Nutrient Enhancing and Flesh Quality Improvement in Catfish (*Clarias gariepinus)* FedDietarySweetPotato(*Ipomoa butatas)*Leaves AqueousExtract

1. ABSTRACT

Dietary sweet potato(*I. batatas*)leaves extract was assessed for nutrient enhancing abilityand improvement of flesh quality in catfish (*C. gariepinus).* Thirty five (35) % crude proteinfeed was formulated using locally available ingredients. Four different diets were preparedfrom the formulated feed by adding varying quantities of sweet potato leaves extracts asfollows: Oml/kg; 50ml/kg; 100ml/kg; and 150ml/kg and labeled as Do, D1, D2 and D3respectively.Onehundredandtwenty(120)sub-adult*C.gariepinus*wereusedfortheexperiment,theyweredividedintofourgroupsintriplicatesof10. Feedingwiththeexperimental diets (Do-D3) commenced after two weeks of acclimatization and they were fedfor eight (8) weeks, and water quality parameters such as temperature, dissolve oxygen andpH were determined daily, and measurement of length and weight was done fortnightly. Afterthe feeding period fish were collected from each of the groups for proximate compositionanalysis and organoleptic assessment. The proximate composition of the diets were done toassesstheeffectsof*I.batatas*onthequalityofthediets.Theresultsrevealedthefollowing: (i) the diets had no effects on the assessed water quality parameters; (ii) there were nosignificance difference in the proximate composition of the experimental diets; (iii) the *I.batatas* leaveextracts enhanced the lipids, protein and fibre contents on the flesh of *C.gariepinus;* (iv)the*I.batatas*improvestexture,taste,appearanceandgeneralacceptabilityof *C. gariepinus* flesh; (v) nutrient utilization parameters such as protein intake (PI), proteinefficiency ratio (PER), protein retention (PR), fat retention (FR) and net protein retention(NPU) increases significantly as the quantity of *I. batatas* extracts increases in the diet (Do-D3).Itwasconcludedthatsweetpotato(*I.batatas)*leavesextractsimprovesnutrientsutilization and flesh quality in*C. gariepinus* by enhancing bioavailability, digestion andabsorptionofnutrients.

Keywords: NutrientUtilization,OrganolepticAssessment,ProximateCompositionofExperimentalfishflesh,Proximatecomposition ofexperimentaldiets

2. INTRODUCTION

Fisheries and aquaculture plays significant role in the promotion of food sufficiency, and itcontributesabove 15% to the protein consumed by humans especially in the underdevelopedcountries of the world (1). One of the problems in aquaculture is the availability of goodquality fish feed and a healthy environment free of diseases. Good quality feed will boost

theproductionoffish,enhancegrowthratesandreducediseasepresence(2,3).Thequalityofa fish feed is determined by the quality of nutrients in its ingredients, and how the fish utilizesthese nutrients determines the growth rate and taste of the fish. The growth and taste of thefishis furtherdeterminedbythebioavailabilityofnutrientsinthefish feed(4). Oneoftheessentialingredientsinfishfeedproductionisprotein,becauseofitsuniqueroleinthedevelopmentoffish.Proteinplaysanimportantroleinthegrowthandhealthoffish(3). Fishmeal is among the desirable protein ingredients because of it's high content of aminoacids,butthedecreaseinit'ssupplyasaresultofdemandandcostisputtingthesustainability of the aquaculture industry at risk (1). Since the cost of fishmeal is increasingeach passing day, identifying alternative feedstuffs to fishmeal will enhance productivity inaquaculture (5). So many authors have reported the importance of plants in the improvement of growth andhealth in fish (6, 7, and 8). (9) reported that sweet potato leaves (*Ipomoa batatas)* containsvarying percentages of ash, fat, protein, fibre, carbohydrate etc, and posses some importantphytochemicals such as flavonoid, coumanins, sapoinine, tannins, anthraquinnies, alkaloidsand phenols. (9) further stated that these components of the *I.batatas* has the capacity to boostgrowth and health in fish culture. The phytochemicals contained in *I. batatas* have the abilitytoenhances digestibilityandabsorption ofnutrientsin fish (10, 11). African catfish (*Clarias gariepinus)* is one of the most cultured fish outside its environmentbecause of its ability to survive in high stocking density, resist disease and good flesh quality.Thisresearchinvestigatedthedietary effectsofsweetpotato(*I.batatas*)leavesonthenutrientutilization and flesh qualityof *Clarias gariepinus.*

3. MATERIALSANDMETHODS

3.1 ExperimentalArea

The experiment was carried out in the fish farm of the Department of Fisheries and AquaticEnvironment,Rivers StateUniversity, Nigeria.

3.2 ExperimentalFish/Acclimatization

The fish (sub-adult *Clarias gariepinus)* was purchased from a reputable fish farm withinRivers State, and was taken to the experimental area between the hours of 6am – 7am in themorning. The fish was acclimatized for two (2) weeks, observed for disease presence andfeedingto satiation was donetwiceaday,whilewaterparameters weremonitored.

3.3 PreparationofExperimentalHerb/Diets

Sweetpotato(*Ipomoabatatas*)leaveswereharvestedwithinRiversState.Itwaswashedclean and processed using the methods of (12). The *I. batatas* leaves were pounded to pasteand soaked in hot water (50^{o}c) at 500g/L for twelve (12) hours. It was filtered and the filtratewasused immediately.

35% crude protein feed was formulated using locally available ingredients, and four differentdiets were produced from the feed by adding varying quantities of the prepared *I. bantatas*extracts as follows: 0ml/kg, 50ml/kg 100ml/kg and 150ml/kg and labeled as Do, D1, D2 andD3respectively.

