

Original Research Article

Influence of Dietary Inclusion of *Afrostryrax lepidophyllus* bark powder on Growth Performances, Feed nutrients utilization and Body Composition of *Clarias gariepinus* juvenile (Burchell, 1822).

Comment [s1]: The title is too long, keep it short and clear

Abstract

Aims: This study was conducted to evaluate the effects of dietary inclusion of the bark of *Afrostryrax lepidophyllus* on growth and body composition of *Clarias gariepinus*.

Study design: This study was carried out from April to May 2022 in the Agro-ecological Farm of Bilone at Obala Lekié Division, Center Region of Cameroon.

Methodology: Juvenile weighing 9.29 ± 0.15 g were divided into four triplicate treatments before being fed with diets containing 0 g (T_0 or control), 1 g (T_1), 1.5 g (T_2) and 2 g (T_3) *A. lepidophyllus* diet for 56 days. Fishes were fed at the rate of 5% body weight and every 14 days, intermediate sampling was done during which juveniles per treatment were counted, measurements were taken on a representative sample and the feeding rate was adjusted. The main water parameters were recorded daily before feeding.

Results: Adding the bark of *A. lepidophyllus* in the diet significantly enhanced growth, feed nutrients utilization and body composition of juvenile *C. gariepinus* independent of the inclusion level. Fish fed T_3 diet recorded final weight, weight gain (WG), feed conversion ratio (FCR) and protein efficiency ratio (PER) significantly high ($P < 0.05$) to those recorded in fish fed with the control diet. The same trend was observed with macro-nutrient retention as compared to the control.

Conclusion: This study clearly showed that dietary inclusion of the bark of *A. lepidophyllus* powder improves growth performances, feed nutrients utilization and body composition of juveniles *C. gariepinus*.

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Key words: *Afrostryrax lepidophyllus*, Dietary inclusion, *Clarias gariepinus*, Zootechnical Performances

1. Introduction

Fish is the main source of animal protein for about one billion people worldwide [1]. The consumption of fish in Africa is increasing exponentially [2], despite the decrease in marine and continental capture fisheries products. Aquaculture introduced in sub-Saharan Africa and in Cameroon in particular to compensate for this deficit, has so far experienced very timid growth due to many factors that hinder its development. The major constraint being the high cost of feed, which represents around 50 to 60% of the cost of fish production [3]. These feeds, which are mostly imported, are not always available. However, intensive fish production is closely linked to nutrition (types of feed used, availability and costs) and requires the production of high-performance local feeds that can improve the productivity of farmed species. In Africa and Cameroon in particular, there are a multitude of nutrient-rich agricultural products and by-products whose combination and addition of appropriate ingredients (additives or food supplements) could keep fish healthy and promote their growth [4,5]. Numerous research studies have shown that herbs, spices and their products (phytobiotics) contain active principles: alkaloids, flavonoids, pigments, polyphenols, terpenoids, steroids which have various properties and functions such as: growth promoter, appetite stimulator, antioxidants, anti-stress, antimicrobials, and immunostimulant [6]. Among these plants, *Afrostyrax lepidophyllus* figures prominently.

Afrostyrax lepidophyllus is a plant of the huaceae family and is commonly found in Equatorial and Tropical Africa [7,8,9]. This plant is used in Congo as an antiseptic and in traditional medicine for the treatment of gastroenteric diseases [10]. In the Central African Republic and in Cameroon, the seeds and bark of this plant are traditionally used as a spice. Moreover, pharmacological studies have been carried out by several researchers and have shown that the extracts of *A. lepidophyllus* possess very interesting properties. [11] revealed that *A. lepidophyllus* bark contains sulfur and phenylpropanoid (eugenol) which have the ability to stimulate the function of pancreatic enzymes (lipases, amylases and proteases) and increase the activity of digestive enzymes of gastric mucosa. In addition, the bark contains polyphenolics compounds possessing significant antioxidant properties [12,11] with many other attributes including digestive enzymes stimulation, lipid metabolism and modulation of microbial populations [13]. The studies carried out by [8] on *A. lepidophyllus* bark showed significant free radical scavenging and antioxidant properties. They also exhibited a higher protective potential

