



Research Article

Growth Performance and Nutrient Utilization of *Clarias gariepinus* Fed Soaked *Boschia senegalensis* Supplemented Diets

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ABSTRACT

The present study investigated the nutritional suitability and cost-effectiveness of a Sahelian plant seeds, Aizien (*Boschia senegalensis*) as alternative to Soy bean meal in the diet of African Catfish (*Clarias gariepinus* Burchell, 1822). Raw seeds of the *B. senegalensis* were subjected to processing method intended to reduce levels of the most important antinutritional factors (ANFs). The resultant product was used to formulate five isonitrogenous (40%) diets, containing the seed meals at inclusion levels of 25% to 100% of dietary protein and fed to Fingerlings of the African Catfish at 5% of their body weight for a period of 24 weeks. The feeding trial involved one hundred and fifty (150) fingerlings of *C. gariepinus* (2.43g – 3.10g) randomly stocked at ten fish per Tank (200L) in a non-flow through design with regular water replacement and water quality monitoring. Important growth performance and nutrient utilization indices, weight gain (WG), specific growth rate (SGR), feed conversion ratio (FCR), protein efficiency ratio (PER), and Feed conversion efficiency (FCE) of fish in the experimental groups fed SBS based showed that Fish fed 50% SBS diet recorded the highest WG (439.14g), SGR (1.34%/day) and FCR (1.35). This could be attributed to the protein quality of the diets in relation to the dietary essential amino acid profile of the experimental diets used. Generally, the Fish fed the 100% SBS diet recorded the lowest growth performance with regards to WG (360.68g), SGR (1.25), FCR (1.61), PER (1.58) and FCE (62.22%). From the results of this experiment, for better production of African catfish *C. gariepinus*, replacement levels of 50 SBS may serve as good alternative to SBM in feed formulation for *C. gariepinus*.

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INTRODUCTION

Increasing human population has resulted in increased demand for high quality animal protein particularly fish which has been reported to be of high nutrient profile. However, sustained exploitation of the ocean and other natural water bodies by human through over fishing, habitat destruction and pollution has significantly decreased the supply of this important commodity with wild fish harvests decreasing from 10.7 million tons in 2004 to 4.2 million tons in 2010 (FAO, 2012). This has proved the earlier assertions by the FAO (2007) that the ocean and other natural bodies have reached their maximum yield potentials in 2003. Fish farming has been considered to be the only answer to the short falls in global fish production.

In Nigeria, effective aquaculture development has been identified as one of the viable means of improving local fish production thus reducing the current deficit in fish demand and supply situation. However, high cost of imported feeds and competition for conventional feed ingredients limit the growth and expansion rate of aquaculture industry in Nigeria. Abdel-Hakim *et al.* (2012) reported that cost of feed in intensive fish culture represents about 60-70% of the total cost of production. Fishmeal production is rather localised in some regions of the world, as a result of which it is becoming more expensive and difficult to obtain in many countries practising aquaculture (Jimoh and Aroyehun, 2011).

Over the years, Soya bean meal have been used to replace fish meal in Aquaculture diets, but, wider utilization and availability of this conventional feed stuff (soya bean) for fish feed is limited by increasing demand for human consumption and by other animal feed industries which resulted in the hike of its price in Nigeria (Siddhuraju and Becker, 2001). This situation has hindered the expansion and profitability of aquaculture enterprise in many developing

countries and has to encourage the need to look for cheaper alternative protein source for the development of low-cost feed that can replace this conventional feedstuff without reducing the nutritional quality of the diets (Agbabiaka *et al.*, 2012; Hassan *et al.*, 2015). It then becomes a priority to look for less expensive plant protein sources which would be beneficial in reducing feed costs (Barros *et al.*, 2002)..

One of such unconventional feed ingredients showing great potentials for investigation in fish feeds and feeding are Aizen (*Bosciasenegalensis*) seed meal. Aizen (*B.senegalensis*) is a drought resistant shrub whose seeds are used in West Africa as food. It grows wild in Algeria, Benin, Burkina Faso, Cameroon, Central African Republic, Chad, Ghana, Guinea, Kenya, Mali, Mauritania, Niger, Nigeria, Senegal, Somalia, Sudan and Togo. It appears that aizen originated in this part of the world only (NRC, 2008). According to IBGR (1984) *B. senegalensis* is an evergreen shrub or small tree less than seven meter high, native to the sahilian zones of Africa. It is well known to the population of Northern part of Nigeria as famine food. According to FAO (1989), this little desert shrub seems at first to offer little direct economic benefit. But during the 1984-85 Sudan famine, its seed effectively became the staple of market society, replacing millet and sorghum (which morphed into luxury foods). This study therefore, was intended to evaluate the possibility of replacing soy bean meal with *B. senegalensis* seed in the diets for *C. gariepinus*.

