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Research Article

Growth performance and body composition of the African catfish (*Clarias gariepinus*) juveniles fed diets supplemented with *Afrostyrax lepidophyllus* fruit powder

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Abstract

To minimize the dependence of pisciculture on imported feed and improve the production of fish through the valorization of local feeds, this study was conducted to evaluate the effects of dietary inclusion of *Afrostyrax lepidophyllus* fruit powder on the growth and chemical composition of *Clarias gariepinus* juveniles. The juveniles weighing 13±3.1 g were divided into four treatments in triplicates and fed with diets containing 0 (T_0 or control), 2 (T_1), 4 (T_2), and 6 (T_3) g/kg *A. lepidophyllus* fruit powder for 63 days. The feeding rate was 5% of their body weight. The results showed that adding different levels of *A. lepidophyllus* fruit powder to the diets improved growth, feed utilization, and carcass quality attributes. The African catfish fed with T_3 diet recorded higher final weight (43.44±0.23 g), weight gain (WG, 31.43±0.41 g), feed conversion ratio (FCR, 0.91±0.05), and protein efficiency ratio (PER, 2.67±0.14) than those recorded in the control group (40.20 g final weight, 27.20±0.52 g WG, 1.1±0.05 FCR, and 2.24±0.10 PER). The same trend was observed in the body macro-nutrient retention (32.33±0.58 % crude protein, 25.33±0.58 % lipid, and 23.33±0.58 % ash) compared to the control group (20.67±0.58 % crude protein, 16.00±0.00 % lipid, and 17.33±0.58 % ash). Finally, this study clearly showed that dietary inclusion of *A. lepidophyllus* fruit powder at 6 g/kg improves growth performance, feed nutrient utilization, and body composition in juvenile *C. gariepinus*.

Keywords: *Afrostyrax lepidophyllus*, Carcass quality, *Clarias gariepinus*, Zootechnical performance

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Introduction

The amount of wild-caught fish has not increased since 1980; aquaculture has mainly contributed to the supply of fish for human consumption in the world (FAO, 2016). In Africa, fish production is hampered by the unavailability of aqua-feed which is mostly imported and very expensive (Atangana *et al.,* 2019). However, in Africa and particularly in Cameroon, there is a wide range of products and agricultural by-products rich in nutrients and the addition of some feed additives or dietary supplements can keep fish healthy and enhance growth rate (Sayed *et al*., 2011; Adegbesan *et al*., 2019). Research shows that herbs and spices (phytobiotics) are used as supplements or feed additives in animal diets (Muneendra *et al*., 2014; Mohsen *et al.,* 2018).

Phytobiotics contain active secondary metabolites belonging to the classes of isoprene derivates, flavonoids, and phenols compounds which have been suggested to act as antioxidants (Frankič *et al*., 2009; Sumczynski *et al*., 2015). Beneficial effects of phytobiotics in farm animals result from feed intake improvement and secretion of digestive enzymes, immune stimulation, anti-bacterial, anthelmintic, antiviral, anti-inflammatory, and antioxidant properties (Muneendra *et al*., 2014). Previous studies revealed that ginger (*Zingiber officinale*), garlic (*Allium sativum*), and scent leaf (*Ocimum gratissimum*) contain active substances such as alkaloids, tannins, flavonoids, saponins, and phenols compounds (Muhammad *et al*., 2009; Abdou *et al*., 2010). Those compounds are known to improve animal performances through their anti-oxidative and anti-microbial actions and improve feed palatability (Muneendra *et al*., 2014). An example of a plant possessing secondary metabolites is *A. lepidophyllus* fruit (Moukette *et al*., 2015; Namkona *et al*., 2017; Sokamte *et al*., 2018).

A. lepidophyllus is a plant of the Huaceae family and is commonly found in Equatorial and Tropical Africa (Cronquist, 1981; Moukette *et al*., 2015; Namkona *et al*., 2017). This plant is used in Congo as an antiseptic and in traditional medicine in treating gastroenteric diseases (Bouquet, 1969). In Cameroon, the seeds of this plant are traditionally used as a spice. Moreover, pharmacological studies showed that the extracts of *A. lepidophyllus* seed possess very interesting properties. Ngono (1999) demonstrated the antifungal activity and identified Afrostyraxthioside A, Afrostyraxthioside B, and Afrostyraxthioside C. Agbor *et al*. (2005) and Boufack *et al*. (2021) showed that the seed extracts possess antioxidant properties. In addition, Toumnou *et al*. (2012) reported the insecticidal activity of the extract from the seeds of *A. lepidophyllus*. Qualitative analysis of *A. lepidophyllus* fruit showed the presence of total pholyphenols, flavonoids, tannins, and anthocyanins (Namkona *et al*., 2017). These compounds possess significant antimicrobial activity (Sokamte *et al*., 2018) and antioxidant properties (Oben *et al*., 2010; Fogang *et al*., 2014; Sokamte *et al*., 2018) with

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many other attributes including digestive enzyme stimulation, lipid metabolism, and microbial load modulation (Muneendra *et al*., 2014).