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against some liver markers involved in oxidative stress. [11] also reported the presence of eugenol methyl, limonene, β -ocimene, apinene, trithiapentane, methyl-trithiahexane, dimethyl-tetrathiooctane and pentathiaundecane in the bark of *A. lepidophyllus*. Furthermore, [14] reported that, supplementing broilers diet with the bark of *A. lepidophyllus* improved growth performances, blood serum components and reduced the cost of production.

Based on the chemical composition of the bark of *A. lepidophyllus*, its ability to modulate microbial populations and digestive enzymes stimulation as revealed by previous studies [12,13], we believe that this spice is mostly made up of volatile sulfur-containing compounds [15] which are known to stimulate appetite and digestion [16] could positively impact other physiological functions, help to ensure good health welfare and consequently improved growth performances of *C. gariepinus*. Thus, the objective of this study was to determine the effect of the bark of *A. lepidophyllus* powder on growth performances, feed nutrients utilization and body composition of juveniles *C. gariepinus*.

2. Materials and Methods

Area of study

This study was carried out from April to May 2022 in the Agro-ecological Farm of Bilone at Obala Lekié Division, Center Region of Cameroon. This farm is located at 4°10' North and 11°31' East and at an altitude of 557 m above sea level. The annual average temperature is 25°C. Average Rainfall is 1577 mm per annum, 9 months of rainy season (March to October).

Experimental design, housing and equipment

Out of three hundred and ten (310) juveniles *C. gariepinus* with a mean weight of 9.29 ± 0.15 g resulting from an artificial reproduction carried out in the farm hatchery. Ten (10) juveniles were randomly sampled for initial determination of carcass composition. The remaining three hundred (300) juveniles were distributed in a complete randomized design, in triplicate of four treatments with 75 fishes per treatment. The juveniles were lodged in 12 experimental Hapas of size 0.5x 0.5 x 1m³ containing 25 subjects each placed in a concrete rectangular tank of 13m³ and 1.5m high. Water supply was done using 32 Ø pvc pipes and draining with 90 Ø pvc pipes. The distribution

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of the different feed rations was done manually at a frequency of three times per day (in the morning (at 6 a.m.), in the afternoon (12:00 noon), and in the evening (at 5 p.m.); at a rate of 5% of fish biomass. Growth and quantities of feed distributed per period was monitored, using a landing net, control fishing was done after 14 days and during the cool hours of the day (6:00 a.m.). The different individual weights and lengths were respectively measured using a 1 g precision electronic scale balance and an ichthyometer. Physico-chemical parameters such as temperature (T°C) was measured every day before feeding, using a Maximum-minimum thermometer, dissolved oxygen (D.O) using JBL Test Kits, pH nitrite (NO₂⁻) and nitrate (NO₃⁻) using Test strips (JBL Easy Test 6in1). The values of the physico-chemical parameters of water recorded during the experiment are presented in Table 1.

Table 1: Water quality parameters (Mean ± SD) at 56 days of experimental period

Parameters	Rearing period (days)			
	0-14	14-28	28-42	42-56
T (°C)	28.25±1.08	28.65±1.13	28.67±0.92	28.7±0.84
pH	6.68±0.29	7.05±0.18	7.2±0.29	7.2±0.19
D.O (ppm)	7.85±0.02	7.89±0.55	7.63±0.59	7.5±0.13
NO ₂ ⁻ (mg/L)	0±0	0.02±0.01	0±0	0.1±0.02
NO ₃ ⁻ (mg/L)	0±0	0.3±0.01	0±0	0.25±0.03

Temperature (T°C); Hydrogen potential pH; dissolved oxygen (D.O); nitrite (NO₂⁻); nitrate (NO₃⁻)

Experimental diet

The bark of *A. lepidophyllus* were bought at the local market, ground, sieved and the powder was incorporated at different rates into the locally produced feed. Four (04) isoprotein, isolipidic and isoenergetic experimental diets T₀, T₁, T₂ and T₃ were formulated by adding in basal ration (T₀ or control) respectively 1, 1.5 and 2% of *A. lepidophyllus*. The characteristics of the basic ration (T₀) are summarized in Table 2.

