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Original Research Article

Effect of an Extruded Feed Enriched with Garlic and Ginger on Production Parameters and Organosomatic Indices of Red Tilapia Fingerlings Reared in a Concrete Tank

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Abstract: A 63-day study was conducted to determine the effect of the extruded feed enriched with garlic and ginger on the growth performances, whole body composition, and organosomatic indices of red tilapia fingerlings raised in a concrete tank. The 1,320 mixed-sex red tilapia fingerlings, weighing 4.77±0.14g were randomly allocated in triplicate in 12 hapas corresponding to four treatments. Treatment T0 (control) received the basal diet, while the fingerlings in treatments T1, T2, and T3 were fed the basal diet enriched with 1.5% garlic, 1.5% ginger, and 1.5% garlic-ginger mixture, respectively. Feeding took place four times a day at a rate of 5–4% of the biomass, with intermediate sampling occurring every three weeks for biometric assessments and total fish counts. The results indicate that all the parameters assessed were significantly improved in red tilapia fingerlings fed the experimental diets compared to the control. However, the best performances were obtained in fish fed the diet enriched with garlic powder with a weight gain (64.96±4.88g), specific growth rate (2.71±0.28%/d), protein efficiency ratio (2.85±0.30), and feed conversion ratio (0.97±0.10) significantly different from 26.22%, 33.95%, 25.26%, and 20.49% compared to control. For the body composition, the same observations were made regarding the contents in protein, lipid, ash, and energy, with a significantly higher impact on the body retention of the aforementioned nutrients, justifying thereby the best growth and welfare state of the gastrointestinal organs of the produced fish in treatment T1 compared to other treatments, particularly the control treatment.

Keywords: Red Tilapia, Garlic, Ginger, Growth, Body composition and indices.

INTRODUCTION

The aquaculture industry is experiencing remarkable growth in a number of sub-Saharan African countries, such as Nigeria. In Cameroon, on the other hand, although introduced in 1948, aquaculture in general and fish farming in particular have unfortunately long been neglected by the local population. The country's involvement in a number of bilateral projects and multifaceted interventions on the field to encourage people to adopt this new type of farming only began to bear fruit in 2010 with the observation of a few commercial fish farms. Since then, fish farming has been booming, with more and more farms being set up in both urban and peri-urban areas. The city of Douala and the surrounding area are home to several commercial fish farms. This is supported by favourable climatic, ecological, and socioeconomic factors, driven by a rising demand for quality fresh fish. Furthermore, the practice of fish culture in earthen ponds, floating cages, concrete tanks, and tarpaulin ponds is supported by a dense hydrographic network that comprises an abundant ichthyologic fauna with potential for aquaculture. Scale fish such as Nile tilapia, although being the species most appreciated by the local populations in Cameroon's coastal regions for their feeding habits, is nevertheless the second highest species after African catfish for several reasons, including those related to the strain used in most fish farms with low growth and reproductive performance in addition to the scarcity of reasonably

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priced, high-quality feed (Nyadjeu *et al*., 2021b). According to Lubembe *et al*., (2022), one of the reasons for low aquaculture production in sub-Saharan Africa, due to low fish yields compared to other regions such as Asia, is the lack of use of improved strains. In order to improve the quantity and quality of national tilapia production, red tilapia (*Oreochromis sp*) was introduced to Cameroon. While the genetic heritages of the strains introduced are not well documented, their derivation is generally attributed to crossbreeding of mutant reddish-orange *Oreochromis mossambicus*. The first introduction in Cameroon came from Holland in 2011, while the second one came from Thailand and the Philippines in 2020-2021. Since its introduction as a new aquaculture species, red tilapia producers have gained in popularity among fish farmers because, in addition to its resemblance to marine species of high economic value such as sea bream, its flesh is highly appreciated by consumers. Red tilapia is an excellent candidate for aquaculture due to a number of biological characteristics, such as high adaptation capability to adverse environmental conditions, high resistance to disease, omnivore feeding behaviour, rapid growth, and delicious taste (Mirabent *et al*., 2020). However, among the major problems encountered in tilapia farming is the inconsistent supply and high-cost of imported feeds. One of the solutions is to develop all links in the fish farming value chain, in particular the production of aquafeeds that meet the nutritional requirements of the cultures species by using local available ingredients including phytoadditives to improve the nutritional quality of the feeds and the physiological conditions of the fish. Garlic and ginger are phytoadditives with well-known nutritional potential that have been shown to be effective in promoting growth and improving health in a variety of freshwater fish species, including *Clarias gariepinus, Oreochromis niloticus, and Cyprinus carpio* (Jafarinejad *et al*., 2020; Abu-Alya *et al*., 2022; Nyadjeu *et al*., 2023).

Ginger (*Zingiber officinale*), belongs to the Zingiberaceae family. All around the world, people utilise the rhizome of the plant as a spice in their food. Pharmacological and nutritional investigations have identified alkaloids, flavonoids, polyphenols, saponins, steroids, tannins, fibre, carbohydrates, vitamins, carotenoids, and minerals. It is also rich in naturally occurring antioxidant compounds, such as zingerone, shogaols, and gingerols (Yashin *et al*., 2017). Mohammedi *et al*., (2020) found that adding ginger to fish feed can improve growth by improving digestion, protein and lipid metabolism, and overall homeostasis by producing antioxidant mediators that shield organs, tissues, and cells from free radical damage.