In the view of the chemical composition of *A. lepidophyllus* fruit, its ability to balance the gut microbial load and stimulate digestive enzymes (Frankič *et al*., 2009; Oben *et al*., 2010), this phyto-additive can positively affect the growth performance of *C. gariepinus*. This study aims to determine the effects of *A. lepidophyllus* fruit powder on growth performance, feed utilization, and body composition of the African catfish (*Clarias gariepinus*) juveniles.

Materials and methods

Site of study

This study was conducted from April to May 2021 in the research and applied farm in fishery and aquaculture of Kanhé-Moyo (FRAPAIK) in Baham, the western region of Cameroon. This farm is located at 5°19′ North and 10°24′ East and an altitude of 1728 m above sea level. The annual average temperature is 23°C. Rainfall ranges between 1500-2000 mm per annum, over 9 months of the rainy season (March to November).

Experimental design

360 *C. gariepinus* juveniles were distributed following a completely randomized design to four treatments of 90 fish each, the average weight was 13±3.10g. Each experimental treatment had three (03) experimental units (hapas) of 30 juveniles each placed in a non-fertilized pond of 80 m^2**.**

Origin of A. lepidophyllus

A. lepidophyllus fruit were bought from a local market then ground, sieved and the powder was incorporated at different levels in locally produced feed.

Animal material

Three hundred and sixty *C. gariepinus* (360) juveniles, were purchased from a renowned fish farm in Douala. These juveniles were acclimatized for two weeks in 03 hapas of 1 m^3 each, they were fed during the first three days with a commercial imported feed (Gouessant, France; 2 mm) with 46% crude protein, 10 % crude fat, 2.83 % crude fiber, 8.1 % crude ash, 1 % calcium, 1.4% phosphorus, and 0.4 sodium as declared by the company. From the fourth day, 25% of their ration was substituted with local feed without *A. lepidophyllus*. From the seventh to the tenth day respectively 50 and 75 % of the imported feed was substituted. On the thirteenth and fourteenth days, the animals were entirely fed with local feed (100%). At the end of this acclimatization period, ten *C. gariepinus* juveniles were randomly sampled for the determination of the carcass quality characteristics.

Housing and equipment

After acclimatization, juveniles were randomly transferred to 12 experimental hapas of 0.64 m^2. The different feed rations were distributed manually at a frequency of three times per day (6:00 a.m., 12:00, and 5:00 p.m.); at a rate of 5% of the fish biomass. In order to monitor growth and adjust the quantities of feed distributed, using a landing net,

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control fishing was done after 21 days and during cool hours of the day (6:00 a.m.). The different individual weights and lengths were respectively measured using a 1g precision electronic scale balance and an ichthyometer. A 50cm long Secchi disc, JBL Test Kits (JBL GmbH & Co. KG–Dieselstraβe 3 - 67141 Neuhofen – Germany). Maximum-minimum thermometer and pH meter were respectively used daily to measure water transparency, dissolved oxygen, temperature, and pH. The values of the physico-chemical parameters of water recorded during the experiment are resumed in Table 1.

Table 1: Water quality parameters (Mean ± SD) during the experimental period (63 days).

Parameters	Experimental period (days)			
	0-21	21-42	42-63	Optimum values
T(°C)	22.55±1.41	20.63±1.60	22.2±1.66	20-30
pH	7.03±0.08	6.81±0.49	7.07±0,73	6.5-8
D.O(ppm)	5.85±0.02	7,89±0,55	7.63±0,59	7.5-9.1
NO_3^- (mg/L)	30±0	23±2.64	25±3	<50
Transparency (cm)	45.23±6.62	43.04±7.20	42.17±7.04	<60

Temperature (T˚C); Hydrogen potential pH; dissolved oxygen (D.O); nitrate (NO_3^-)

Experimental diet

In addition to the locally prepared diet (T_0 or control), three isoprotein, isolipidic and isoenergetic diets including T_1, T_2, and T_3 were made by incorporating 2, 4, and 6g/kg *A. lepidophyllus* fruit powder, respectively. The basal diet (T_0) ingredients and proximate composition are summarized in Table 2.