3.4 ExperimentalDesignandFeedingTrials

A total of one hundred and twenty (120) sub-adult *Clarias gariepinus* were distributed intofour (4) groups in triplicates of ten (10) fish per replicate into twelve (12) aquariums (10fish/aquarium). The fish were acclimatized in the aquariums for two weeks and were fed tosatiation twice a day with a commercial diet. After the acclimatization period, the fish werefed with the experimental diets (Do – D3) according to their group for a period of eight (8)weeks,andcompletewaterexchangewas done ones daily.

3.5 ProximateAnalysisoftheExperimentalDietsandExperimentalFish

The proximate analysis of the experimental diets and fish were carried out in the DepartmentofFood Scienceand Technologyin theRivers StateUniversity, usingthemethods in

(13).

3.6 DeterminationofNutrientUtilization

Thefollowingparameterswereevaluatedtodeterminethenutrientutilization,usingthemethodsin (14) and (15):

- **FeedIntake(FI)**

FI = $\frac{Weightof\ \ feedconsumed(g)}{Numberof\ \ fish}$

- **NetProteinUtilization(NPU)**

NPU = $\frac{FishProtein}{ProteinFed} x100$

- **FoodConversionRatio(FCR)**

FCR = $\frac{Feedintake(g)}{Weightgain(g)}$

- **ProteinIntake(PT)**

PI = PercentagecrudeproteinoffeedXFeedConsumed(g)

- **ProteinEfficiencyRatio(PER)**

PER = $\frac{Weightgain(g)}{Proteinintake(g)}$

- **FatRetention(FR)**

FR = $\frac{FFCxFFW(g)-(IFCxIFW(g)}{FCDxFCRx[FFW(g)-IFW(g)]} X100$

whereFR = Fatretention

FFC = Finalfatconcentration

FFW = Finalfishweight

IFC = Initialfishconcentration

IFW = Initialfishweight

FCD = Fatcontentofdiet

FCR = Feedconversionratio

- **ProteinRetention(PR)**

$$PR = \frac{FPC - FFW(g) - (IPCxIFW(g)}{PCDxFCRx[FFW(g) - IFW(g)]} X100$$

where PR = Proteinretention

FPC = Finalproteinconcentration

FFC = Finalfishweight.

IPC = Initialproteinconcentration

IFW = Initialfishweight

FCR = Feedconversionratio

3.7 DeterminationofWaterQualityParameter

Thetemperature(Temp)anddissolveoxygen(Do)weremonitoreddaily.WhilethepHwasmonitoredt wiceaweek.Theyweremonitored asfollows:

- Temperature:Thetemperaturewasdeterminedusingmercuryglassthermometer
- PH: ThePHwas determinedusingpHmeter
- DO: Thedissolveoxygen wasdeterminedusingtheDometer

3.8 OrganolepticAssessmentoftheExperimental FishFlesh

This was determined using the sense of touch, smell, taste and sight (16). A ten man panel ofjudges were constituted for the assignment. Five fish from the different diets were evisceratedand soak in brime solution for five (5) minutes; they were later dried in an electric fishsmoking oven. At the end of every taste exercise the panelists were given cabin biscuits andwaterto erasethetastebeforetastinganotherset.

3.9 StatisticalAnalysis

The data analysis was expressed as a mean + SE for each of the variables. The statisticaldifference ($P<0.05$) of the determined values were tested using one way ANOVA. Followedtoaturkeymulti-comparison test withspss 17.0packagesoftware(17).

4. RESULTS

4.1 PhysicochemicalParametersoftheExperimentalWaters

Theresultsofthephysicochemicalparametersisshownintable1.Therewereno significantdifferenceacrossthetreatments,thevaluesforthetestedparametersweresimilar.

4.2 ProximateCompositionofExperimentalDietsand*Clariasgariepinus*FedDietary*Ipomea batatas*forEightWeeks

Theproximatecompositionoftheexperimentaldietsformulatedwithdifferentlevelsof *Ipomoabatatas*arepresentedinTable2.Theresultsobtainedindicatedthatthevaluesfor moisturecontentwaswithinthesamerange(11.30–11.43)betweendietsD_1-D_2.However,alowervalue of10.82±1.29 %was recordedin dietD_3.The sametrendwas equallyobserved in ash, where the same values (16.20-16.92) were recorded between diets D_0 - $D_2$and a higher value of 17.55±3.72 % was recorded in diet across the diets D_3. The value ofcrude fiber andlipidwere withinthe same range.The valuesfor lipidcrude fibre andcarbohydratewerehigherinDo (6.69±0.29and 15.08±3.19respectively).

4.3 ProximateCompositionof theFleshof theExperimental Fish(*C.gariepinus*)

Theproximatecompositionofthefleshof*Clariasgariepinus*feddietary*Ipomeabatatas*for eightweeksarepresentedinTable.3.Theresultsindicatedthatthevalues formoisture, crude protein and lipid were higher in the *I. batatas* fed fish (D1-D2) compared to the control(Do). While the values of carbohydrates in the experimental fish varied significantly (P<0.05)among the dietary treatments with no definite pattern. However, the values of ash and crudefibrewerewithin thesamerangeof2.36-2.90and0.29-0.42 respectively.