Allium sativum, also known as garlic, is a perennial plant that forms bulbs and is a member of the Liliaceae family's genus Allium. It has been utilised for many years as a functional food and aromatic to enhance both mental and physical well-being. Numerous organo-sulfur compounds, including allicin, ajoene, -allylcysteine, diallyl disulfide, Smethylcysteine sulfoxide, and S-allylcysteine, have been found in garlic extracts (aqueous, ethanol), as well as dry powder (Chi *et al*., 1982). Furthermore, biochemical analyses also revealed the presence of minerals such as phosphorus and calcium, as well as vitamins A, C, and B, linolenic acid, carbohydrates, and other useful substances like iodine and silicates whose positive effects on the skeleton and circulation are well-established. According to earlier studies, adding garlic to a fish diet can boost growth, improve antioxidant status, and improve immunological, and haematological markers (Yilmaz and Ergün, 2012).

The current study was therefore undertaken to evaluate the effects of extruded feed enhanced with ginger and garlic on the growth performance and organosomatic indices of red tilapia fingerlings raised in concrete tanks in order to better understand the utility of these spices as potential ingredients in fish feed.

MATERIAL AND METHODS

The study was carried out in the technical installations of a private fish farm (AQUARIN SARL) located at Bomono Ba-Jedu in the Dibombari Subdivision of the Littoral Region of Cameroon at 15 km of the city of Douala.

Processing of phytoadditives

Fresh ginger roots (*Z. officinale*) and garlic bulbs (*A. sativum*) purchased from the local market were washed under running, clean tap water and wiped with a clean kitchen towel. Garlic and ginger were individually peeled to remove foreskin, cut into small pieces, and air dried before being ground using a household grinder and sieved to obtain 1 kg each of the powders, which were then stored in dry containers till formulation and preparation of the experimental diets.

Experimental Diet Formulation and Manufacture

Four isonitrogenous diets (38% CP) were formulated to meet the nutrient requirements of red tilapia, according to El-Sayed *et al*., (2004) and NRC. (2011). The ingredients used for the diet formulation were purchased from a feed retailer and Belgocam store. Ginger and garlic powder were added to the basal diet or control diet (T0) at 1.5g/100g (1.5%) to formulate the experimental diets T1 with 1.5% garlic inclusion, T2 containing 1.5% ginger inclusion, and T3 with the mixture of the two additives at 1.5% inclusion. Composition and proximate analysis of the control basal diet and experimental diets are shown in Table 1. For the manufacturing of different diets, each group of ingredients was ground into a fine powder, gradually mixed with water and oil, and then extruded at the extruding temperature of 125°C into a floating pellet with a diameter of 2.0 to 3.0 mm using a single-screw extrusion machine model LIMA (LM80 200 to 300 kg/h floating fish feed extruder machine). The extruded feeds were sundried at ambient temperature (28-30°C) and then 10g of each diet was taken for biochemical analysis while the rest was packed in airtight polyethylene bags and stored until use for the feeding trial.

Table 1: Ingredients, and proximate composition of different diets (g/100g dry mater)

Ingredients	**T0: Control**	**T1: 1.5% garlic**	**T2; 1.5% ginger**	**T3: 1.5% garlic-ginger**
Fish meal	50	50	50	50
Soybean cake	15	15	15	15
Groundnut cake	5	5	5	5
Crayfish meal	2	2	2	2
Wheat bran	10	10	10	10
Corn flour	10	10	10	10
Cassava flour	5	3.5	3.5	3.5
Garlic powder			1.5	0.75
Ginger powder		1.5		0.75
Vitamin premix	0.5	0.5	0.5	0.5
Bone meal	0.25	0.25	0.25	0.25
L-lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
Vitamin C	0.25	0.25	0.25	0.25
Salt	0.5	0.5	0.5	0.5
Vegetable oil	1	1	1	1
	Proximate composition (%.DM)			
Protein	38.57±0.27	38.26±0.27	38.32±0.27	38.44±0.27
Lipid	9.80±0.42	10.70±0.42	8.60±0.42	7.60±0.07
Ash	18.50±0.35	18.00±0.01	18.00±0.01	17.00±0.01
Moisture	7.50±0.01	7.00±0.01	8.00±0.01	6.50±0.01
Energy (kcal/100g DM)	375.00±3.54	381.50±2.12	371.00±2.12	370.00±0.35

Experimental Design and Set Up

The experimental design was a complete randomised design with all experimental samples homogenous, while the only source of variation were the test ingredients (garlic and ginger). The outdoor experimental set-up of 12 hapas (70 x 70 x 100) cm was installed in a 5 m^3 rectangular concrete tank supplied with borehole water from the farm and constant aeration using aeration stones.

Fish Rearing, Feeding, and Sampling

A total of 1,320 mixed-sex red tilapia fingerlings with an average weight of 4.77± 0.14g selected from one of the farm's grow-out tanks randomly distributed in triplicate in 12 hapas corresponding to four treatments (T0, T1, T2, and T3) containing 330 fingerlings each were allowed for a two-week acclimatisation period during which fish were fed a commercial diet. At the end of the acclimatisation period, 15 fingerlings per treatment were set aside for the initial body analysis and the others (315) for the trial that lasted for sixty-three days, during which fish in treatment T0 were fed with the control diet without phytoadditives while those in the experimental treatments T1, T2, and T3 were fed with diets enriched with 1.5% garlic, 1.5% ginger, and 1.5% garlic-ginger mixture, respectively. Fish were fed four times a day (8:00, 11:00, 14:00, and 17:00) at 5% body weight during the first 42 days and 4% during the last 21 days of the experiment. Water was partially (25 %) drained and replaced with fresh water daily and totally drained twice a week. Some water quality parameters such as temperature (T˚C), pH, dissolved oxygen (D.O), ammonia (NH_3), nitrite (NO_2^-) and nitrate (NO_3-) were monitored daily before feeding (table 2). Forty per cent of the fish of each experimental unit were weighed at 21 days interval and feeding rate readjusted based on change in body weight.