Preparation of diets

The raw ingredient was finely ground in a mill. *A. lepidophyllus* previously crushed was incorporated in the mixtures while respecting the different proportions specified in Table 2. In each treatment, cold water (20% per treatment) was mixed, then stirred delicately before extrusion in a DGP60-C brand extruding machine, with a capacity of 120-150kg/hour, at a 105°C temperature equipped with a die of 2.5mm. The extrudates were sun-dried for 20 hours then placed in plastic bags, labeled, and kept away from humidity until use.

Table 2: Composition of the basal diet.

Ingredients	% in dry matter (DM)
Fishmeal	27
Soybean meal	15
Peanut meal	20
Cotton meal	8
Wheat bran	8
Maize meal	16
*Premix 5%	5
Palm oil	1
Total	100
Chemical composition	
Protein (% DM)	41.136±3.68
Energy (kcal/kg DM)	2759.24±6.04
Lipid (% DM)	11.18±0.5
Ash (% DM)	11.101±0.95
Moisture (% DM)	5.5±0.57
Fiber (% DM)	6.31±0.63
Dry matter (%)	94.5±0.57

*Premix 5%: Crude protein =40%; Lysine =3.30; Methionine= 2.40; Calcium= 8; Phosphorus= 2.05; Metabolized Energy = 2078 kcal/kg.

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The formulated diet samples (10g) was analyzed following the procedures of AOAC (1990). Moisture content was determined by drying the sample in an oven at 105°C overnight. Crude protein was analyzed in a KJELTEC SYSTEM 1002 Distilling Unit made in Belgium following the Kjeldahl method while lipid content was determined by extraction with hexane using the Soxhlet method. The ash content was determined by combustion in a muffle furnace at 500°C for 6 h.

Growth, survival rate, and feed utilization parameters

Growth performance, survival rate, feed utilization, and nutrient retention were assessed per treatment by determining the weight gain (WG), specific growth rate (SGR), survival rate (SR), condition factor (K), feed intake (FI), feed conversion ratio (FCR), feed efficiency ratio (FER), protein efficiency ratio (PER) and nutrient retention (NR). The calculations were done using the following formulae:

$$WG\ (g) = Wf - Wi$$

$$SGR\ (\%/day) = \frac{\ln Wf - \ln Wi}{T} \times 100$$

Where, Wf = final weight; Wi = initial weight; T = experimental period (days);

$$SR\ (\%) = \frac{\text{final number of fish}}{\text{initial number of fish}} \times 100$$

$$K = \frac{\text{Weight}}{\text{Length}^3} \times 100$$

$$FI\ (g/fish) = \frac{\text{total dry feed distributed}}{\text{number of fish}}$$

$$FCR = \frac{\text{feed intake}}{\text{Fish weight gained}}$$

$$FER = \frac{\text{Fish weight gained}}{\text{feed intake}}$$

$$PER = \frac{\text{Fish weight gained}}{\text{Protein consumed}}$$

$$\text{Protein consumed} = \frac{\text{Total feed consumed x Crude protein in feed}}{100}$$

$$NR\ (\%) = \frac{\text{Final carcass composition} - \text{Initial carcass composition}}{\text{Amount of nutrient fed}} \times 100$$

Statistical analysis

Results on growth performance, survival rate, feed utilization, and nutrient retention obtained from each replicate were used for statistical analysis. Data collected were submitted to a one-way Analysis of Variance test by the General Linear Model's procedure of Statistical Package for Social Science (SPSS 20.0) software. Where there was a significant difference between treatments, their means were separated using Duncan's multiple range test and probability values less than 0.05 were considered significant.

Results

Growth performance

Independent of the incorporation level of *A. lepidophyllus* fruit powder in different levels, Figure 1 shows an inflection in the body weight and weight gain curves on the 42nd day of the experiment. After this point, the curves have a linear and increasing evolution until the end of the experiment. Moreover, the evolution of

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weight and weight gain of *C. gariepinus* juveniles is proportional to the increasing incorporation level of *A. lepidophyllus* powder in the diets. Thus, after the 21st day, the curve of *C. gariepinus* juveniles fed diet supplemented with 6 g/kg *A. lepidophyllus* (T_3) remained above all the other curves. At the end of the trial, the body weight (44.43±0.23 g) was significantly higher (p<0.05) by 9.52%, 4.82%, and 2.99% compared to those fed respectively T_0 (40.20±0.30 g), T_1 (42.29±0.14 g) and T_2 (43.10±0.2 g). On the other hand, weight gain (31.43±0.41 g) was significantly higher (p<0.05) by 13.46%, 6.78%, and 4.23% compared to those fed with T_0 (27.20±0.52 g), T_1 (29.30±0.24 g), and T_2 (30.10±0.34 g), respectively.