MATERIALS AND METHODS

Experimental Site

The Feeding trial was conducted in an indoor facility at the Department of Biology, Ahmadu Bello University Zaria. Analysis of the antinutritional factors and the proximate composition analysis of dietary feed ingredients and formulated feed, were carried out at Institute of Agricultural Research and National Animal

Production Research Institute, Zaria respectively.

Sources of Experimental Feed Ingredients

The test ingredients (*B. senegalensis*) seeds were obtained from rural women in Bursari Local Government area of Yobe State. The other ingredients viz viz: soy beans, wheat Brand, Corn (maize), Bone meal, Fish meal, Palm oil, Salt, Minerals and Vitamin Premix were purchased from commercial outlets in Zaria. Ingredients were used within 6 months and proximate composition was analysed before any diet formulation to check the nutritional quality.

Preparation and Processing of Experimental Feed Ingredients

Aizen seed (*B. senegalensis*) were dried in the sun for periods ranging from 3-7days depending on the environmental temperature at time of the experiment. The seeds were then pounded to remove the outer seed coat, thereby making the seed ready for soaking in water following the modified method described by Kpanja *et al.* (2016). Approximately one kilogram (1Kg) of raw *B. senegalensis* seeds was soaked in 2.5 litres of water in an open container for 72 hrs with the water constantly changed after every 8 hours. The water was finally drained and the seeds were sun-dried to a constant weight and kept in polythene bag at ambient Temperature until required for analysis.

Proximate Analysis

The proximate analysis of dietary ingredients, experimental diets, fish whole body, and faecal samples were carried out according to the methods outlined by (AOAC, 2000) as described by Alagbaoso *et al.* (2015).

3.7 Source of Experimental Fish

Six hundred (600) uniform sizes (2.43g – 2.83g) Fingerlings of *C. gariepinus* were procured from a commercial fish farm, Soltek in Zaria, Kaduna State, Nigeria.

Acclimatization and Weighing Procedures

One week before the start of each experiment, fish were transferred to the experimental tanks

for acclimation. In order to reduce variability in weight of fish within each tank, fish were graded into similar sizes of $\pm 1g$ before stocking randomly at a density of ten (10) fingerlings per tank (200l) in triplicates and fed with the control pellets during this period.

Thereafter, Fish were netted, drained off water and gently blotted on a soft paper towel (in an attempt to reduce errors of fish weights recorded due to water adhering to each fish) before individual weighing to the nearest 0.01g on a Mettler PC 400 electronic top pan balance. Fish length was measured to the nearest 0.1cm using a fish measuring board.

For all intermediate weight measurements, fish were bulk weighed fortnightly, where all fish in each tank were netted, using a fine mesh hand net. Excess water was then removed from the fish by blotting the net on a soft paper towel and transferred to a tarred, water-filled, container and weighed collectively to the nearest 0.01g. The weekly mean weight of fish was used to calculate the daily food ration for the following weeks.

Feeding of Fish and Determination of Feed Acceptability

The fish were fed to apparent satiation (until fish stopped feeding) by 10 min of gradual hand feeding three times daily (9am, 3pm and 9pm) during the first two weeks so as to determine the feeding rate. Thereafter, fish were fed according to percentage of their biomass at 5% three times daily for the first three months and adjusted accordingly to 5% of their biomass at feeding frequency of two (2) times for the last three (3) months of the experiment.

To monitor the amount of feed administered, each tank had its own labelled container to which the pre-weighed feed was added. The un-administered feed in each container was used to determine the apparent feed intake for each group while Diet palatability was assessed subjectively by direct observation of fish behaviour and feeding responses.

Feed Formulation and Compounding

The experiment involving *C. gariepinus* consisted of five treatments and their triplicates designated as T1, T2, T3, T4 and T5. These treatments corresponded to five experimental diets containing the *B. senegalensis* seed meals at varying levels of 0%, 25%, 50%, 75% and 100%, formulated at 40% Cp. T1 served as the control diet.