Table 2: Water quality parameters (Mean±SD) during 63 days of the experimental period

Parameters	**Sampling period (days)**			
	1	**21**	**42**	**63**
T°C (°C)	28.26±1.25	28.05±0.78	28.35±1.05	27.71±0.71
pH	7.79±2.59	7.53±0.33	7.47±0.46	7.63±0.59
D.O (mg/l)	9.00±0.58	7.67±1.08	8.00±1.00	8.00±1.73
NH_3 (mg.l^{-1})	0.02±0.00	0.03±0.00	0.03±0.00	0.03±0.00
NO_2^- (mg.l^{-1})	1.75±0.06	1.78±0.08	1.82±0.03	1.78±0,03

Fish Measurements, Organ Sampling, and Bromatological Analysis of Feeds and Fish

The total length and weight of the fish were measured at the beginning, during intermediate sampling, and at the end of the experiment. Prior to the biometric measurements, all fish were starved for 24 hours in order to empty their digestive tract of any feed residue. At the end of the feeding period, 75 fish of both sexes were randomly selected from each treatment, and 15 of them were sacrificed for final whole body analysis. The remaining 60 were also sacrificed, dissected, and their stomach, intestine, spleen, liver, and gonads were extracted and weighed. For analysis of the bromatological composition of the diets and that of the whole body of fish, the diet and fish samples from each treatment were subjected to proximal analysis according to the method of Association of Official Analytical Chemistry (AOAC, 1990) to determine the percentage composition of the various components of both the feed and fish. Moisture was analysed by drying the sample in an air convection oven at 105 °C overnight. Crude protein was analysed by the Kjeldahl method after acid digestion (% crude protein = % nitrogen x 6.25), while the crude lipid was determined by extraction with petroleum ether using the Soxhlet method. The ash content in the diet was analysed by combustion of samples in a muffle furnace at 550 °C for 12 h.

Growth and Feed Efficiency Parameters

Growth performances, survival rate, feed utilization and nutrients retention were assessed for each treatment by determination of weight gain (WG), specific growth rate (SGR), survival rate (SR), condition factor (K), feed conversion ratio (FCR), lipid efficiency ratio (LER), protein efficiency ratio (PER) and nutrients retention (NR). Calculations were carried out using the following formulae:

– WG (g) = Wf – Wi, where Wf is the final weight and Wi is the initial weight

– SGR (% /day) $= \frac{(\ln Wf - \ln Wi)}{t} \times 100$, where t is the number of days

– SR (%) $= \frac{\text{Final number of fish}}{\text{Initial number of fish}} \text{ X } 100$;

– K $= \frac{\text{Weight(g)}}{\text{Length(cm)}^3}\ X\ 100$

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

– FCR $= \frac{\text{weight of feed consumed}}{\text{Fish Weight Gain}}$;

– PER $= \frac{\text{Fish Weight Gain}}{\text{Protein fed}}$;

where, Protein fed (g) $= \frac{\text{Total feed consumed x Crude protein in feed}}{100}$;

– NR (% dry feed intake) $= \frac{\text{Final carcass composition} - \text{Initial carcass composition}}{\text{Amount of nutrient fed}} X\ 100.$

Organosomatic indices

– Stomachtosomatic index (StSI, %) $= \frac{\text{Stomach weight}}{\text{Body weight}} \text{ X } 100$;

– Intestinosomatic index (ISI, %) $= \frac{\text{Intestine weight}}{\text{Body weight}} \text{ X } 100$;

– Spleenosomatic index (SpSI, %) $= \frac{\text{Spleen weight}}{\text{Body weight}} \text{ X } 100$;

– Hepatosomatic index (HSI, %) $= \frac{\text{Liver weight}}{\text{Body weight}} \text{ X } 100$;

– Gonadosomatic index (GSI, %) $= \frac{\text{Gonads weight}}{\text{Body weight}} \text{ X } 100.$

Statistical Analyses

The mean ± SD was used to express all results. One-way analysis of variance (ANOVA-1) repeated measure and Tukey's multiple comparisons test were used to analyse the data gathered during each fish sampling, with n=3 replications containing 100 fish each. When $p<0.05$, differences were considered significant. All statistical analyses were conducted using GraphPad Prism version 6.0.

RESULTS

Growth Performance

During the feeding trial, it was observed that red tilapia fingerlings in all treatments fed voraciously. Figure 1 illustrates the effect of dietary inclusion of garlic and ginger powder on weight gain and specific growth rate (fig 1B) on red tilapia fingerlings for 63 days. It is noted that from the first fish sampling till the last, weight gain in experimental treatments increased significantly compared to control. At the end of the feeding trial, fish in treatment T1, receiving the diet enriched with garlic, expressed the highest value of weight gain of 64.96±4.88g, significantly high by 26.22% compared to control 7.64% and 9.81% compared to treatments T2 and T3, respectively (fig 1A). Results of the specific growth rate presented in figure 1B shows that fish in all treatments grew quickly over the first 21 days of feeding. Growth velocity then gradually decreased until the feeding trial was over, reaching its maximum value of 2.71+0.28%/d in treatment T1, which was substantially higher than control by 33.95%, 17.93%, and 13.65%, respectively, than treatments T0, T2 and T3.