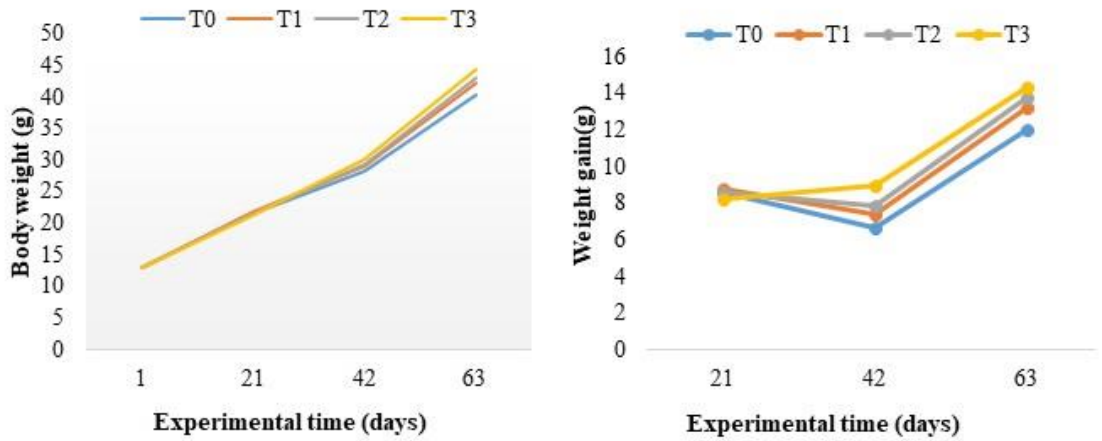


Figure 1: Body weight and weight gain of *Clarias gariepinus* juvenile fed different levels of *Afrostyrax lepidophyllus*. T_0= control ration, T_1= T_0+2g/kg *A. lepidophyllus*, T_2= T_0+4 g/kg *A. lepidophyllus*, T3= T_0+ 6 g/kg *A. lepidophyllus*.

The relationship between fish growth and dietary inclusion level of *A. lepidophyllus* powder is illustrated by the linear regression curve (Figure 2) below. *C. gariepinus* juvenile growth rate increased with increasing inclusion level of *A. lepidophyllus* in the diet (R^2=0.9671).

The specific growth rate of *C. gariepinus* juveniles fed with different experimental diets for 63 days is illustrated in Figure 3. It is noted that irrespective of the treatments, the growth was faster during the first week of feeding and gradually decreased with the increasing experimental period. At the end of the experimental period, fish fed 6 g/kg A. *lepidophyllus* powder (T_3) had a specific growth rate of 1.95±0.06% g/d, significantly higher (p<0.05) compared to the other treatments T_0 (1.79±0.02%g/d), T_1 (1.87 ± 0.009% g/d), T_2 (1.90 ± 0.01% g/d).

Survival Rate and Feed Nutrient Utilization

Table 3 resumes the survival rate and feed nutrient utilization of *C. gariepinus* juveniles at the end of the feeding period. It is noticed that, though no

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significant difference was observed amongst treatments. Mortalities occurred in two treatments T_1 and T_2 with a survival rate of 93.33 ± 0.00%. Determination of the feed nutrients utilization parameters (feed conversion ratio, feed efficiency ratio, and protein efficiency ratio) indicated that the fish fed diets supplemented with *A. lepidophyllus* had better feed utilization characteristics (p<0.05) compared to the control diet. On the other hand, we notice a significant increase in the value of condition factor K concerning the dietary inclusion level of *A. lepidophyllus*.

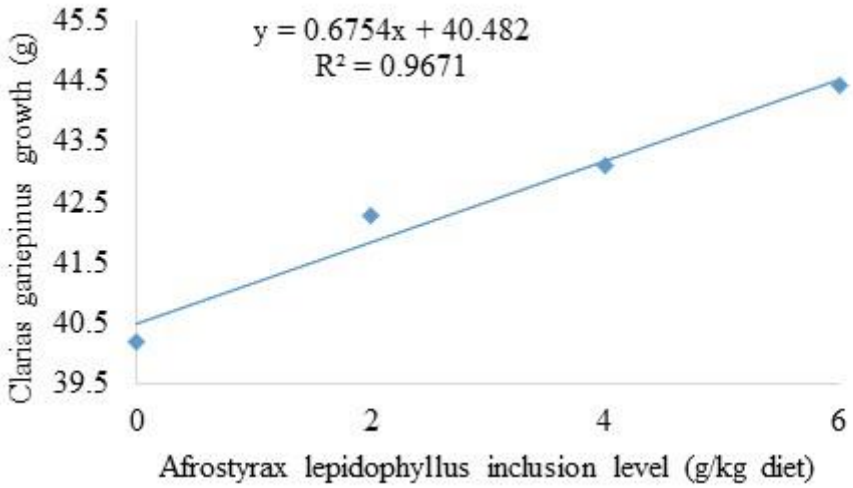


Figure 2: Regression curve between *Clarias gariepinus* growth and dietary inclusion levels of *Afrostyrax lepidophyllus* fruit powder.