Feed ingredients; soy bean, corn, fish meal, *B. senegalensis* seed were separately milled, screened to fine particle size (<250 µm) and weighed according to the formulation. The ingredients were mixed until uniformly blended, with addition of water (20%-30%) slowly to the mixture and continuous stirring until dough-like consistency was formed. This was followed by pelleting using a hand operated pelleting machine at different die sizes of 2mm, 4mm and 6mm different stages of fish growth respectively. The pelleted feeds were sun dried and packaged in two layers of plastic bags measuring two (2) kilogram each, for storage in a well-ventilated room under ambient temperature.

Experimental Design and Procedure

The fingerlings were randomly stocked at a stocking density of Ten Fish per experimental plastic Tank (200 litre capacity, Black horse cylindrical container). Water level in the container was maintained at 75 litres in all treatments and the control throughout the period of the feeding trial.

The experiment was designed to accommodate five treatments and replications. The experimental treatments were designated as T₁, T₂, T₃, T₄ and T₅. These nomenclatures were corresponding to the respective levels of replacements of SBS. The fish were fed in the morning (8:00am), afternoon (2pm) and in the evening (8:00pm). Weighing and length measurement of fish was done to ascertain their initial mean weight (g) and initial mean length (cm) and subsequently after every two weeks

using top-load weighing balance (MetlerTolardo567) and fish measuring board, respectively.

Monitoring and management of some water quality parameters

Important water quality parameters such as Temperature, Dissolved Oxygen and pH were monitored regularly using mercury -in- glass Thermometer and automatic DO/pH Analyzer (model Jpb 607) respectively. To maintain this optimality, water in the culture containers were regularly changed every week (7 days) during the first 8 weeks of the experiment. However, after this period (8week), the water replacement schedule was adjusted to compensate the increased daily feed allowances and its corresponding increased faecal matter. Partial and complete water replacements were adopted after every five days and fortnight respectively.

Measurements of growth and Nutrient Utilization parameters

- a. **Weight gain (WG):** - Is the difference between the mean final body weight and the mean initial body weight of fish over a period of time.

$$WG = W2 - W1$$

Where, W1 represents initial weight

W2 represents Final weight.

- b. **Percentage weight gain** was calculated using the formula:

$$PWG = \frac{w2-w1}{w1} \times 100$$

- c. **Specific growth rate:** is the instantaneous change in weight of fish expressed as the percentage increase in body weight per day over any given time interval (Richer, 1979). It is calculated by taking natural logarithms of body weight, and expresses growth as %/day-1.

$$SGR = \frac{Lnfbw - Lniwb}{T} \times 100$$

Where, Lnfbw= natural log of final body weight, Lniwb= natural log of initial body

Weight and T= experimental period in days.

d. Survival rates of fish (SR) = $\frac{N2}{N1} \times 100$

Where, N1 = number of fish stocked, N2 = number of fish at the end of the feeding trial.

- e. Condition factor (K):** is information indicating the physiological status of the fish relating to its health and welfare (Balogun *et al.*, 2004). The K was calculated according to Fultons formulae described by Onie *et al.* (1983) as follows:

$$K = \frac{W \times 100}{L^3}$$

(Oni *et al.*, 1983)

Where: W = Weight of fish. L = Standard length of fish.

- f. Feed conversion ratio (FCR):** is defined as the amount of dry feed fed per unit live weight gain. It was calculated as:

$$FCR = \frac{FI}{WG}$$

Where, FI= feed intake and WG = weight gain
(Balfour, 1988).

- g. Protein Efficiency Ratio (PER):** is defined as the ratio between the weight gain of fish and the amount of protein fed (De Silva and Anderson, 1995). The PER was determined using methods of Balfour (1988) as follows:

$$PER = \frac{WG}{PF}$$

Where, WG= weight gain and PF= dietary protein fed.

- h. Protein Assimilation (PA):** this parameter was calculated using faecal protein to evaluate protein assimilation

$$(PA) = \frac{PC-FP}{PC} \times 100$$

Where, PC=protein consumed, FP=faecal protein (Kumar *et al.*, 2011).

- i. Protein produced at assimilated protein**

$$(PAP) = \frac{PG}{PA}$$

Where, PG= protein gain and PA = protein assimilated

- j. Net Protein Utilization (NPU):** sometimes also called efficiency of protein utilization, evaluates the protein in the diet by the ratio between the protein retained in fish tissues and the dietary protein fed. NPU is determined by carcass analyses of samples of fish taken before and after feeding with the evaluated protein, and generally expressed as a percentage of the protein fed.

$$NPU = \frac{CPG}{DPF} \times 100$$

Where, CPG= carcass protein gained and DPF = dietary protein fed

Data Analysis

Data obtained were subjected to one way analysis of variance (ANOVA) to test for significance among treatment means. Where there was significant difference ($P \leq 0.05$), Duncan multiple range test was applied to rank treatment means.