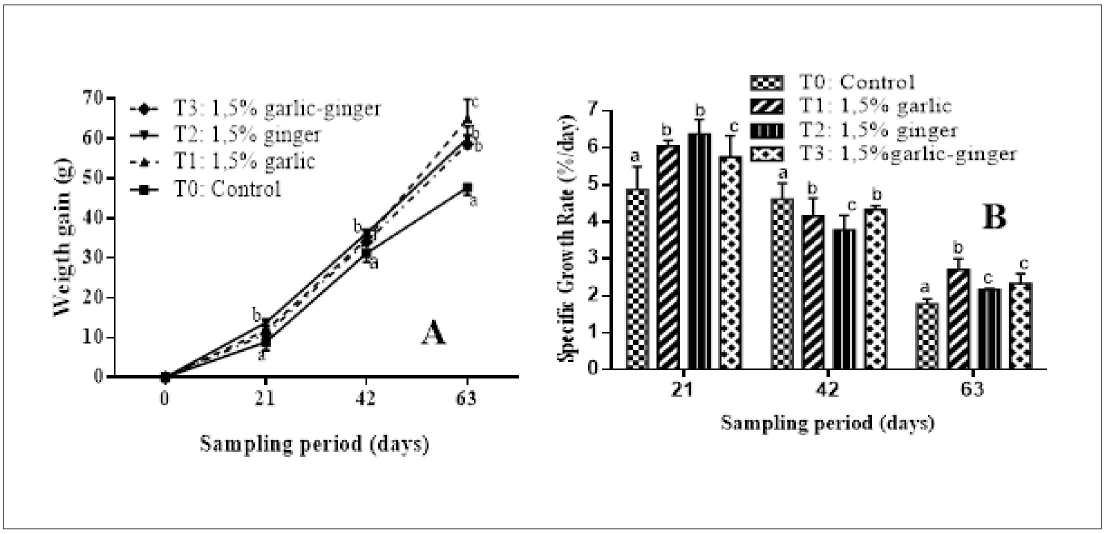

Figure 1: Effect of diet enriched with garlic and ginger powders on weight gain (A) and specific growth rate (B) of red tilapia fingerlings for 63 days. Means on the same sampling period carrying different superscripts are significantly different from each other at p<0.05

Survival Rate and Feed Nutrient Utilisation Characteristics

Table 3 below presents the survival rate and the feed nutrient utilisation characteristics of red tilapia fingerlings after 63 days of feeding. It is noted that survival rate (SR), feed intake (FI), protein intake (PI), as well as lipid intake (LI) and condition factor (K) did not differ significantly ($p>0.05$) among various treatments. On the other hand, feed conversion ratio (FCR), protein efficiency ratio (PER) and lipid efficiency ratio (LER) have varied significantly among treatments. Fingerlings fed the diet with garlic powder have presented the best values of FCR (0.97±0.10) and PER (2.85±0.30), significantly different ($p<0.05$) of 20.49% and 25.26% compared to control.

Table 3: Survival rate and feed nutrient utilisation characteristics of red tilapia fingerlings fed diet enriched with garlic and/or ginger for 63 days

Parameter	T0: Control	T1: 1.5% garlic	T2: 1.5% ginger	T3: 1.5% garlic-ginger	P
Ni	330	330	330	330	ns
Nf	300	309	312	305	ns
Wi (g)	4.92±0.26	4.65±0.60	4.87±0.19	4.65±0.34	ns
Wf (g)	52.58±1.99	69.60±4.32	64.90±2.65	63.20±24.15	ns
Lf (cm)	14.79±0.82	15.89±0.57	15.24±0.33	15.42±0.64	ns
FI (g/fish)	58.32±5.16	62.95±3.02	66.82±2.27	63.05±2.73	ns
PI (g/fish)	22.81±2.02	24.61±1.18	26.13±0.89	24.65±1.07	ns
LI (g/fish)	5.72±0.51	6.74±0.32	5.75±0.20	4.79±0.21	ns
SR (%)	90.91±0.91	93.64±1.82	94.55±2.41	92.42±1.89	ns
K	1.64±0.20	1.74±0.10	1.83±0.05	1.73±0.10	ns
FCR	$1.22±0.06^{a}$	$0.97±0.10^{b}$	$1.11±0.01^{ab}$	$1.08±0.03^{ab}$	*
PER	$2.13±0.10^{a}$	$2.85±0.30^{b}$	$2.28±0.02^{ab}$	$2.41±0.08^{ab}$	*

Values are mean ± standard deviation of three replicates of 10 fish each. Mean within a row with different superscripts are significantly different each from other at p<0.05. ns, p>0.05; *, p<0.05; ***, p<0.001.

Ni, initial number of fish; Nf, final number of fish; Wi, initial body weight of fish; Wf, final body weight of fish; Lf, final length of fish; FI, feed intake; PI, protein intake; LI, lipid intake; SR, survival rate; K, condition factor; FCR, feed conversion ratio; PER, protein efficiency ratio.