T₀= Control diet

T₁=T₀+1% *A. lepidophyllus* bark powder

T₂= T₀+1.5% *A. lepidophyllus* bark powder

T₃= T₀+2% *A. lepidophyllus* bark powder

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Table 2: Formulation and proximate composition of experimental diets

Ingredients	Quantities (g)
Fish meal	27
Soybean meal	15
Peanut meal	20
Cotton meal	8
Wheat bran	8
Maize meal	16
premix 5%	5
Palm oil	1
Total	100
Biochemical composition (%)	
Protein	38.02±1.71
Energy (kcal/kg DM)	283.25±3.17
Lipid	8.73±0.64
Ash	18.67±0.57
Moisture	9±1.00
Fiber	7.18±0.63
Dry matter	91±1.00

*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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Preparation of diets

The raw ingredient was finely ground in a mill. *A. lepidophyllus* previously crushed were incorporated into the mixtures while respecting the different proportions specified in Table 2. In

each treatment, cold water was added, mixed to obtain a proper consistency. The resulting mixture was pelletized using an electric pelleting machine with a capacity of 150kg/hour, with a diameter of 2.5 mm. The pellets obtained were sun dried for 3 days then packaged in labelled plastic bags and stored from humidity until use. Formulated diet samples (10 g) were analyzed following the procedures of [17]. Moisture content was analyzed by drying the sample in an air convection oven at 105°C overnight. Crude protein was analyzed in a KJELTEC SYSTEM 1002 Distilling Unit made in Belgium, using the Kjeldahl method after acid digestion (percentage crude protein = % nitrogen × 6.25) while crude lipid content was determined by extraction with petroleum ether using the Soxhlet method. The ash content in the diet was analyzed by combustion of the samples in a muffle furnace at 550 °C for 12 h.

Growth, survival rate and feed utilization parameters

Growth performances, survival rate, feed utilization and nutrients retention were assessed for each 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 nutrients retention (NR). Calculations were carried out using the following formulae:

$$1) \text{ WG (g)} = W_f - W_i ;$$

$$2) \text{ SGR (\%/day)} = \frac{\ln W_f - \ln W_i}{T} \times 100$$

Where: W_f = final weight; W_i = initial weight; T = number of days in the experimental period;

$$3) \text{ SR (\%)} = \frac{\text{final number of fish}}{\text{initial number of fish}} \times 100$$

$$4) \text{ K} = \frac{\text{Weight}}{\text{Length}^3} \times 100$$

$$5) \text{ FI (g/ fish)} = \frac{\text{total dry feed distributed}}{\text{number of fish}}$$

$$6) \text{ FCR} = \frac{\text{feed intake}}{\text{Fish weight gained}}$$

$$7) \text{ FER} = \frac{\text{Fish weight gained}}{\text{feed intake}}$$

$$8) \text{ PER} = \frac{\text{Fish weight gained}}{\text{protein fed}},$$

$$9) \text{ Where, Protein fed} = \frac{\text{Total feed consumed} \times \text{Crude protein in feed}}{100}$$

$$11) \text{NR} (\%) = \frac{\text{Final carcass composition} - \text{Initial carcass composition}}{\text{Amount of nutrient fed}} \times 100$$