Results and Discussion

Performance of the experimental fish with regards to growth and nutrient utilizations are presented in Table 1 and Figure I respectively. Growth parameters such as weight gain, Hepatosomatic index (HI) and Specific growth rate increased with increase of SBS up to 50%. Further, increase of SBS to 75% and 100% resulted in decreased WG, HI and SGR respectively. Similarly, following nutrient utilization parameters; Protein efficiency Ratio (PER); Feed conversion efficiency (FCE) and Net protein utilization (NPU) increased with increase of SBS up to 50% and further increase of SBS in the diets resulted in decrease of those parameters. For instance, the initial weight ranged from 2.43g to 2.89g which were not significantly ($P > 0.05$) different between reference and the test diets. Mean final weight, Mean weight gain, Specific growth rate, Feed intake, Feed conversion ratio, Protein efficiency

ratio and Hepatosomatic index were all significantly ($P < 0.05$) lower at 100% SBS diets compared to the control and other test diets.

Mean final weight (414.40g) of the Fish fed the control diet (0% SBS) was lower than the values (441.22g) recorded for Fish fed test diet T_3 (50% SBS). However, the lowest (363.43g) was observed for fish fed diet T_5 (100% SBS). Similarly, trend corresponding to the mean final weight was sustained for mean weight gain (WG) and Specific growth rate (SGR), where T_3 (50% SBS) recorded the values (439.22g and 1.34%/day respectively). Consistently, the fish group fed 100% SBS recorded the lowest WG and SGR values (360.83 ± 32.82 g and 1.25 ± 0.02) respectively. Generally, there was appreciable increase in weight of Fish fed all the experimental diets including the control. Growth performance was initially slow (Fig 1) and closely uniform among treatments and the control within the first month, thereafter, growth started increasing with increase in months. By the fourth month, growth accelerated and differences in growth among treatments were observed.

Growth response of the experimental fish (*C. gariepinus*) fed the experimental diets revealed no significant variation ($P < 0.05$) in Final body weight and Mean final weight gain and other growth performance indices such as specific growth rate and condition factor. However, fish fed 100% levels of SBS diets showed exceptionally lower growth performance compared to the control and other experimental diets. This could be due to genetic composition of the fish since the performance of the experimental Fish fed diets containing 100% SBS did not show any significant variation ($P > 0.05$) with the 75%. Inherent difference in genetic expression as possible reason for variation in growth has been earlier reported by Sundström *et al.* (2003). Another palpable reason for this variation may be due to

experimental errors inherent with feeding trial involving fish.

Generally, there was improved growth performance of the experimental fish compared to the weight at onset of the experiment. Growth rate was highest at week 12 of the experiment (Figure 1). The highest growth performance was recorded in group fed 50% SBS and the control diets respectively. However, important growth performance indices, Specific growth rate (SGR), weight gain (G) and condition factor (FC) did not show any significant variation among experimental treatments and the control diets. This could be due to the increase protein digestibility of the experimental diets as previously reported by Oke *et al.* (2017).

Condition factor is information relating to the physiological status of the fish relating to its welfare and health, fatness or wellbeing of fish (Nath *et al.*, 2006). It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition (Ndemele *et al.*, 2010). Condition factor is also a useful index for monitoring of feeding intensity, age, and growth rates in fish (Ndimele *et al.*, 2010). The condition factors, (0.85–1.39) of fish fed the dietary treatments and the control were not significantly different ($P > 0.05$) indicating that dietary replacement of Soya bean Meal with *B. senegalensis* Seed Meals did not affect the welfare of the experimental fish.

In the present investigation, all the experimental diets were accepted by the experimental fish, indicating that the levels of incorporation of SBS did not affect the palatability of the diets. Nutrient utilization parameters evaluated in this study, showed improved feed intake with increasing levels of SBS in the diets where the highest feed intake (592.83g) was recorded in fish groups fed diets containing 50% replacement of soya bean meal by SBS. This value did not significantly differ with the values (592.96g) recorded for the control group and the other dietary treatments. This might be attributed

to the processing technique which involved soaking and drying that might have reduced the antinutritional compounds in the SBS, thereby increasing its palatability in *C. gariepinus* diets. This observation corroborates the works of Sidhuraju and Becker (2001); Francis *et al.* (2001) and Solomon *et al.* (2013). These authors reported that reduction in antinutrients by different processing methods of feed ingredients resulted in better palatability and growth in fish. Wee and Shun-Sen (1987), reported that soaked *Leucaenaleucocephala* leaf meal gave a significantly better growth response than sundried or commercial leaf meal in the diets of Nile Tilapia, possibly due to a destruction of the mimosine content by the processing technique.