Whole Body Biochemical Composition and Nutrient Retention

Table 4 shows the body bromatological composition and nutrient retention of adults red tilapia obtained after 63 days of feeding. It appears that the moisture and ash content did not differ significantly, neither between the starting fish compared to those produced nor among fish in different treatments. On the other hand, opposite effects were observed for body protein, lipid, and energy content, which increased significantly ($p<0.05$) in experimental fish as compared to both the starting and control fish, with the best values obtained in fish fed with the diet containing garlic powder. The results obtained on the body nutrient retention revealed that the dietary inclusion of garlic and/or ginger induced a significant ($p<0.05$) increase in body retention of protein, lipid, ash, and energy as compared to control. Once again, the highest values of the above macronutrient retention are obtained in fish receiving the diet containing garlic powder.

Table 4: Bromatological composition (% or kcal/100g WW) of fish after 63 days of feeding

Parameters	initial	T0: Control	T1: 1.5% garlic	T2: 1.5% ginger	T3: 1.5% garlic-ginger	P
Whole body Composition (% or kcal/100g WW)						
Moisture	75.00±0.0	76.00±0.00	74.00±0.00	75.00±0.00	75.00±0.00	ns
Ash	3.72±0.12	3.25±0.25	3.38±0.26	2.88±0.37	3.50±0.25	ns
Protein	15.20±0.09^{a}	17.20±0.22^{b}	18.50±0.23^{b}	18.30±0.15^{b}	18.50±0.24^{b}	**
Lipid	2.88±0.14^{a}	2.65±0.15^{b}	3.45±0.15^{c}	3.40±0.15^{c}	2.60±0.15^{d}	***
Energy	95.50±1.20^{a}	100.25±0.25^{a}	105.69±0.26^{b}	105.50±0.75^{b}	99±0.25^{a}	**
Nutrient Retention (% dry feed)						
Ash		14.10±1.28^{a}	19.20±1.65^{b}	14.00±2.07^{a}	19.00±1.53^{b}	**
Protein		37.90±0.50^{a}	53.00±0.66^{b}	42.00±0.40^{c}	45.40±0.64^{d}	***
Lipid		21.90±1.26^{a}	35.50±1.51^{b}	34.90±1.58^{c}	31.50±1.84^{d}	***
Energy		22.00±0.08^{a}	28.80±0.09^{b}	25.70±0.22^{c}	24.90±0.09^{d}	***

Values are mean ± standard deviation of three replicates of 35 fish each. Mean within a row with different superscripts are significantly different each from other at $p<0.05$. ns, $p>0.05$; *, $p<0.05$; **, $p<0.01$; ***, $p<0.001$.

Organosomatic Indices

Table 5 shows the organosomatic indices of adults red tilapia following 63 days of feeding. Except for the spleenosomatic index, which did not significantly change across treatments, the inclusion of garlic and/or ginger in the diets induced a significant effect on the Stomachtosomatic Index (StSI), Intestinosomatic Index (ISI), and Hepatosomatic Index (HSI). After being fed the garlic-ginger, adults red tilapia obtained have presented the greatest StSI (0.62±0.03), with a significant high of 20.97% over the control group (StSI=0.49±0.01). On the other hand, when compared to the control, feeding red tilapia fingerlings with the diet containing ginger powder resulted in the highest increase in ISI and HSI, leading to a significant increase of 23.10% and 23.76%, respectively.

Table 5: Organosomatic indices of adults red tilapia obtained after 63 days feeding

Parameter	T0: Control	T1: 1.5% garlic	T2: 1.5% ginger	T3: 1.5% garlic-ginger	P
StSI (%)	0.49±0.01^{a}	0.58±0.03^{b}	0.60±0.03^{b}	0.62±0.03^{b}	***
ISI (%)	1.60±0.05^{a}	2.01±0.06^{b}	2.08±0.06^{b}	1.83±0.08^{b}	***
HSI (%)	1.66±0.07^{a}	2.31±0.21^{b}	2.33±0.17^{b}	1.88±0.12^{b}	**
SpSI (%)	0.13±0.05	0.13±0.02	0.12±0.01	0.12±0.03	ns

Values are mean ± standard error of the mean of three replicates of 4 fish each. Mean within a row with different superscripts are significantly different each from other at $p<0.05$. ns, $p>0.05$; **, $p<0.01$; ***, $p<0.001$.
StSI: Stomachtosomatic index, ISI: Intestinosomatic index, HSI: Hepatosomatic index, SpSI: Spleenosomatic index.