Table1: SummaryofthePhysicochemcialParametersof theExperimentalWaters(Mean±SE)

	Treatments			
Parameters	**D_o**	**D_1**	**D_2**	**D_3**
Dissolveoxygen (mg/L)	4.65±0.17	4.11±0.31	4.01±0.21	3.81± 0.34
Temperature(^oC)	25.09±1.01	28.37±1.13	28.17±0.91	27.39±1.21
pH	6.91±1.31	6.31±0.09	6.09±0.09	6.13±1.23

Meanswithinthesamecolumnwithdifferentsuperscriptaresignificantlydifferent(P<0.05)

Table2: ProximateCompositionofCompositionofExperimentalDiets(Mean±SD)

Treatments	**ProximateParameters(%)**					
	Moisture	**Ash**	**CrudeProtein**	**Lipid**	**CrudeFibre**	**Carbohydrate**
D_0	11.30 ± 0.71^b	16.86 ± 1.49^a	35.15 ± 0.23^a	6.69 ± 0.29^b	15.08 ± 3.19^b	29.15 ± 0.28^b
D_1	11.43 ± 0.69^b	16.20 ± 0.30^a	35.24 ± 0.09^a	4.57 ± 0.50^a	12.72 ± 2.32^a	26.72 ± 0.92^a
D_2	11.36 ± 0.35^b	16.92 ± 0.45^a	35.34 ± 0.15^a	5.76 ± 0.88^a	12.74 ± 7.78^a	25.93 ± 0.56^a
D_3	10.82 ± 1.29^a	17.55 ± 3.72^b	35.17 ± 0.01^a	4.10 ± 0.06^a	11.10 ± 3.48^a	26.16 ± 0.24^a

Meanswithinthesamecolumnwithdifferentsuperscriptaresignificantlydifferent(P<0.05)

Table3:ProximateCompositionofC*C.gariepinus*FleshFedDietary*I.batatas*LeavesExtract(Mean±SD)

Treatments	**ProximateParameters**					
	% Moisture	**% Lipids**	**%Protein**	**%Carbohydrate**	**%Ash**	**% Fibre**
BeforeExperiment	58.73 ± 1.50^{a}	4.80 ± 0.45^{a}	14.91 ± 0.59^{a}	0.76 ± 0.14^{a}	2.26 ± 0.16^{a}	0.29 ± 1.31^{a}
D_0	71.90 ± 0.04^{c}	5.82 ± 1.20^{a}	16.52 ± 1.22^{b}	1.02 ± 0.56^{b}	2.88 ± 0.60^{a}	0.40 ± 1.12^{a}
D_1	71.90 ± 0.08^{c}	6.81 ± 1.12^{b}	17.17 ± 1.30^{c}	0.86 ± 1.91^{a}	2.93 ± 0.43^{a}	0.41 ± 0.35^{a}
D_2	71.61 ± 1.36^{c}	6.66 ± 0.97^{b}	18.37 ± 0.91^{d}	0.91 ± 0.79^{a}	2.66 ± 0.93^{a}	0.42 ± 0.77^{a}
D_3	69.29 ± 1.53^{b}	6.35 ± 0.59^{b}	17.89 ± 0.07^{c}	0.87 ± 1.23^{a}	2.28 ± 1.15^{a}	0.41 ± 0.29^{a}

Meanswithinthesamecolumnwithdifferentsuperscriptaresignificantlydifferent(P<0.05)

4.4 OrganolepticAssessmentof*Clariasgariepinus*FedDietary*Ipomeabatatas*Leafextract sforEightWeeks

Theorganolepticassessmentof*Clariasgariepinus*feddietary*Ipomeabatatas*leafextracts foreightweeksare presentedinTable4.The resultsrevealedasignificant(P<0.05) differenceinthetasteoftheexperimentalfishbetweenthecontrol(D_0)andotherexperimental diets ofD_1,- D_3. The aroma of *C. gariepinus* were within the same range of7.33-7.67 in the fish fed D_o – D_2, while the fish fed D_3 had higher value (8.33 ± 0.58). However,thefishfeddietsD_1-D_3hadhighervalue(8.33±0.58). ThefishfeddietsD_1–D_3 hadhighervalues(6.00±1.00–8.33±1.53)fortexturecomparedtothevalueinthecontrol (Do)(5.00±1.00).Intermsofappearance,thefishfed withdietarytreatmentsof*Ipomea batatas* of D_1,- D_3 recorded significantly (P<0.05)higher values of 7.33±1.16 , 8.95±1.16and 8.67±0.07 respectively while the fish fed Do had 6.67 ±1.53. In terms of mouthful andacceptability, C.*gariepinus* fish fedwith dietary treatments of *Ipomea batatas* ofD_1 - D_3recorded significantly (P<0.05)higher values than the those fed with control diet D_0, but dietD_2recorded thehighest amongall thedietarytreatments.

4.5 NutrientUtilizationof*Clariasgariepinus*FedDietary*Ipomeabatatas*LeafextractsforE ightWeeks

Thesummaryofnutrientutilizationof*Clariasgariepinus*feddietary*Ipomeabatatas*for eightweeksarepresentedinTable5.Theresultsindicatedthatthevaluesofproteinintake (PI) in the experimental fish fed with different dietary treatments were within the same range,however higher values of 34.84±0.01, 34.56±1.16 and 35.33±0.09 were observed in D_1,D_2andD_3respectively.Infoodconversionratio(FCR),lowervaluesof1.21±0.07and1.20±0.04 were observed in D_2 and D_3. While higher values of 1.97±0.05 and 1.50±0.09 wereobservedin $D_2$and D_3

Table.4:OrganolepticAssessmentof*Clariasgariepinus*FedDietary*Ipomeabatatas*LeafextractsforEightWeeks(Mean±SD)

Treatments	**OrganolepticParameters**					
	Taste (10)	**Aroma (10)**	**Texture (10)**	**Appearance (10)**	**MouthFull (10)**	**Acceptability (10)**
D_0	6.67±2.08[a]	7.67±1.53[a]	5.00±1.00[a]	6.67±1.53[a]	7.07±2.08[a]	34.33±7.09[a]
D_1	8.00±0.00[b]	7.33±0.37[a]	7.33±1.33[b]	7.33±1.16[a]	7.67±0.58[a]	38.00±0.00[a]
D_2	8.67±1.53[b]	7.33±2.08[a]	8.33±1.53[b]	8.95±1.16[b]	9.00±1.00[b]	41.00±4.36[b]
D_3	7.67±1.53[b]	8.33±0.58[b]	6.00±1.00[a]	8.67±0.07[b]	8.00±0.00[b]	39.33±2.31[a]