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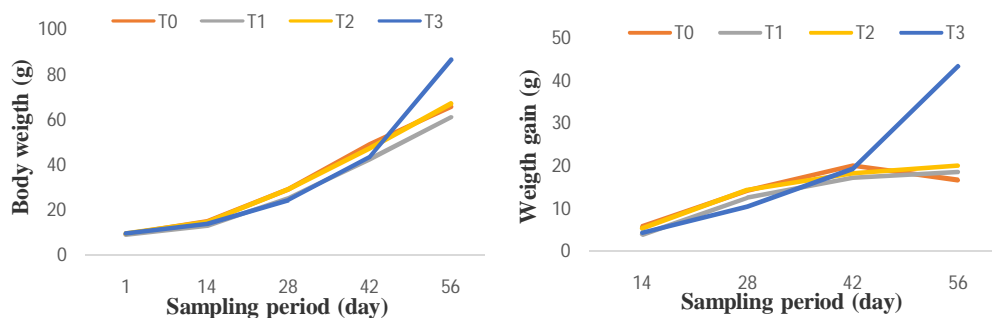
Statistical analysis

The results on growth performance, survival rate, feed nutrients utilization and nutrients retention obtained from each replicate were expressed as mean and used for statistical analysis. The data were analyzed using one-way Analyses of Variance test by General Linear Model's procedure of Statistical Package for Social Science (SPSS 20.0) software. Significant treatment means were separated using Duncan's multiple range tests and probability values less than 0.05 were considered as significant [18].

3. Results

Growth performance

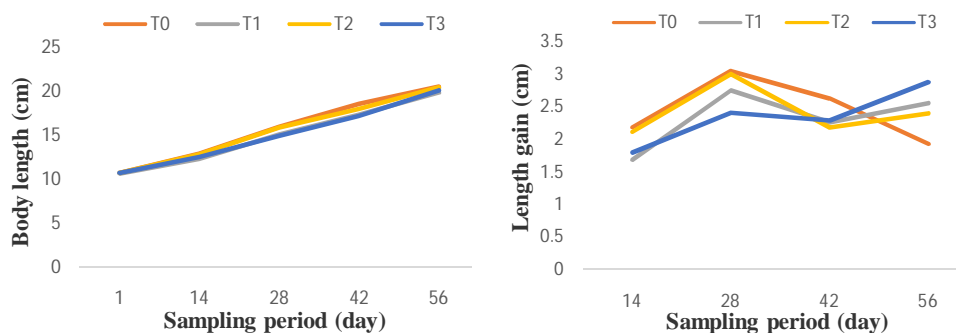
Figure 1 shows Body Weight (BW) and Weight Gain (WG) of juvenile *C. garepinus* fed rations supplemented with *A. lepidophyllus* bark powder. It shows that, regardless of the treatment, the BW and the WG of the juveniles of *C. garepinus* increased linearly with time until the 42nd day of rearing which constitutes the inflection point for the T₃ curve which shows an accelerated increased in growth until the end of the trial. Compared to the control group, the BW and WG of juvenile *C. garepinus* fed ration supplemented with 2% *A. lepidophyllus* bark powder (T₃) were significantly higher ($p < 0.05$) and recorded an increase of 31.62% and 158.97% respectively at the end of the trial.



T₀= control ration, T₁= T₀+1% *A. lepidophyllus*, T₂= T₀+1.5% *A. lepidophyllus*, T₃= T₀+ 2% *A. lepidophyllus*

Figure 1: Body weight and weight gain of juvenile *C. gariepinus* fed diet containing *A. lepidophyllus* for 56 days