Another possible reason for the improved acceptability of the experimental diets could be due to the presence of flavonoids in the SBS which enhanced the palatability of the diets irrespective of the presence of alkaloids. Johnson (2001) reported that flavonoids are a large and complex group of phenolic compounds that contribute to the flavour and colour of vegetables and fruits, and account for most of the dissolved solids in beverages such as tea, coffee and wine. Similar, observations were made by Ogunji *et al.* (2016) on processed African yam bean (*Sphenostylis stenocarpa*) fed to *C. gariepinus*.

Feed conversion ratio, FCR calculated from the results of this study generally showed significant variation due to the dietary treatments. Although, there were slight differences in the trend of these values, the highest FCR was recorded for fish group fed 100% replacement of SBS diets and the lowest was observed in fish

group fed 50% SBS based diets. The variation may be due to the relatively higher and lower feed intake observed in the two dietary treatments respectively. This finding is in agreement with the work of Robinson and Li (2015) who opined that such observation could be traced to the non-availability of natural food in the culture tanks which is a very important factor both in quantity and quality. It is also in agreement with the works of Alemayehu and Getahun (2017) who reported similar trend on *C. gariepinus* fed processed Pigeon pea, *Cajanuscajan* meals as a replacement for soya bean meals diets.

The Protein Efficiency Ratio and Net Protein Utilization Parameters evaluated in this study revealed that no significant differences were observed between the control group and dietary treatments except Diet 5 (100% SBS) which recorded significantly lower values compared to the other dietary groups. This appreciable performance of the experimental fish may be due to protein quality of SBS which ensured efficient utilization of nutrients and assimilation by the fish. This characteristic feed utilization efficiencies and consequent growth rates has earlier been reported and attributed to dietary protein quality by Sotolu and Faturoti (2008) and Tihamiyu *et al.* (2015).

CONCLUSIONS

The results of the present study demonstrated that inclusion of soaked Boscia seed meals at 50% level for Soya bean meal may be used for potential diet formulation resulting in good growth performance and nutrient utilizations of *C. gariepinus*.

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Table 1: Gross composition of Experimental Diets

Ingredients	T ₁ (0%)	T ₂ (25%)	T ₃ (50%)	T ₄ (75%)	T ₅ (100)
Maize	17.21	16.09	14.99	13.89	12.63
Wheat Bran	17.21	16.09	14.99	13.89	12.63
Fish Meal	33.35	33.39	33.35	33.35	33.35
SBM	22.23	16.67	11.15	5.55	--
Bone meal	2.00	2.00	2.00	2.00	2.00
SBS	-----	7.76	15.52	23.32	31.39
Binder	1.00	1.00	1.00	1.00	1.00
Palm Oil	1.00	1.00	1.00	1.00	1.00
Premix	2.00	2.00	2.00	2.00	2.00
Salt	0.50	0.50	0.50	0.50	0.50
Methionine	1.50	1.50	1.50	1.50	1.50
Lysine	1.50	1.50	1.50	1.50	1.50
Cr ₂ O ₃	1.00	1.00	1.00	1.00	1.00
Total	100	100	100	100	100

Table 2: Growth Performance and Nutrient Utilization of *C. gariepinus* Fed SBS supplemented Diets