Meanswithinthesamecolumnwithdifferentsuperscriptaresignificantlydifferent(P<0.05)

Table5:SummaryforNutrientUtilizationof*Clariasgariepinus*FedDietary*Ipomeabatatas* for Eight Weeks (Mean ±SE)NutrientUtilizationParameters

	FW	**WG**	**FI**	**PI**	**FCR**	**PER**	**NPU(%)**	**PR(%)**	**FR(%)**
D_0	231.01±3.50[a]	54.00±2.75[a]	89.46±2.03[a]	31.32±0.72[a]	1.97±0.05[b]	1.85±0.36[a]	46.99±0.92[a]	31.62±7.97[a]	16.47±7.41[a]
D_1	263.65±3.90[b]	74.65±4.90[b]	99.53±0.93[a]	34.84±0.33[a]	1.50±0.09[b]	2.07±0.11[b]	48.72±0.72[a]	43.48±1.82[b]	53.00±35.02[b]
D_2	259.87±0.87[b]	84.37±4.13[c]	98.72±0.02[a]	34.56±0.01[a]	1.21±0.07[a]	2.41±0.12[b]	50.98±2.43[b]	59.85±11.56[c]	68.47±27.20[c]
D_3	265.12±0.38[b]	87.62±2.13[c]	102.34±1.22[b]	35.53±0.09[b]	1.20±0.04[a]	2.45±0.10[b]	50.87±0.76[b]	55.93±3.48[c]	62.56±38.98[c]

Meanswithinthesamecolumnwithdifferentsuperscriptaresignificantlydifferent(P<0.05)

For protein efficiency ratio of the experimental fish fed with different dietary treatments were withinthe same range of 2.07-2.45 between diets D_1 to $D_{3.}$ However, a higher value of 1.85±0.36 wererecorded at diet $D_{0.}$ In Apparent Net Protein Utilization (ANPU) in *C.gariepinus* fed withdifferentlevels of *Ipomea batatas* inclusion dietary treatments over eight weeks, the values of ANPU obtainedwere within the same range of 7.14-8.11 in diets $D_{0,}$ $D_{2,}$ and$D_{3.}$ However, a higher value of13.14±2.43wererecordedatdiet$D_{2.}$Thevaluesofproteinretention(PR)obtainedintheexperimental fish varied significantly ($P<0.05$) among the dietary treatments, with the highest value(59.85±11.56) observed in diet $D_{2.}$And the lowest (31.62±7.97) observed in diet $D_{0.}$ Also, the valuesof FR obtained in the experimental fish varied significantly ($P<0.05$) among the dietary treatments,withthehighestvalue(68.47±27.20)observedindiet$D_{2.}$,whilethelowest(16.47±7.41)wasobservedin diet $D_{0..}$

Comparativevaluesofproteinincrease(PI)in*C.gariepinus*fedwithfedwithdifferentlevelsof *Ipomeabatatas*inclusiondietarytreatmentsovereightweeksisshowninFigure1.Thevaluesof PIincreasedastheexperimentalperiodincreased.Inalldietarytreatments.Thehighestvalueof 42.70obtainedindietD_3atweek8.Whilethelowest(25.90)wasobservedatdietD_0atweek2. Comparatively,thevaluesofFCRin*C.gariepinus*fedwithfedwithdifferentlevelsof*Ipomea batatas*inclusiondietarytreatmentsovereightweeksare presentedin Figure2.The valuesofFCR reduced as the experimental period increased in all dietary treatments. With the highest value of 3.29obtained in diet D_3 at week 2, while the lowest (1.04) was observed at diet D_2at week 8. ThecomparativevaluesofPERin*C.gariepinus*fedwithfedwithdifferentlevelsof*Ipomeabatatas* inclusiondietarytreatmentsovereightweeksisshowninFigure3.The valuesofPERincreased as theexperimentalperiodincreased.Inalldietarytreatments.Thehighestvalueof2.86obtainedindietD_3atweek2. Whilethe lowest (0.87) wasobserved at diet D_0at week 2.