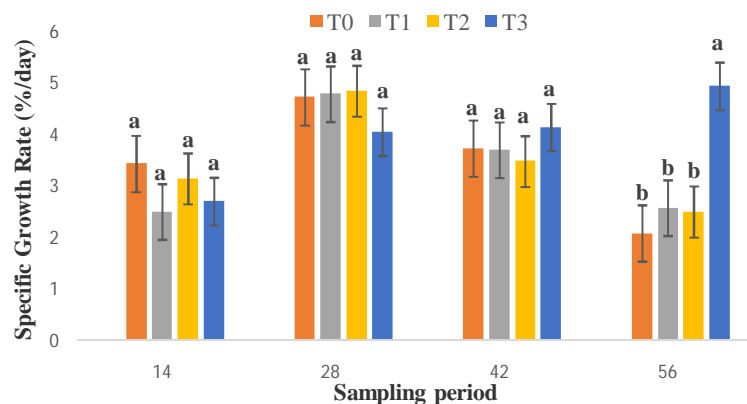
The bi-weekly evolution of body length shown in Figure 2 shows an identical profile and pattern in all the treatment groups throughout the study. Although the curves are grouped and almost merged, the curve for juveniles fed diet supplemented with 2% *A. lepidophyllus* bark powder (T₃) remained below the other three throughout the trial. Furthermore, irrespective of the level of incorporation of *A. lepidophyllus* bark powder in different rations, Figure 2 shows a zig-zag pattern for length gain throughout the trial. However, at the end of the trial, the highest length gain (p < 0.05) was recorded with T₃ group.



T₀= control ration, T₁= T₀+1% *A. lepidophyllus*, T₂= T₀+1.5% *A. lepidophyllus*, T₃= T₀+ 2% *A. lepidophyllus*

Figure 2: Body length and length gain of juvenile *C. gariepinus* fed *A. lepidophyllus* diet for 56 days.

The Specific growth rate (SGR) of juveniles *C. gariepinus* fed *A. lepidophyllus* diets for 56 days is presented in figure 3. It was found that the SGR of *C. gariepinus* juveniles fed ration supplemented with 2% *A. lepidophyllus* bark powder (T₃) increased with rearing time, unlike the SGR of juveniles from the other three treatment groups (T₀, T₁, T₂), which increased from the 14th to the 28th week before decreasing continuously until the end of the trial. However, at 56 days of rearing, the SGR was significantly (p < 0.05) higher in juveniles fed T₃ group.



T₀= control ration, T₁= T₀+1% *A. lepidophyllus*, T₂= T₀+1.5% *A. lepidophyllus*, T₃= T₀+ 2% *A. lepidophyllus*

Figure 3: Specific growth rate of juvenile *C. gariepinus* fed different diets for 56 days. Means on the same rearing period carrying different superscripts were significantly different at $p < 0.05$

Survival Rate and Feed Nutrients Utilization

Table 3 presents the survival rate and feed nutrients utilization of juveniles *C. gariepinus* at the end of the feeding period. It is noticed that, the survival rate recorded in the different treatments during the study were not related to the dietary inclusion level of *A. lepidophyllus*. The highest survival rate registered at the end of the feed trial was observed with juveniles in treatment fed T₃ diet supplemented with 2% *A. lepidophyllus* powder. Determination of feed nutrients utilization parameters (feed conversion ratio, feed efficiency ratio and protein efficiency ratio) indicate that fish fed diets supplemented *A. lepidophyllus* had better feed utilization characteristics ($p < 0.05$) compared to the control diet. On the other hand, we notice a significant increase on the value of condition factor K with respect to the level of dietary inclusion of *A. lepidophyllus*.

Table 3: Survival and feed utilization of *Clarias gariepinus* at the end of the feeding trial.

Parameters	Treatments				P. value
	T ₀	T ₁	T ₂	T ₃	
Ni	75	75	75	75	
Nf	73	73	71	75	

SR (%)	97.33 ± 0.00	97.33 ± 0.00	94.67 ± 0.00	100.00 ± 0.00	
Wi (g)	9.29 ± 0.51 ^a	9.11 ± 0.29 ^a	9.47 ± 0.51 ^a	9.41 ± 0.29 ^a	0.725
Wf (g)	65.85 ± 1.91 ^b	61.12 ± 6.29 ^b	67.08 ± 3.65 ^b	86.67 ± 6.27 ^a	0.000
Li (cm)	10.76 ± 0.13 ^a	10.67 ± 0.03 ^a	10.67 ± 0.15 ^a	10.75 ± 0.09 ^a	0.685
Lf (cm)	20.54 ± 0.38 ^a	19.90 ± 0.24 ^a	20.46 ± 0.50 ^a	20.12 ± 0.57 ^a	0.318
K	0.76 ± 0.02 ^b	0.77 ± 0.56 ^b	0.78 ± 0.001 ^b	1.06 ± 0.01 ^a	0.000
FI (g/fish)	70.22	61.07	68.88	61.59	
FCR	1.24 ± 0.05 ^a	1.18 ± 0.14 ^a	1.20 ± 0.07 ^a	0.80 ± 0.07 ^b	0.001
FER	0.80 ± 0.03 ^b	0.85 ± 0.10 ^b	0.84 ± 0.05 ^b	1.25 ± 0.10 ^a	0.000
PER	2.12 ± 0.09 ^b	2.24 ± 0.28 ^b	2.20 ± 0.14 ^b	3.30 ± 0.28 ^a	0.000