DISCUSSION

The aquaculture industry is expanding quickly in sub-Saharan Africa, especially in Cameroon, as a result of the rising demand for premium animal protein. One of the main reasons for this is the use of formulated fish feeds that meet the nutritional requirements of farmed fish. Tilapia is among the most straightforward and lucrative fish to raise in a confined environment because of it omnivorous diet, resistance to disease and handling, ease of reproduction in captivity, and ability to tolerate a wide range of environmental conditions (Suresh, 2003). Nonetheless, red tilapia culture is strongly influenced by environmental characteristics such as temperature, pH, and dissolved oxygen that can compromise water quality and impact red tilapia physiology, development, metabolism, feed consumption, and survival (Bilale & Teklie, 2017). This is why during the current study, a number of physico-chemical characteristics of the rearing water were recorded. The temperature values obtained were between 27.71 and 28.35°C, corresponding, according to Ebeling *et al*., (2006) and Ndour *et al*., (2011), to the ideal temperature range for healthy tilapia development. These results match with those of Azaza *et al*., (2008) and Faruk *et al*., (2012), who showed that tilapia fingerlings utilised feed nutrients most effectively for growth at a temperature of 25 to 30°C. The pH of the water recorded ranged from 7.47 to 7.79, suitable for tilapia culture, according to Bahnasawy *et al*., (2009). These findings support those of Grace and Isagani. (2017) and El-Sherif and El-Feky. (2009), who reported that tilapia prosper best in water with a pH of 7-8 for maximum growth and survival. Furthermore, during the feeding period, dissolved oxygen recorded were ranging from 7.67 to 9.00. Because it is necessary for the breakdown of glucose and the release of energy within fish cells, dissolved oxygen is one of the most crucial elements for fish survival, feed intake, body development, and metabolism, especially in an intense aquaculture system (Swann, 2007; Tran-Duy *et al*., 2012). Red tilapia fingerlings in the current study were never exposed to oxygen insufficiency, as confirmed by Dagne *et al.*, (2013), who reported that the ideal dissolved oxygen level for tilapia culture falls between 3 and 9. These values are in good agreement with those obtained during the current study. In fish farming, intoxication by nitrogenous metabolic waste excreted through the gills, urine and faeces depends essentially on temperature, the size of the fish, and the digestibility of the feed distributed. The concentrations of these nitrogenous metabolic waste must be kept below the critical threshold for tilapia by not exceeding 2 mg/l for nitrites and 15 mg/l for nitrates (Malcolm *et al*., 2000), as observed during the present work. The appreciable water quality maintained in the rearing tank during the present study could be attributed to siphoning of faeces and feed waste during the daily process of partial replenishment of the rearing water. This observation aligns with the findings of Ofori. (2001), who reported that the risk of water quality deterioration and an associated reduction in fish growth and survival are improved when the accumulation of organic matter is minimised. Overall, water parameters did not adversely affect the survival and growth of experimental fish, as they were within the recommended limits for red tilapia fingerling grow-out. Consequently, the few deaths recorded in all the treatments could have causes other than those linked to water quality or diet. According to the FAO (2024), aquaculture production, which accounted for 51% of total production in 2022, has surpassed capture fisheries for the first time in history, with an increase of 0.8% for Africa. This rise can be justified not only by a continuous improvement in farming conditions but, more importantly, by the use of high-quality feeds with well-established nutritional values. According to Nyadjeu *et al*., (2023), the feed's quality depends on the kind of ingredients used. Among these are feed additives, or more precisely, phytoadditives such as garlic and ginger, whose various properties, both pharmacological and nutritional, have caught the interest of aquaculture nutrition specialists. They are rich in bioactive compounds that promote fish growth and well-being (Rezaei *et al*., 2022). It is also well known that including powdered garlic and ginger in the diet enhances the growth of the main freshwater species raised in sub-Saharan African countries, such as African catfish, Nile tilapia, red hybrid tilapia, and common carp (Samson, 2019; Jafarinejad *et al*., 2020; Santos *et al*., 2020, Mohd Faudzi *et al.*, 2024; I.Megbowon *et al*., 2024). However, limited research has been conducted on the effect of adding, individually or in combination, these phytoadditives to the diet on the growth performance of red tilapia fingerlings under conditions that are as close to actual intensive farming conditions as feasible.

This study found that feeding red tilapia fingerlings with diets enriched in garlic and ginger, individually or in combination, significantly improves growth characteristics, feed nutrient utilisation and retention, as well as whole-body bromatological composition. This is probably due to better functioning of the organs of the gastrointestinal tract evaluated by the determination of organosomatic indices. During feeding, red tilapia fingerlings fed diets containing garlic, ginger, and their combination were more agitated than those on the control diet. This observation confirms that previously made by Nyadjeu *et al*., (2021a and 2023) with African catfish fry and juveniles raised under similar conditions, suggesting that adding the above-mentioned phytoadditives to the diet would improve the flavour and palatability of the feed, which would justify the great feed intake levels observed in the experimental fish. Furthermore, dietary nutrient utilisation characteristics, including feed conversion ratio (FCR) and protein efficiency ratio (PER), were significantly improved in experimental fish compared to control fish, with the lowest FCR and highest PER recorded in fish fed 1.5% dietary garlic inclusion. Although the results on fish somatic growth contrast with those of Samson (2019) obtained after feeding red tilapia fingerlings with dietary garlic supplementation for 6 weeks, probably because of the short feeding time, i.e., 6 weeks versus 9 weeks for the present study, which would have been certainly insufficient to allow the bioactive garlic components to express their real growth potential. On the other hand, the results on feed utilisation characteristics, in particular FCR, correspond well with those obtained by Samson (2019) and can be attributed to the bioactive compounds in garlic, such as allicin, which is known for its stimulating properties on the intestinal flora, leading to better digestion and energy utilisation and therefore better growth through the feed nutrients accumulation to the fish flesh. This was demonstrated through the bromatological analysis of the fish produced, which revealed both significantly high body contents and retentions of protein, lipid, ash and energy in experimental fish, especially those fed the diet with garlic at 1.5% inclusion compared to the control.