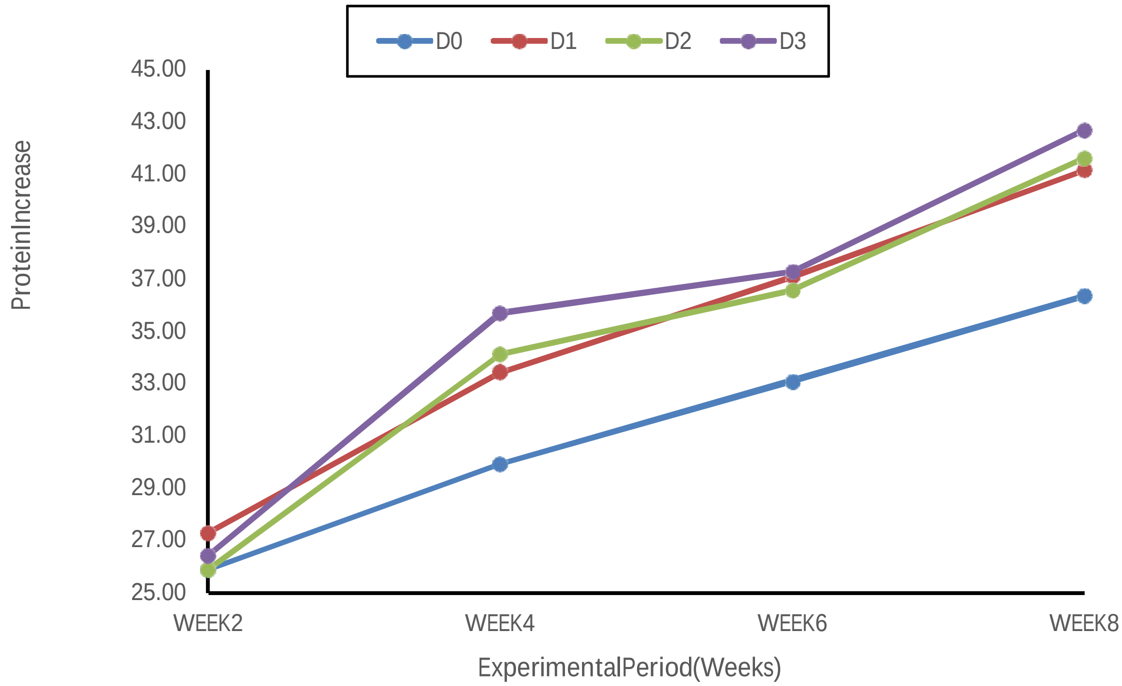

Figure1:ComparativevaluesofProteinIncreasein*C.gariepinus* fedwithdietary*Ipomeabatatas*leafextractsforeightweeks

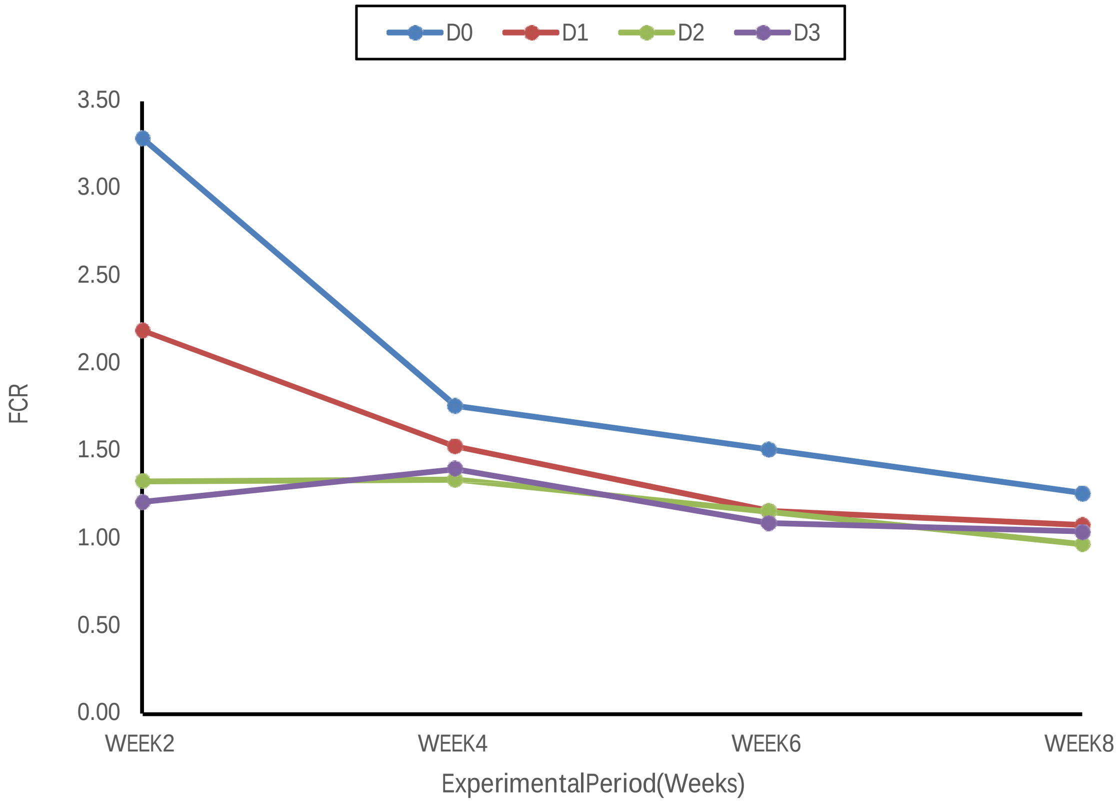

Figure 2: Comparative values of Feed Conversion Ratio in*C.gariepinus*fedwithdietary*Ipomeabatatas*leafextractsforeightweeks