Values are mean ± standard deviation of three replicates of 25 fish each. Mean within the same row with different superscripts are significantly different at $p < 0.05$. Ni, initial number of fish; Nf, final number of fish; FI, feed intake; Li, initial length of fish; Lf, final length of fish; K, condition factor; FCR, feed conversion ratio; FER, feed efficiency ratio; PER protein, efficiency ratio.

T₀= basal diet; T₁ = basal diet + 1% *A. lepidophyllus*; T₂ = basal diet + 1.5% *A. lepidophyllus*; T₃= basal diet + 2% *A. lepidophyllus* ;

Body Composition and Nutrient Retention

Whole-body composition of *C. gariepinus* juveniles produced at the end of 56 days of culture is recorded in Table 4. As compared to fish carcass composition at the beginning of the study, it is noted that the macro-elements that constitute the whole-body biochemical composition of fish fed supplemented diets significantly increased ($p < 0.05$) but not proportional to the rate of dietary inclusion level of *A. lepidophyllus*. Fishes fed T₃diet induced the highest and most significant retention in protein, lipid, ash, energy and dry matter compared to other experimental diets.

Table 4: Proximate composition (% or kJ/g WW) of carcass and nutrient retention in juvenile *C. gariepinus* produced after 56 days of feeding

parameters	Initial	T ₁	T ₂	T ₃	T ₄	P. value
Whole body Composition (% or KJ/g WW)						
Protein	11.55±0.01 ^e	13.44±0.01 ^d	16.22±0.02 ^c	16.46±0.01 ^b	17.02±0.02 ^a	0.000

Lipid	0.76±0.02 ^d	1.06±0.01 ^c	1.54±0.02 ^b	2.61±0.01 ^a	2.63±0.03 ^a	0.000
Energy	62.49±00.01 ^e	77.05±0.00 ^d	95.82±0.01 ^c	110.61±0.1 ^a	109.56±0.00 ^b	0.000
Ash	2.25±0.01 ^d	3.01±0.01 ^c	3.58±0.02 ^a	3.19±0.1 ^b	3.53±0.03 ^a	0.000
Dry matter	21±0.02 ^d	24±0.01 ^c	28±0.01 ^b	29±0.00 ^a	28±0.01 ^b	0.000

Nutrient Retention (% dry feed)

Protein	29.33±1.32 ^d	38.94±3.06 ^b	37.32±2.07 ^c	58.36±2.19 ^a	0.000
Lipid	10.31±0.33 ^d	28.73±0.93 ^b	15.97±3.08 ^c	41.07±3.07 ^a	0.000
Energy	22.74±0.74 ^d	35.93±1.79 ^b	28.89±4.04 ^c	51.07±3.94 ^a	0.000
Ash	13.01±0.44 ^d	15.36±1.01 ^c	17.01±1.77 ^b	24.77±1.93 ^a	0.000
Dry matter	21.81±0.72 ^d	28.56±1.63 ^b	26.77±3.29 ^c	39.77±3.13 ^a	0.000

Values are mean ± standard deviation of three replicates of 25 fish each. Mean within the same row with different superscripts are significantly different at $p < 0.05$. P= probability