Growth	T ₁ (0%SBS)	T ₂ (25%SBS)	T ₃ (50%SBS)	T ₄ (75%SBS)	T ₅ (100SBS)
W1	2.83±0.18 ^a	2.43±0.32 ^a	2.75±0.08 ^a	2.75±0.06 ^a	2.59±0.07 ^a
W2	414.46±2.20 ^{ab}	420.00±12.98 ^{ab}	441.73±54.31 ^a	403.03±20.04 ^{ab}	363.43±32.25 ^b
WG	411.78±1.95 ^{ab}	417.20±12.94 ^{ab}	439.14±54.29 ^a	400.28±20.11 ^{ab}	360.68±32.82 ^b
SGR	1.28±0.01 ^{ab}	1.29±0.01 ^{ab}	1.34±0.02 ^a	1.29±0.01 ^{ab}	1.25±0.02 ^b
PER	1.72±0.08 ^a	1.87±0.13 ^a	1.99±0.07 ^a	1.74±0.05 ^{ab}	1.58±0.02 ^b
SR	73.33±3.33 ^b	73.6±3.33 ^{ab}	76.66±3.33 ^{ab}	86.66±6.66 ^a	86.66±6.66 ^a
FCE	69.01±1.86 ^{ab}	72.11±4.99 ^{ab}	74.10±3.09 ^a	69.07±3.54 ^{ab}	62.22±6.66 ^b
HIS	1.74±0.19 ^{ab}	1.79±0.13 ^a	1.96±0.25 ^a	1.43±0.18 ^{ab}	1.18±0.01 ^b
NPU	26.48±0.78 ^{ab}	28.43±0.01 ^{ab}	28.56±3.79 ^a	25.48±0.62 ^{ab}	23.27±0.03 ^b
FCR	1.44±0.03 ^{ab}	1.39±0.11 ^{ab}	1.35±0.05 ^b	1.45±0.09 ^a	1.61±0.02 ^a
CF	1.18±0.11 ^a	1.23±0.13 ^a	1.39±0.02 ^a	0.96±0.05 ^a	0.85±0.42 ^a
FF	592.96±15.68 ^a	578.60±73.33 ^a	592.83±99.27 ^a	579.45±18.36 ^a	579.60±41.17 ^a

Values (means ± standard error of means) with different superscript along a row are significantly different (P<0.05) from each other.

IW=Initial Weight, FW= Final Weight, WG= weight Gain, SGR= Specific growth rate; FCR= feed conversion ratio; CF= condition Factor; Feed fed; PER= Protein efficiency ratio; SR = Survival rate, MR= Mortality rate; FCE= Feed conversion efficiency; HIS= Hepatosomatic index and NPU= Net Protein Utilization.

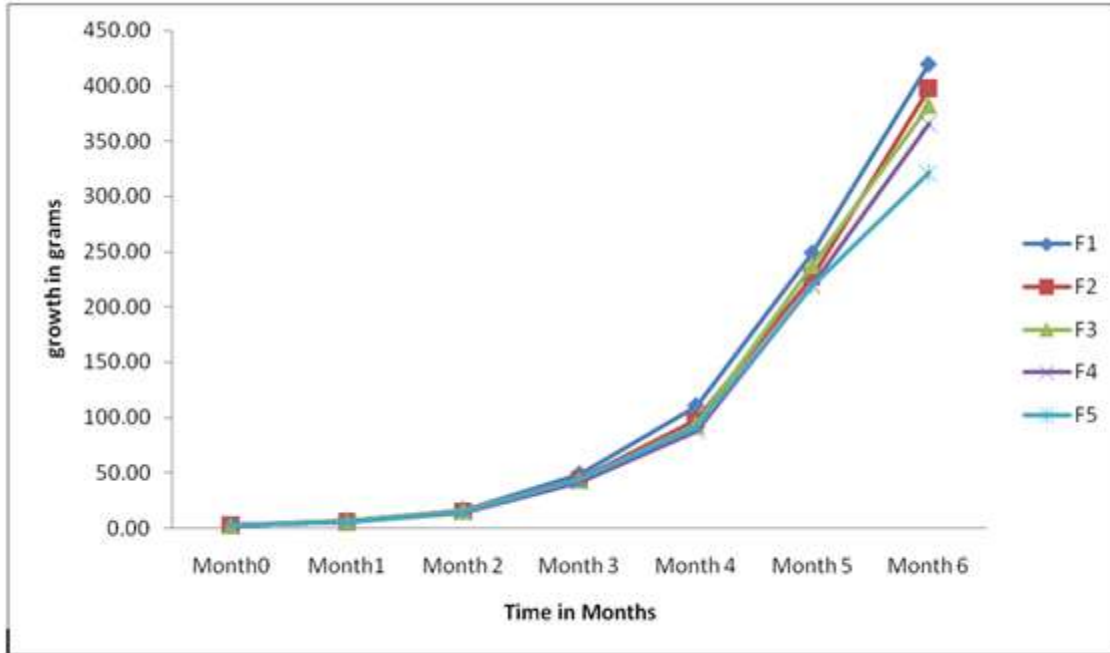


Figure 1: mean monthly increase in weight of *C. gariepinus* fed FPS based diets for 24 weeks