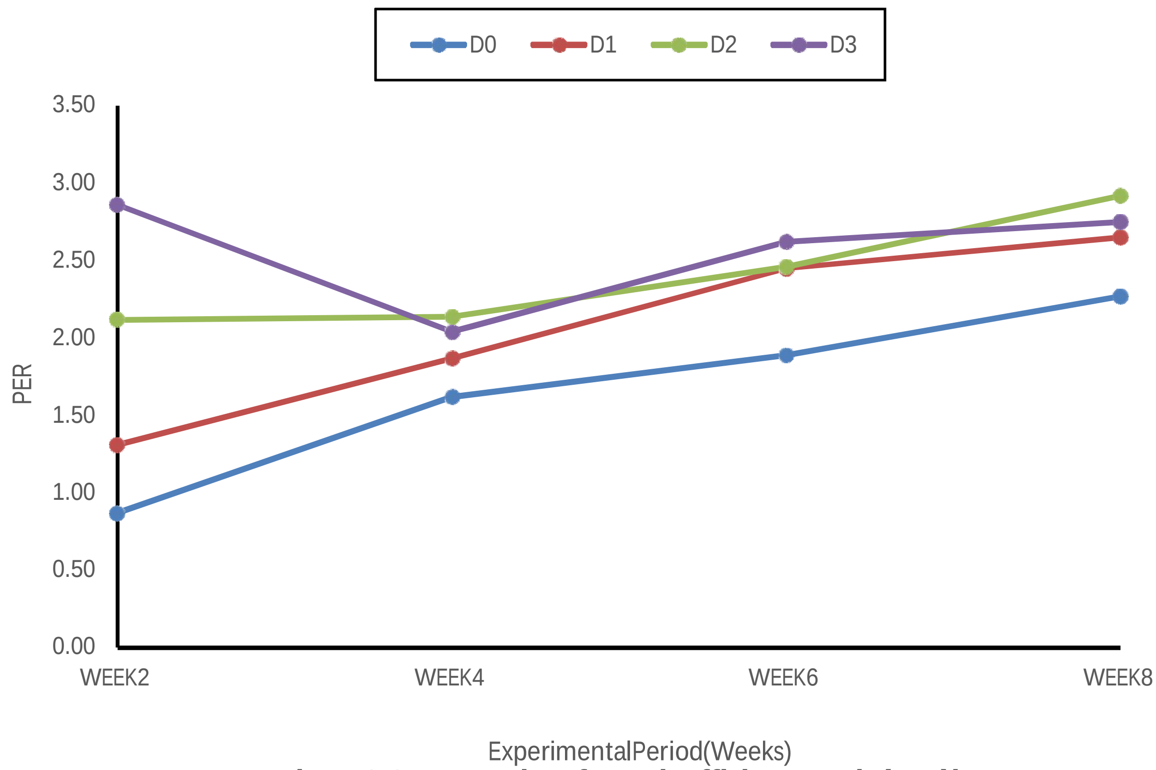

Figure3:ComparativeofProteinEfficiencyRatio(PER)in *C.gariepinus*fedwithdietary*Ipomeabatatas*leafextracts*for*eightweeks

Thecomparativevaluesoffeedintake(FI)in*C.gariepinus*fedwithdifferentlevelsof*Ipomea batatas*inclusiondietarytreatmentsovereightweeksisshowninFigure4.ThevaluesofFI increasedastheexperimentalperiodincreased,inalldietarytreatments.Thehighestvalueof 122.00obtainedindietD_3atweek8.Whilethelowest(75.3)wasobservedatdietD_0atweek2. However,dietarytreatmentD_0consistentlyrecordedthelowestvalueamongallthedietarytreatmentsinall experimental periods.

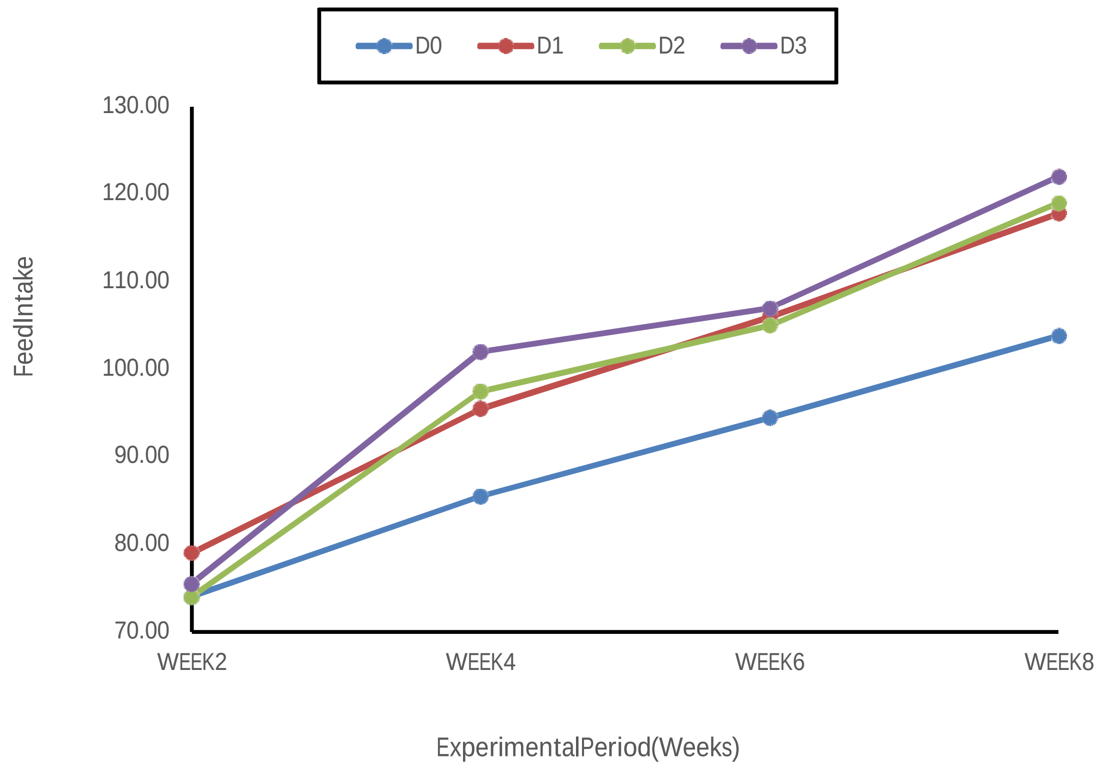

Figure.4:ComparativevaluesofFeedintakein*C.gariepinus*fedwith dietary*Ipomeabatatas* leafextractsforeightweeks

DISCUSSION

5.1 ProximateCompositionofExperimentalDiets

Theresultsforthephysiochemicalparameters(table1)weresimilartothatof(9),whostated that they were conducive for aquaculture practice. (18) reported that water qualities such astemperature,dissolveoxygenandpHdeterminestoalargeextendthegrowthandhealthoffishinaquaculture.Thegrowth,healthandreproductionofcommercialfishandotheraquaticanimals are primarily dependent upon an adequate supply of nutrient, both in terms of quantityand quality, irrespective of the culture system in which they are grown. Therefore, supply ofinputs(feeds,fertilizersetc.)mustbeensuredsothatthenutrientsandenergyrequirementsofthe species under cultivation are met and the production goals of the system are achieved (*19*).Nowadays formulated and commercial fish feeds are widely used formore yield in aquaculture.The protein requirement of commercial fish is influenced by various factors such as commercialfish size, water temperature, feeding rate, availability and quality of natural foods and overalldigestible energy content of diet (20). In this study, the crude protein content of the experimentaldietsanalysedwerewithinthe acceptable range recommended for commercial fish(21).(22) reported that most of the commercial fish feeds for example catfish feeds contain 32%crude protein.(23) estimated the protein requirement for tropical catfish to be 35-40, 25-35 and28-32%forfry,grow-outandbroodstockrespectively.However(24)observedthatfishproduction increased through the utilization of high amounts of protein i.e., 35% and above intheirdietanddietaryproteinhavebeenreportedtoimprovethequalityoffishflesh(25).