T₀ = basal diet; T₁ = basal diet + 1% *A. lepidophyllus*; T₂ = basal diet + 1.5% *A. lepidophyllus*; T₃ = basal diet + 2% *A. lepidophyllus*; WW, wet weight;

4. Discussion

In the present study carried out to evaluate the effects of dietary inclusion of the bark of *A. lepidophyllus* powder on growth, feed utilization and whole-body composition of juvenile *C. gariepinus*, the physico-chemical parameters of the experimental water tank were observed to be within the range recommended for fresh water fish culture. [19] recommended 25-30°C for the culture of *C. gariepinus*. Dissolve Oxygen level greater than 5mg/l is essential to support good fish production. [20] reported that the ideal pH level is between 7.5 and 8.5 and any value above and below this could be stressful to the fishes. However, the highest survival rate registered was observed with juveniles fed T₃ diet supplemented with 2% *A. lepidophyllus* powder compared to the juveniles fed the control (T₀) and other experimental diets T₁ (1%) and T₂ (1.5%). These could be attributed to the quantity of bioactive compounds in the spices that was more concentrated in the T₃ diet. This observation corroborates that of [21] who observed that the highest value of survival rate was obtained in fry fed with the experimental diet containing the highest value (2%) of *Allium Sativum*. These could be attributed to the antioxidant properties of the phyto-additives contained in the feed. According to [22], spices are useful in aquaculture industry not only to improve the palatability of feed and as a flavouring agent but also because of their high antioxidant property. The main bioactive compounds contain in spices are known to improve fish

Comment [s9]: Adding new references according to the results of this study

health through their ability to eliminate free radicals, antioxidant properties [8] and modulation of microbial populations [13]. The nutritional status thus strengthens the host's defense against pathogens and helps the fish to do better.

The results of this study showed positive effects of dietary *A. lepidophyllus* powder on growth performance and feed nutrients utilization. Supplementing *C. gariepinus* with *A. lepidophyllus* enhanced body weight, body weight gain and feed nutrients utilization as compared to the control diet. These results agree with the findings of [14] who incorporated the bark of *A. lepidophyllus* in broilers diet enhanced Body Weight, Body Weight Gain and tend to reduce Feed conversion ratio compared to the control diet. This result can be explained by the presence of polyphenolic compounds possessing significant antioxidant properties [12,11] with many other attributes which are known to stimulate digestive enzymes and lipid metabolism [13] and therefore improve growth performance. The highest response was observed in fish fed with the highest level of phyto-additive. These results agree with the findings of [23] and [24] who demonstrated that the highest final weight and weight gain in fish resulted from the highest level of *Garcinia mangostana* in African catfish and *Zingiber officinale* powder in common carp, *Cyprinus carpio* diets. The highest improvement in body weight recorded with *C. gariepinus* fed on supplementing diet at 2% could be attributed not only to the digestive enzymes stimulation but also to the antimicrobial properties of their specific active compounds and their impact on gut function. The increased level of incorporation of *A. lepidophyllus* in the ration increased flavonoids and phenolic compounds, which are known to improve animal performance by changing the intestinal ecosystem of the animal through their antimicrobial action [25]. These compounds act by forming complexes with many proteins, cause the destruction of the bacterial membranes, making unavailable certain substrates for the bacteria and inactivate bacterial enzymes [16]. The changes in intestinal ecosystem due to their antimicrobial action could lead to a greater availability of some nutrients for the host and consequently improve body weight gain and feed utilization. This is in agreement with [16], who noticed that the growth promoting effect of most herbs and spices act by killing parasites that hinder digestibility and growth performance of animal. On the other hand, the improvement in body weight of *C. gariepinus* juveniles obtained with high level of incorporation of *A. lepidophyllus* could also be attributed to the potent antioxidant properties of their major components as reported by [11] and [8].