CONCLUSION

To summarise, the study found that dietary inclusion of the spices ginger and garlic, individually and in combination in a red tilapia grow-out feed, has significantly improved the productive parameters as well as the nutritional characteristics of the produced fish compared to the control, with the most pronounced effect obtained with the dietary garlic supplementation. Therefore, the inclusion of garlic in the diet of red tilapia is a possible alternative to the use of synthetic or chemical supplements to improve growth, feed nutrient utilisation, nutritional composition of the fish body, and thereby its qualitative production.

REFERENCES

- Abu-Alya, IS, Sheraiba, N. I., Aziz, E. K., Osman, N. A., & Kishta, A. A. (2022). Impact of garlic (*allium sativum*) and/or ginger (*zingiber officinale*) oils supplementation on the growth performance, physiological responses, and gene expression of nile tilapia. Advances in Animal and Veterinary Sciences. 10 (11): 2356-2366. http://dx.doi.org/10.17582/journal.aavs/2022/10.11.2356.2366
- AOAC. (1990). Official Methods of Analysis of the Association of Official Analytical Chemists. 15th Edition, Association of Official Analytical Chemists, Washington DC. 1298.
- Azaza, M. S., Dhraïef, M. N., & Kraïem, M. M. (2008). Effects of water temperature on growth and sex ratio of juvenile Nile tilapia *Oreochromis niloticus* (Linnaeus) reared in geothermal waters in southern Tunisia. *Journal of thermal Biology*, 33(2): 98-105.
- Bahnasawy, M., Khidr, A. A., & Dheina, N. (2009). Seasonal variations of heavy metals concentrations in mullet, Mugil cephalus and Liza ramada (Mugilidae) from Lake Manzala, Egypt. Egyptian Journal of Aquatic Biology and Fisheries, 13(2): 81-100.
- Bilale, A. M., & Teklie., A. T. (2017). Evaluation of growth performance of Nile tilapia (*Oreochromis niloticus*, Linnaeus, 1752) with supplementary feeding of brewery waste in concrete ponds at Tehuledere district, Amhara Region, Ethiopia. International journal of fisheries and aquatic studies, 5(4): 295-299.
- Chi, M.S., Koh, E.T., & Stewart, T.J. (1982). Effects of garlic on lipid metabolism in rats fed cholesterol or lard. The Journal of Nutrition. 112 (2): 241-248.
- Dagne, A., Degefu, F., & Lakew, A. (2013). Comparative growth performance of mono-sex and mixed-sex Nile tilapia (*Oreochromis niloticus* L.) in pond culture system at Sebeta, Ethiopian. International Journal of Aquaculture, *3*.
- Ebeling, J. M., Timmons, M. B., & Bisogni, J.J. (2006). Analyse technique de la stoechiométrie de l'élimination photoautotrophe, autotrophe et hétérotrophe de l'azote ammoniacal dans les systèmes d'aquaculture. Aquaculture, 257: 346-358.
- El-Sayed, A-F. M., Ezzat, A., & Mansour, C. R. (2004). Nutritional requirements of red tilapia. Journal of Aquaculture in Tropics. 19 (3): 179-190.
- El-Sherif, M. S., & El-Feky, A. M. I. (2009). Performance of Nile tilapia (Oreochromis niloticus) fingerlings. I. Effect of pH. International Journal of Agriculture and Biology, 11(3): 297-300.
- FAO. (2024). In Brief to The State of World Fisheries and Aquaculture 2024. Blue Transformation in action. Rome. https://doi.org/10.4060/cd0690en
- Faruk, M. A. R.., Mausumi, M. I., Anka, I. Z., Hasan, M. M., &Mausumi, M. I. (2012). Effects of temperature on the egg production and growth of monosex Nile tilapia Oreochromis niloticus Fry. Bangladesh Research Publication Journal, 7: 367-377.
- Grace, H., Mones., Isagani, P., & Angeles Jr. (2017). Performance of Red tilapia (Oreochromis sp.) fed diet with fermented banana (Musa acuminata × balbisiana) peel at different stages of ripeness following Aeromonas hydrophila infection. International Journal of Agricultural Technology 13(7.1): 1041-1064.
- I.Megbowon, E. A., Ukenye, O. R., Oguntade, M. M. A., Akinwale, J. B., Joseph, B., Edah, A. B., Usman, B. A., Sokenu, R. O., & Adeleke, C. (2024). Individual and combined effects of moringa leaf, ginger and garlic powder on growth and innate immune response of *Clarias gariepinus* juveniles, Cogent Food & Agriculture, 10:1, 2328427, DOI: 10.1080/23311932.2024.2328427
- Jafarinejad, R., Gharaei, A., & Harijani, J. M. (2020). Dietary ginger improve growth performance, blood parameters, antioxidant capacity and gene expression in Cyprinus carpio. Iranian Journal of Fisheries Sciences, 19, 1237–1252. https://doi. org/10.22092/ijfs.2018.119876
- Lubembe, S. I., Okoth, S., Hounsounou, H. R. B., Turyasingura, B., Moenga, K. O., & Mwalughali, T. B. S. (2022). Is Aquaculture a Success? Evidence from Africa, East African Journal of Agriculture and Biotechnology, 5(1), 223-237. doi:10.37284/eajab.5.1.974.
- Malcolm, C., Beverdije, H., & McAndrew, B. (2000). Tilapias: biologie and exploitation. Institute of aquaculture. *University of stirling, Scotland. Kluwer Academic Publishers*, 185 p.
- Mirabent Casals, M., Toledo Pérez, S., Castro Ferrer, A., & Jaime Ceballos, B. (2020). Commercial Cuban feed evaluation for red tilapia (Oreochromis niloticus x O. mossambicus) fry culture in seawater. Revista de Producción Animal, 32(2). https://revistas.reduc.edu.cu/index.php/rpa/article/view/e3425
- Mohammadi, G., Rashidian, G., Hoseinifar, S. H., Naserabad, S.S., & Doan, V. H. (2020). Ginger (*Zingiber officinale*) extract affects growth performance, body composition, haematology, serum and mucosal immune parameters in common carp (*Cyprinus carpio*). Fish and Shell fish Immunology. 99: 267–273.