Lipids are primarily included in formulated diet to maximize their protein sparing effect (26) bybeingasourceofenergy.Theobservedlipidvalueswereinlinewiththatof(23)whoreported that 10-20% of lipid in most freshwater fish diets gives optimal growth rates without producingan excessively fatty carcass. On the other hand,(27) reported that lipid level in catfish feedsshouldbe5to6%.Moreover,(28)and(29),alsostatedthatdietarylipidlevelsof5to6%are often used in tilapia diet. In this study, the lipid content of the experimental diets (D_1 – D_3) werelower, this may be due to the fact that *Ipomea batatas* leaves extract is low in fat content (30), itcould also be that the phytochemicals in *Ipomoa batatas* leaves facilitated the reduction of thelipidsinthediets.

All plant ingredients contain a certain amount of fibre, and fibre provides physical bulk to thefeeds. Adequate quantity offibre in feed permits better binding and moderates the passage offeed through the alimentary canal. However, (31) noted that it was not desirable to have a fibrecontent above 8-15% in diets for animals, as the increase in fibre content would consequentlyresult in the decrease of the quality of nutrient in the diet. (32) also stated that high fibre contentin feeds tends to increase the energy content in the feeds, with the resultant effects of poorgrowth. The analysed crude fibre content of all the diets under study were within the safe dietarylimitforfish.

5.2 ProximateCompositionofExperimentalFishFlesh

The moisture and carbohydrate content of the experimental fish fed D1 – D3 after the feedingtrial were elevated above the control values. While the ash and fibre content of the fish werewithin same range across the diets. This result agrees with the findings of (33) in the flesh of *C.gariepinus* fed with cassava leaves. The result of the proximate composition of the experimentalfish shows higher protein and fat values in fish fed diets D_1- D_3 compared to the fish fed Do andthevaluesbeforethecommencementoftheexperiment.Similarresultwasrecordedin(14) when sea bass (*Dicentrarchus labrak)* was fed dietary Thyme, but Rosemary and Fenugreek inthe same experiment showed no significant difference in the protein content of the experimentfish, and (34) who reported improvement in the protein content and reduction in the fat contentwhen *Ipomoea batatas* leaf meal was administrated to *Tilapia Zilli.* (35) also reported increase inboth protein and fat content when African catfish was fed with 40% *Ipomoea batatas* leaf mealfor fourteen days. The deviation in the fat content of *Tilapia Zilli* sited above compare to thepresent result could be as a result of the life stage of the fish. The increase in the protein and fatcontent of the fish fed D1-D3 could be as a result of the bio-active compounds and mineralscontain in *Ipomoea batatas* leaves extracts (36) that enhanced the digestion and absorption of theprotein and fat in the diets. Minerals such as calcium, phosphorous, potassium etc contain in*Ipomoea batatas* (36) are known to improve fish flesh quality (37, 38). (39) reported the positiveeffects of plant phytochemicals such as astaxanthin and carotene on the flesh quality of Atlanticsalmon.

5.3 OrganolepticAssessmentsoftheExperimentalFish

Fishes are great source of highly valuable protein that is premium in human nutrition (40), withits irregular water and fat content (41). The crude protein content of the fish is also affected bythe quantity of salt and water-soluble protein in the diets (42), and the presence of endogenousenzymeandbacteriainfluencingdeteriorationduringtheprocessingperiod(43).

Eating healthy is a prerequisite to a good and sustainable live, and people are more concern withwhat they eat (44). One factor that influences organoleptic assessment in fish is acceptability ofavailablefeedbythefish.(45)postulatedthattheoverallacceptabilityandsensorycharacteristic of the fish is correlated to the quality of the water body, and (46) also reporteddifferenceintastewhen*Sardinellaspp*and*M.pontasson*fromdifferentlocationswithinthe

South-WestNigeriawereorganolepticallyaccessed.Despitethatseveralmethodshavebeenused to evaluate the flesh quality and freshness of fish, sensory evaluation remains the valuableand trusted means of obtaining the best result (47).(48) reported a positive correlation betweenbody composition and sensory quality, whereas (49) observed no significant differences in thesensory evaluation of fresh fish fed different diets. In this study, fish fed diets D1-D3 weresignificantlysuperiortothosefedthe control diets(Do)intheorganolepticassessment.

The superiority of the fish fed D1-D3 in the organoleptic assessment could be as a result of thebio-active compounds present in the diets, that enhanced bioavailiability of the nutrients in thediets. This assertion is supported by (4) who postulated that the quantity of nutrient delivered tothe blood steam for use is more relevant than the quantity present in the feed. Some of thebioactive compounds found in *Ipomoea batatas* leaves includes phenolic compounds, flavonoids,carotenoids,dietaryfibres,dietaryproteinetc(50;51;9)andessentialmineralsandtraceelements such as iron, calcium, zinc, copper among others (52; 51). *Ipomoea batatas* leaves havebeen proven to have high digestibility for proteins/amino acids (11) and digestibility enhancesabsorption of nutrients (10). (52) also reported that herbs stimulate the secretion of pancreaticenzymeswhichfacilitatesnutrients digestionandassimilation.