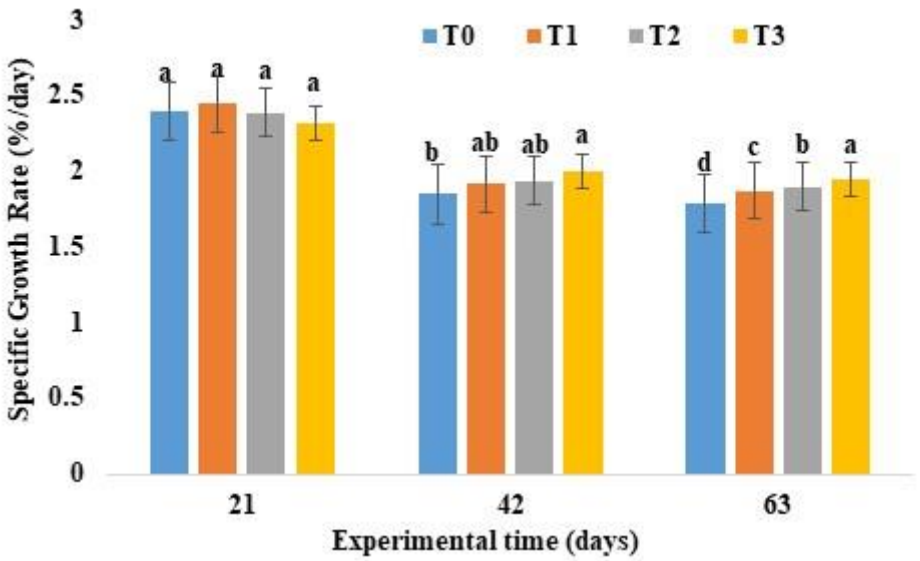


Figure 3: Specific growth rate of *Clarias gariepinus* juveniles fed different levels of *Afrostyrax lepidophyllus* fruit powder. T_0=control ration, T_1=T_0+2g/kg *A. lepidophyllus*, T_2=T_0+4 g/kg *A. lepidophyllus*, T3=T_0+ 6 g/kg *A. lepidophyllus.* Means on the same rearing period carrying different superscripts were significantly different at p<0.05.

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Chemical (nutrient) Composition and Nutrient Retention of C. gariepinus

Nutrient composition of *C. gariepinus* juveniles produced at the end of the experimental period (63 days) is recorded in Table 4. As compared to fish nutrient composition at the beginning of the study, it is noted that apart from the moisture content that dropped significantly (p<0.05) in the juveniles fed diets supplemented with *A. lepidophyllus* powder, other macro-elements like the ash, protein, and lipid levels were significantly (p<0.05) enhanced by increasing the incorporation levels of *A. lepidophyllus* powder in the diets. With the exception of the energy level that was significantly (p<0.05) higher in the fish fed T_2 diet.

Table 3: Survival rate and feed utilization of *Clarias gariepinus* fed diets supplemented with *Afrostyrax lepidophyllus* fruit powder at the end of the feeding period.

Parameters	Treatments				*p*- value
	T_0	T_1	T_2	T_3	
Ni	90	90	90	90	-
Nf	90	88	88	90	-
SR	100.00 ± 0.00	93.333 ± 0.00	93.33 ± 0.00	100.00 ± 0.00	-
FI (g/fish)	39 ± 0.00	38.409 ± 0.00	38.116 ± 0.00	39 ± 0.00	-
Wi (g)	13,02 ± 0.01^{a}	13.01 ± 0.02^{a}	13.02 ± 0.01^{a}	13.01 ± 0.1^{a}	0.977
Wf (g)	40.20 ± 0.30^{d}	42.29 ± 0.14^{c}	43.10 ± 0.2^{b}	44.43 ± 0.23^{a}	0.000
WG (g)	27.20 ± 0.52^{d}	29.29 ± 0.24^{c}	30.10 ± 0.34^{b}	31.43 ± 0.41^{a}	0.000
Lf (cm)	17.38 ± 0.02^{d}	17.59 ± 0.05^{c}	17.94 ± 0.02^{a}	17.72 ± 0.02^{b}	0.000
K	0.76 ± 0.01^{bc}	0.78 ± 0.01^{ab}	0.75 ± 0.004^{c}	0.80 ± 0.002^{a}	0.006
FCR	1.1 ± 0.05^{a}	0.94 ± 0.02^{b}	0.90 ± 0.05^{b}	0.91 ± 0.05^{b}	0.004
FER	0.92±0.04^{b}	1.06±0.03^{a}	1.11±0.06^{a}	1.11±0.06^{a}	0.007
PER	2.24±0.10^{b}	2.59±0.07^{a}	2.69±0.15^{a}	2.67±0.14^{a}	0.007