- Mohd Faudzi, N., Baru, D. D., Ching, F. F. & Senoo, S. 2024. Enhancement of growth performance and body coloration through the inclusion of torch ginger powder in the feed of red tilapia (*Oreochromis sp*). Malaysian Applied Biology, 53(1): 105-112. https://doi.org/10.55230/mabjournal.v53i1.2700
- Ndour, I., Le Loc'h, F., Thiaw, O. T., Ecoutin, J. M., Laë, R., Raffray, J., & de Morais, L. T. (2011). É tude du régime alimentaire de deux espèces de Cichlidae en situation contrastée dans un estuaire tropical inverse d'Afrique de l'Ouest (Casamance, Sénégal) Title: Study of the diet of two species of Cichlidae in contrasting situation in a West African (Casamance, Senegal) inverse tropical estuary. Journal des Sciences Halieutiques et Aquatiques, 4: 120-133.
- NRC. (2011). National Research Council. Nutrient requirements of fish. National Academy Press, Washington, DC.
- Nyadjeu P., Arreytabe D. J., Nkongho G.O., & Tomedi-Tabi M. E. (2023). Growth and Physiological responses of Juvenile African Catfish (Clarias gariepinus) Fed with Dietary Supplementation of Garlic -Ginger Mixture, International Journal of Fisheries and Aquaculture Research, 9, (2), 18-32. doi: https://doi.org/10.37745/ijfar.15/vol9n21832.
- Nyadjeu, P., Djopnang, J. D., Ndjuissi, N. A. T., Ayamba, A. E., Alim, H., & Tabi-Tomedi, M. E. (2021b). Replacing fishmeal with pretreated Lima bean improves growth, feed utilization, whole-body composition and nutrient retention in Nile-tilapia fingerlings. Journal of Applied Aquaculture, *34*(4), 922–937. https://doi.org/10.1080/10454438.2021.1910604
- Nyadjeu, P., Yemdjie, D. D. M., Ndjuissi, N. A. T., Nguenang, G. N., Dedou, N. Y. C. & Tabi-Tomedi, M. E. (2021a). Effect of *Zingiber officinale* and *Allium sativum* Powders as Natural Feed Additives Promoting Growth, Feed Utilization and Whole-Body Composition in *Clarias gariepinus* Fry. Food and Nutrition Sciences, 12, 526-543. https://doi.org/10.4236/fns.2021.126040
- Ofori, J. K. (2001). Effects of on-farm residues on pond water quality, productivity and fish growth in an aquaculture ecosystem in Ghana. PhD. Thesis. Kumasi, Department of Biological Sciences, Kwame Nkrumah University of Science & Technology. 182 pp.
- Rezaei, O., Mehrgan, M.S., & Paknejad, H. (2022). Dietary garlic (*Allium sativum*) powder improved zootechnical performance, digestive enzymes activity, and innate immunity in narrow-clawed crayfish (*Postantacus leptodactylus*). Aquaculture Report. 24: 101129.
- Samson, J. S. (2019). Effect of garlic (*Allium sativum*) supplemented diets on growth, feed utilization and survival of red tilapia (*Oreochromis* sp.). International Journal of Agricultural Technology 15(4): 637-644.
- Santos, E. L., Barbosa, J. M., Soares, E. C,. Lima, M. R., Ludke, J. V., Rabello, C. B-V., do Carmo, M., & Mohaupt, M. L. (2020). Evaluation of the addition of garlic powder in Nile tilapia ration (*Oreochromis niloticus*). Revista Desafios. 7-3.
- Suresh, V. (2003). Tilapias. In: Lucas, J.S. and Southgate, P.C., (Eds.) Aquaculture: Farming of Aquatic Animals and Plants, pp 321-345. Oxford, UK: Blackwell Publishing.
- Swann, L. (2007). A Fish Farmer's guide to understanding Water Quality.Aquaculture Network Information Centre (AquaNIC).
- Tran-Duy, A., Van Dam, A., & Schrama, J.W. (2012). Consommation alimentaire, croissance et métabolisme du tilapia du Nil (*Oreochromis niloticus*) en relation avec la concentration en oxygène dissous. Recherche en aquaculture, 43: 730-744.
- Yashin, A., Yashin, Y., Xia, X., & Nemzer, B. (2017). Antioxidant activity of spices and their impact on human health: A review. Antioxidants. 6 (70): 1–18.
- Yilmaz S,. & Ergün S (2012). Effects of garlic and ginger oils on hematological and biochemical variables of sea bass Dicentrarchus labrax. journal aquatic animal health, 24(4): 219224. https://doi.org/10.1080/08997659.2012.711266.

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