Fish fed on diet containing 2% of *A. lepidophyllus* powder at the end of the study presented specific growth rate value significantly high ($p < 0.05$) to the rest of the treatments. This is in contrast to the results obtained using dietary *Zingiber officinale* extract in juvenile beluga (*Huso huso*) diet [26]. The conflicting results of the present study with those of [26] could be attributed to the different between the species used, feeding program and even the culturing conditions. On the other hand, this result agrees with the findings of [24] who observed at the end of the culture period a specific growth rate value significantly high with *Cyprinus carpio* juvenile fed diet supplemented with the highest level of *Zingiber officinale* (2%). However contrary to the results obtained by [21] who observed that irrespective of the treatment, the growth of fry was faster during the first weeks of feeding and gradually decreases with increased in experimental period, in the present study the SGR of juveniles of *C. gariiepinus* supplemented with 2% *A. lepidophyllus* (T_3) diet increases with increase in experimental period as compared to the other treatment groups. The improvement of SGR of *C. gariiepinus* juveniles induced by the inclusion of *A. lepidophyllus* compared to the performances of those fed with the control diet could have emanated from the presence sulfurphyto-additive and phenylpropanoid (eugenol) which have the ability to stimulate the function of pancreatic enzymes (lipases, amylases and proteases) and increase the activity of digestive enzymes of the gastric mucosa as demonstrated by [11], which may have improved the digestibility of feed and increased the availability of nutrients and their use for growth of juveniles fed supplemented rations. In addition, at 2%, the previously mentioned property of this additive would have been maximized, would have allowed an accelerated increase in the instantaneous rate of growth of the fish and an ever-increasing SGR over the period of the study. This was in contradiction to that obtained by [27] who reported that, the specific growth rate decreases while the muscle mass increases.

Body development or growth of farmed animals, particularly fish, is one consequence of improving whole-body composition due to nutrients retention from distributed feed. The results of the present study revealed that whole-body composition of *C. gariiepinus* juveniles at the end of the study compared to initial fish samples, in term of protein, lipid, energy, ash, and dry matter level significantly increased with the inclusion of the bark of *A. lepidophyllus* powder. This result is in accordance with that of [28] who observed significant increase in the macro-elements that constitute the whole-body biochemical composition of sterlet sturgeon juvenile fed on diet containing different inclusion levels of garlic extract. Similarly, [29] showed that, increasing the

levels of ginger in the diet of *C. gariepinus* juveniles significantly increased protein, lipid and ash contents in their body composition compared to the control. [21,30] also observed significant increase in the macro-elements that constitute the whole-body biochemical composition of *C. gariepinus* fry fed on diet containing different inclusion levels of garlic, ginger powders, ginger and garlic blend. Knowing the phyto-chemical composition of *A. lepidophyllus* bark, the improvement of biochemical composition of the experimental fish whole-body as compared to the control can be attributed to the pharmacological properties of the bioactive molecules in the supplemented plant products than to their nutritional effects. As previously observed with growth and feed utilization parameters, body content of protein, lipid, ash and energy as well as their retention were significantly high in carcass of fish fed 2% *A. lepidophyllus* bark powder supplementation in the diet compared to the rest of the treatments. These results are in agreement with the findings of [31] who observed significant increase in chemical body composition in Major carp fingerlings compared to the control diet after 6 months of feeding with inclusion levels of garlic powder (1% - 3%). These results also corroborate previous findings which established a direct link between the feed utilization efficiency by fish and their bodily level of retention [32,33]. Knowing that body nutrient retention refers to feed nutrient proportion stored as nutrient in the body tissues of fish during rearing process, it is reflected on physical appearance by both weight increase and linear growth.

Conclusion

The present study demonstrated that, supplementing *C. gariepinus* diet with the bark *A. lepidophyllus* powder improved growth performances, feed nutrient utilization and nutrient retention in whole-body composition of the juveniles. The highest effect being obtained with the highest level of inclusion. These observed beneficial effects can be attributed to the presence of bioactive compounds on the bark of *A. lepidophyllus* than to their nutritional properties.

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Comment [s10]: In what treatment? and what percentage is the bark *A. lepidophyllus* powder given?

Comment [s11]: Add new references and check the references

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