T_0= control ration, T_1=T_0+2g/kg *A. lepidophyllus*, T_2=T_0+4 g/kg *A. lepidophyllus*, T3=T_0+ 6 g/kg *A. lepidophyllus*.

Values are mean±standard deviation of three replicates of 30 fish each. Mean within the row with different superscripts are significantly different from other at p<0.05. Ni, initial number of fish; Nf, final number of fish; FI, feed intake; Lf, final length of fish; K, condition factor; FCR, feed conversion ratio; FER, feed efficiency ratio; PER, protein efficiency ratio.

Table 4: Proximate composition (% or kJ/g WW) of carcass and nutrient retention in *Clarias gariepinus* juveniles fed different inclusion levels of *Afrostyrax lepidophyllus* fruit powder.

Parameters	Initial	T_0	T_1	T_2	T_3	*p*- value
	Chemical composition (% or KJ/g WW)					
Ash	2.47±0.38^{d}	2.66±0.34^{c}	2.76±0.24^{b}	2.76±0.26^{b}	2.99±0.84^{a}	0.000
Crude protein	11.34±0.22^{e}	11.96±1.09^{d}	14.32±0.40^{c}	14.72±0.18^{b}	15.08±1.05^{a}	0.000
Lipid	2.36±0.28^{e}	2.50±0.32^{d}	2.55±0.45^{c}	3.10±0.26^{b}	3.17±0.34^{a}	0.000
Energy	7.31±0.58^{e}	7.43±0.40^{d}	8.84±0.35^{c}	9.22±0.46^{a}	9.16±0.22^{b}	0.000
Moisture	81±0.01^{a}	81±0.01^{a}	77±0.01^{b}	77±0.01^{b}	77±0.01^{b}	0.000
	Nutrient retention (% dry feed)					
Ash		17.33±0.58^{c}	19.67±0.58^{b}	20.00±0.00^{b}	23.33±0.58^{a}	0.000
Crude protein		20.67±0.58^{d}	28.67±0.58^{c}	30.33±0.58^{b}	32.33±0.58^{a}	0.000
Lipid		16.00±0.00^{d}	18.00±0.00^{c}	23.67±0.58^{b}	25.33±0.58^{a}	0.000
Energy		19.00±0.00^{d}	26.00±0.00^{c}	28.00±0.00^{b}	29.00±0.00^{a}	0.000
Dry matter		14.00±0.00^{c}	20.00±0.00^{b}	20.33±0.58^{b}	21.00±0.00^{a}	0.000

T_0= control ration, T_1= T_0+2g/kg *A. lepidophyllus*, T_2= T_0+4 g/kg *A. lepidophyllus*, T3= T_0+ 6 g/kg *A. lepidophyllus*; WW, wet weight.

Mean within the same row with different superscripts are significantly different at p<0.05. p= probability

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Results on nutrient retention of *C. gariepinus* carcass (Table 4) after 63 days of feeding revealed that incorporating *A. lepidophyllus* powder in fish diet affects protein, lipid, ash, energy, and dry matter contents. The fish fed T_3 diet had protein (32.33±0.58%), lipid (25.33±0.58%), ash (23.33±0.58%), energy (29.00±0.00%), and dry matter (21.00±0.00%) contents retention significantly higher compared to those fed the other experimental diets. Figure 4 illustrates the linear regression between nutrient retention in the body of fish and the dietary inclusion level of *A. lepidophyllus* powder. Regardless of the nutrient, there is a relationship between nutrient retention and dietary inclusion level of *A. lepidophyllus* powder. This is illustrated by the regression coefficient which indicates the relationship between lipid retention (R^2=0.95) and the inclusion level of *A. lepidophyllus* powder followed by ash retention (R^2=0.91) then by protein retention (R^2=0.86) and finally energy retention (R^2=0.84).

