{d}	-0.79 ± 0.03^{e}	-0.75 ± 0.02^{e}	-0.75 ± 0.02^{e}	-0.71 ± 0.02^{ef}
35	0.20 ± 0.01^{a}	0.19 ± 0.01^{a}	-0.61 ± 0.02^{b}	-0.58 ± 0.01^{c}	-0.26 ± 0.01^{d}	-0.25 ± 0.01^{d}	0.32 ± 0.02^{e}	-0.30 ± 0.02^{e}	0.01 ± 0.00^{f}	0.01 ± 0.00^{f}	0.01 ± 0.01^{f}	0.01 ± 0.00^{f}
42	-0.13 ± 0.01^{a}	-0.12 ± 0.01^{a}	0.46 ± 0.02^{b}	0.44 ± 0.03^{b}	0.52 ± 0.03^{c}	0.49 ± 0.02^{bc}	1.41 ± 0.05^{d}	1.34 ± 0.05^{e}	1.59 ± 0.06^{f}	1.51 ± 0.06^{g}	1.51 ± 0.05^{h}	1.43 ± 0.04^{d}
49	1.92 ± 0.06^{a}	1.82 ± 0.06^{a}	0.54 ± 0.03^{c}	0.51 ± 0.06^{c}	2.60 ± 0.06^{d}	1.47 ± 0.06^{e}	3.57 ± 0.07^{f}	3.39 ± 0.06^{g}	4.68 ± 0.12^{h}	4.45 ± 0.011^{i}	4.45 ± 0.10^{i}	4.23 ± 0.12^{j}
56	0.32 ± 0.02^{a}	0.30 ± 0.02^{a}	0.62 ± 0.03^{b}	0.59 ± 0.02^{b}	0.44 ± 0.02^{c}	0.42 ± 0.02^{c}	0.60 ± 0.03^{b}	0.57 ± 0.03^{b}	0.64 ± 0.03^{bd}	0.61 ± 0.03^{b}	0.61 ± 0.02^{b}	0.58 ± 0.02^{b}

Table 7: Food Conversion Ratio (FCR) of Clarias Gariepinus Juveniles Fed Synthetic Methionine Fortified Diets For 56 Days

Period (days)	Control D_0		**Synthetic Methionine Fortified Diets**									
			D_1 (1.50%/SMT/100g)		D_2 (2.50%/SMT/100g)		D_3 (3.50%/SMT/100g)		D_4 (4.50%/SMT/100g)		D_5 (5.50%/SMT/100g)	
	YM[2]	CVR[3]	YM	CVR	YM	CVR	YM	CVR	YM	CVR	YM	CVR
7	1.22±0.06[a]	1.28±0.06[a]	3.66±0.12[b]	3.84±0.13[c]	1.74±0.07[d]	1.83±0.08[e]	1.54±0.06[f]	1.62±0.06[g]	2.11±0.11[h]	2.22±0.12[h]	1.98±0.10[g]	2.08±0.13[j]
14	1.10±0.06[a]	1.16±0.05[b]	0.93±0.04[c]	0.98±0.04[c]	1.01±0.06[c]	1.06±0.05[cd]	1.11±0.07[d]	1.17±0.06[e]	0.64±0.02[f]	0.67±0.02[f]	0.58±0.02[g]	0.16±0.03[gh]
21	23.11±0.15[a]	24.27±0.16[b]	26.84±0.16[c]	28.18±0.16[d]	20.92±0.15[e]	21.97±0.13[f]	27.75±0.17[g]	29.14±0.16[h]	29.51±0.15[i]	30.99±0.17[j]	29.32±0.16[k]	30.79±0.17[l]
28	-0.27±0.03[a]	-0.28±0.03[a]	119.71±2.06[b]	125.71±1.52[c]	-41.16±0.04[d]	-43.22±0.03[e]	-27.79±0.02[f]	-29.18±0.03[g]	-75.05±0.04[h]	-78.80±0.05[i]	-78.34±0.03[j]	-82.26±0.03[k]
35	189.00±1.13[a]	198.46±1.21[b]	-32.61±0.03[c]	-34.24±0.02[d]	-115.24±0.03[e]	-121.01±0.02[f]	-49.88±0.02[g]	-54.88±0.02[h]	465.51±2.26[i]	488.79±2.24[j]	463.24±2.23[k]	486.40±2.26[l]
42	-13.30±0.02[a]	-13.97±0.02[b]	57.02±1.21[c]	59.87±1.25[d]	66.61±1.26[e]	69.95±1.30[f]	28.71±0.16[g]	30.15±0.17[h]	51.54±1.21[i]	54.12±1.20[j]	50.12±1.19[k]	52.63±1.23[l]
49	3.55±0.12[a]	3.73±0.12[b]	9.34±0.15[c]	9.81±0.16[d]	9.42±0.14[e]	8.84±0.14[f]	7.34±0.13[g]	7.71±0.16[h]	5.38±0.12[i]	5.65±0.12[j]	4.21±0.12[k]	4.42±0.11[l]
56	0.66±0.03[a]	0.63±0.03[a]	4.56±0.13[b]	6.28±0.14[c]	4.45±0.12[d]	4.67±0.12[e]	3.76±0.11[f]	3.95±0.15[g]	3.43±0.12[h]	3.60±i	3.32±0.12[j]	3.49±0.12[k]