The noticeable changes in the catfish aroma, colour and taste are the main criteria that qualifycatfish at table size (53). It was demonstrated in this study that feeding catfish with differentlevels of *Ipomea batatas* leaves inclusion diet enhanced the typical characteristics of fish; taste,aroma,texture,andappearanceincatfishfleshanddidnotyieldanyoffodourorflavour,and thiscanbeattributedtothehigherlipidcontentinthefishfedD1-D3(Table.3). The observation was similarto previous reports whichsuggestedthatthelipidin fish fleshaffects thesenseofflavour andthe generalsensationofcookedfishinthemouthas wellasaroma(53). (54)

also noticed the effect of inclusion of the supplemental plant-based protein in the diet of browntrout on taste, texture, and acceptability. On the contrary, (55) observed that no effects of dietarytreatments were found to affect taste, texture and aroma of the Indian major carps fed withdifferentplant baseddietarytreatments.

5.4 NutrientUtilizationoftheExperimentalDiets

Plants and plants products have been utilized as additive or supplements in fish feeds due to theirability in the maintenance of fish health andenhancing digestibility/absorption of nutrients infeed (56; 10). Plants and plants products are preferred to synthetic drugs as growth enhancers inaquaculture (57), and have been proved to be growth promoters, anti-bacteria, environmentallyfriendly and not immunospecific (58). Some of the bioactive compounds in plants and plantproducts that facilitates the above qualities includes; polyphenols, flavonoids, saponines,

tannins,essentialoilsetc.(8,9),and*Ipomoeabatatas*leavesextractscontainsthesebioactivecompounds (50; 51; 9).

Some of the valuable indices used to determine the effectiveness of how an experimental fishutilizes its diet are: the feed conversion ratio (FCR) which is the expression of how the fishconverts feed to flesh; the protein efficiency ratio (PER) which expresses theeffectiveness ofthefishtoutilizeproteininthedietforgrowth;theproteinintake(PI)whichstatesthequantityof protein taken from the injected feed by the fish, and the feed intake (FI) which expresses thequantityoffeedinjectedbythefish(59; 60 and 32).

There were difference in the PI, FCR, and PER in the fish fed Do – D3, with the value increasingas the concentration of *Ipomoea batatas* leaves extracts in the diets increases. The result of thisresearch shows that the PI and FI increases as the period of feeding increases in fish fed D1-D3comparedtothefishfedDo.Thisresultissimilartothereportof(6)when*Clariasgariepinus*

was fed dietary *Terminalia catappa, Chromolaena odorata* and *Psidium guajava.* The increase inthe feed intake (FI) and protein intake (PI) in the fish fed D1-D3 could be as a result of thepresenceofthebioactivecompoundsin*Ipomoeabatatas* leavesextract,that enhancedthepalatability of the dietsor having directbactericidaleffectson the digestive systemof the fishfedD1-D3therebyenhancingproteindigestion(61).Polyphenols,flavonoids,calcium,phosphorus, and potassium are some bioactive compounds and minerals found in *Ipomoa batatas*and have the ability to enhance palatability and digestion of feed (50*;* 62). The feed conversionratio(FCR)reducedastheperiodoftheexperimentincreasesandwerelowerinthefishfedD1-D3comparedtothefishfedDo(Fig.2).FeedutilizationbythefishdeterminestheFCR(63).
The reduction in the FCR is an indication that the fish made a good conversion of feed to flesh,and the reduced values in D1-D3 depicts that the biochemical compounds in *Ipomoea batatas*enhanceddigestionandabsorptionofthefeedcomparedtofishfedDo(11, 10).

Theproteinefficiencyratio(PER)increasesastheperiodoftheexperimentincreasesinthefish fedD1-D3showingbetterperformance(Fig..3). Proteinefficiencyratioistheabilityofthe fish to use the protein absorbed from the ingredients for growth. The increase in the PER in fishfed D1-D3 depicts the fact that there were enhance digestion and absorption of the proteincomponentsofthedietscomparedtothefishfedDo.Thiscouldbeasaresultofthephytochemicals in *I. batatas* (9), which have been reported to enhance protein digestiability andabsorption in fish (11). Other authors have reported results similar to these findings: (64) whenstriped catfish was fed dietary ginger and (6) when African catfish was fed dietary *Terminaliacatappa.*

Aftertheeight(8)weeksfeedingperiod,theNPU,PRandFRincreasedwithincreasein *Ipomoeabatatas*inclusioninthediet,withsignificantincreaseinPRandFR(Table5).The increase of these parameters (NPU, PR, and FR) in the fish fed D1-D3 compared to Do suggestthe fact that the *Ipomoea batatas* enhanced nutrient utilization, and itis as a result of thestimulating effect of *Ipomoea batatas* leaves extracts on the secretion of pancreatic enzymes thatfacilitatesdigestionandabsorptionofnutrients (52).

Though the PR and FR were higher in the fish fed D1 – D3 the values for PR were highercompared to FR as the *I. batatas* leaves extract increases in their diet (D_0 – D_3). This depicts thefact that more fat was utilized for energy while more protein was utilized for growth, and as aresult led to increase in the quantity of protein deposited in the fish flesh (NPU) which is ameasureofdigestibility.Thispositionis supportedby(14)and (65).

6. Conclusion

The present study shows that application of *Ipomea batatas* leaf extract can be utilized in fishfeed for optimal performance of fish, as it enhances bioavailability, digestion and absorption ofnutrients. It was demonstrated that feeding catfish with different levels of *Ipomea batatas* leafextract inclusion diet improved the typical characteristic of fish such as flesh color, flavour andaroma in catfish fillet and did not yield any off odour, which connotes the fact that what the fishconsume as feed affects the quality of the fish flesh. The result of the study shows that 100 – 150ml/kg dietary inclusion level of *Ipomea batatas* leaves extract produced fish of better fleshqualityandcompositionthanthecontrol.

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