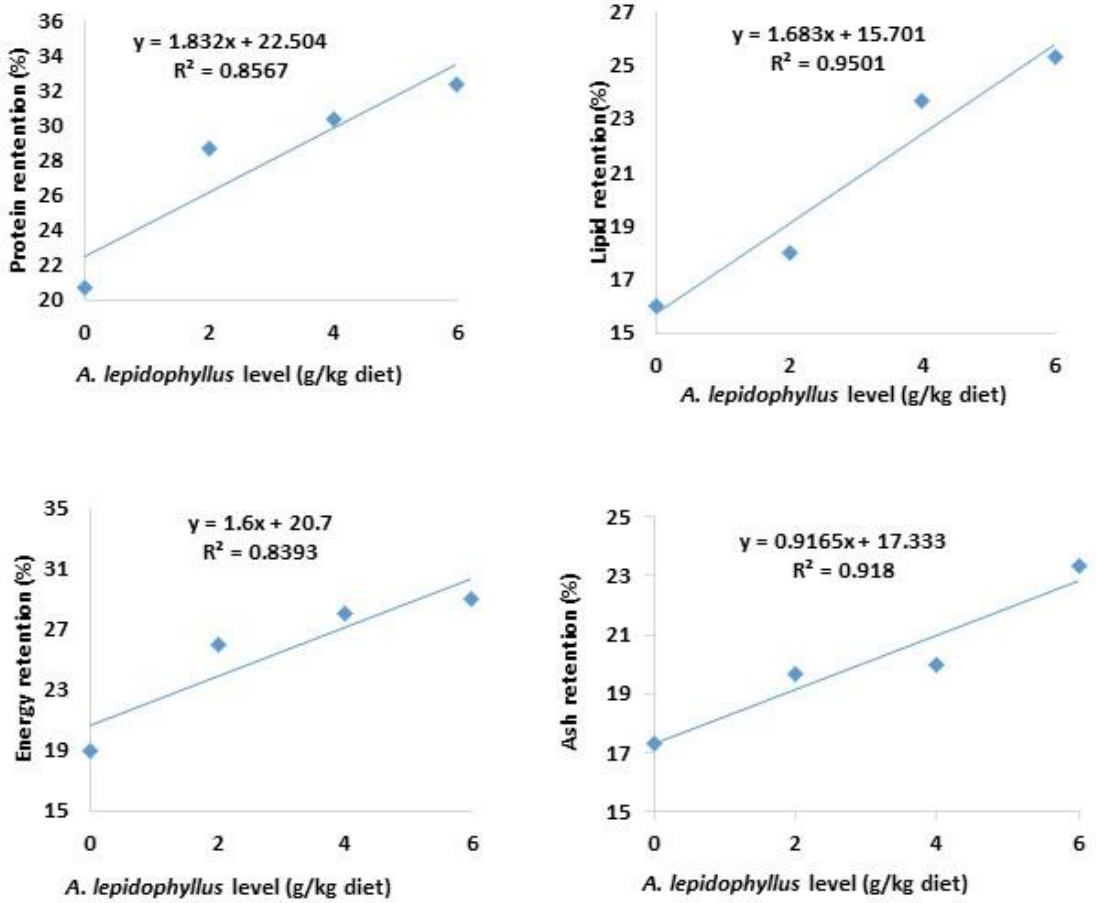


Figure 4: Regression curves between nutrient retention of *Clarias gariepinus* juveniles and dietary inclusion levels of *Afrostyrax lepidophyllus* fruit powder.

Discussion

Water quality parameters had a great influence on fish survival rate as well as on their growth. Moreover, the recorded physicochemical parameters such as temperature, dissolved oxygen, pH, and