[1]Syntheitc methionine, [2] Yellow maize (as energy source), [3]Cassava root meal (as energy), Value on the same row followed by the same superscripts are not significantly different (P>0.05), Values on the row followed by different superscripts differ significantly (P<0.05)

Table 8: Daily Rate of Growth (DRG) of Clarias Gariepinus Juveniles Fed Synthetic Methionine Fortified Diets for 56 Days

Period (days)	Control D_0		Synthetic Methionine Fortified Diets: D_1 (1.50%/SMT/100g)		D_2 (2.50%/SMT/100)		D_3 (3.50%/SMT/100)		D_4 (4.50%/SMT/100)		D_5 (5.50%/SMT/100)	
	YM[2]	CVR[3]	YM	CVR	YM	CVR	YM	CVR	YM	CVR	YM	CVR
7	0.07±0.03[a]	0.06±0.36[a]	0.07±0.03[a]	0.06±0.02[a]	0.08±0.03[a]	0.07±0.03[c a]	0.09±0.04[a]	0.08±0.03[a]	0.10±0.04[a]	0.09±0.03[a]	0.11±0.04[a]	0.10±0.04[a]
14	0.05±0.02[a]	0.04±0.02[a]	0.06±0.02[a]	0.05±0.02[a]	0.07±0.03[a]	0.06±0.02[a]	0.08±0.03[a]	0.07±0.02[a]	0.09±0.03[a]	0.08±0.03[a]	0.10±0.04[a]	0.09±0.03[a]
21	0.04±0.02[a]	0.03±0.01[a]	0.054±0.02[a]	0.04±0.02[a]	0.06±0.02[a]	0.05±0.02[a]	0.07±0.03[a]	0.06±0.02[a]	0.08±0.03[a]	0.07±0.03[a]	0.09±0.03[a]	0.08±0.02[a]
28	0.03±0.01[a]	0.02±0.01[a]	0.04±0.02[a]	0.03±0.01[a]	0.05±0.02[a]	0.04±0.02[a]	0.06±0.02[a]	0.05±0.02[a]	0.07±0.03[a]	0.06±0.02[a]	0.08±0.02[a]	0.07±0.02[a]
35	0.02±0.01[a]	0.01±0.00[a]	0.03±0.01[a]	0.02±0.01[a]	0.04±0.02[a]	0.03±0.01[a]	0.05±0.02[a]	0.04±0.02[a]	0.06±0.02[a]	0.05±0.02[a]	0.07±0.03[a]	0.06±0.02[a]
42	0.02±0.01[a]	0.01±0.00[a]	0.02±0.01[a]	0.01±0.00[a]	0.03±0.01[a]	0.02±0.01[a]	0.04±0.02[a]	0.03±0.01[a]	0.05±0.02[a]	0.04±0.01[a]	0.06±0.02[a]	0.05±0.02[a]
49	0.02±0.01[a]	0.01±0.00[a]	0.02±0.01[a]	0.01±0.00[a]	0.02±0.01[a]	0.01±0.00[a]	0.03±0.01[a]	0.02±0.01[a]	0.04±0.01[a]	0.03±0.01[a]	0.05±0.02[a]	0.04±0.01[a]
56	0.01±0.00[a]	0.01±0.00[a]	0.01±0.00[a]	0.01±0.00[a]	0.01±0.00[a]	0.01±0.00[a]	0.02±0.01[a]	0.01±0.00[a]	0.03±0.01[a]	0.02±0.01[a]	0.04±0.02[a]	0.03±0.01[a]

[1]Syntheitc methionine, [2] Yellow maize (as energy source), [3]Cassava root meal (as energy), Value on the same row followed by the same superscripts are not significantly different (P>0.05), Values on the row followed by different superscripts differ significantly (P<0.05)