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nitrate (NO_3^-) were within the recommended range for freshwater fish breeding. According to the above observations, the mortalities observed in the fish fed with 2 g/kg (T_1) and 4 g/kg (T_2) dietary inclusion of *A. lepidophyllus* fruit powder could be probably attributed to stress-induced during the fish rearing. The application of phytochemical agents (herbal components) in aquaculture has greatly increased as they have been reported to prevent diseases and reduce the use of hazardous antibiotics (Sakai, 1999). Results from this study showed positive effects of dietary inclusion *A. lepidophyllus* on growth performance and feed nutrients utilization. Incorporating *A. lepidophyllus* fruit powder in *C. gariepinus* feed markedly enhanced body weight and body weight gain compared to those fed the control diet. The highest response was observed in fish fed with the highest level of phyto-additive. These results agree with Soosean *et al*. (2010) and Abbasi *et al*. (2017), who showed that the highest final weight and weight gain was recorded when the African catfish was fed the highest level of *Garcinia mangostana* and *Zingiber officinale* powder in common carp, *Cyprinus carpio* diets. This result can be explained by the presence of anti-oxidative and antimicrobial substances such as flavonoids and phenolic compounds (Fogang *et al*., 2014; Namkona *et al*., 2017; Sokamte *et al*., 2018) which are known to maintain gut equilibrium and improve growth performance of animal (Frankič *et al*., 2009). The highest improvement in body weight was recorded with *C. gariepinus* fed 6 g/kg *A. lepidophyllus* powder. This could be attributed to the antimicrobial properties of their specific active compounds and their impact on gut function. Increasing feed inclusion levels of *A. lepidophyllus* increased flavonoids and phenolic compounds, which are known to improve animal performances by changing the intestinal ecosystem of the animal through their antimicrobial action (Odoemelam *et al*., 2013). These compounds act by forming complexes with many proteins, causing the destruction of the bacterial membranes (Frankič *et al*., 2009). The changes in the intestinal ecosystem due to their antimicrobial action could lead to greater availability of some nutriments for the host and consequently improve body weight gain and feed utilization. This is in agreement with Frankič *et al*. (2009), who noticed the growth-promoting effect of most herbs and spices that act by killing parasites that hinder the digestibility and growth performance of animals. On the other hand, the improvement in body weight of *C. gariepinus* juveniles obtained with high a level of incorporation of *A. lepidophyllus* could also be attributed to the potent antioxidant properties of their major components as reported by Fogang *et al*. (2014) and Moukette *et al*. (2015).

Some phyto-additives have been reported to improve specific growth rate (Dada and Ikuerowo, 2009; Nyadjeu *et al*., 2021). In this study, the fish fed diet containing 6 g/kg *A. lepidophyllus*

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powder had the specific growth rate value significantly higher than all the other treatments. This result contradicts those obtained using dietary *Zingiber officinale* extract in beluga juvenile (*Huso huso*) diet (Vahedi *et al*., 2017). The conflicting results of the present study with those of Vahedi *et al*. (2017) could be attributed to the different species, feeding programs, and farming conditions. On the other hand, it was noted that regardless of the treatment, juvenile growth was faster during the first week of feeding and gradually decreased with the increase in the experimental period. This was comparable to that obtained by Gnikpo *et al*. (2014) who reported that the specific growth rate decreases while the muscle mass increases.

The improvement in feed nutrient utilization in *C. gariepinus* juveniles induced by *A. lepidophyllus* inclusion compared to those fed the control diet could have emanated from the presence of bioactive compounds contained in the phytobiotic. These results agree with the findings of Kana *et al*. (2017) where the incorporation of *A. lepidophyllus* fruits in broilers diet enhanced body weight and body weight gain and tended to reduce feed conversion ratio compared to birds fed the control diet. The improvement in growth and feed nutrient utilization in animals could be attributed to gallic acid which was the most abundant phenolic acid present in *A. lepidophyllus* fruit (Sokamte *et al*., 2018). According to Kang Yang *et al*. (2020), gallic acid influences the gut microbiome and modulates the immune response to maintain intestinal health. The improvement of intestinal health reduced the animal's exposure to microbial toxins and other undesired microbial metabolites such as ammonia and biogenic amines (Windisch *et al*., 2008). Thereby, animals are relieved from immune defense stress during critical situations and there is increased availability of essential nutrients for absorption. This is in accordance with the results from this study where there was an increase in nutrient retention (protein, lipid, ash, energy, and dry matter) in the fish fed diets supplemented with *A. lepidophyllus* compared to those in the control diet. Moreover, the fish fed diet containing 6 g/kg *A. lepidophyllus* powder registered the highest nutrient retention of these macro-elements. This result indicates that increasing *A. lepidophyllus* level in *C. gariepinus* diet increases the presence of bioactive compounds present in the phyto-additive such as flavonoids and phenolics compounds (Sokamte *et al*., 2018) These secondary metabolites are known to maintain gut equilibrium (Frankič *et al.*, 2009) of the microbiome that plays a crucial role in the maintenance of physiological homeostasis within the gastrointestinal tract (Kang Yang *et al*., 2020). Hence, they help the animals to grow better within the framework of their genetic potential.

The results of the present study revealed that supplementing *C. gariepinus* diet with *A. lepidophyllus* improved growth performance, feed nutrient utilization, and nutrient

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retention in the African catfish juveniles. The highest effect was obtained with the highest level of inclusion. These observed beneficial effects have been attributed to the bioactive contents of *A. lepidophyllus* than to their nutritional properties. The present findings provided a ray of hope for dietary supplements that are widely and intensively used in aquaculture.

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