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Growth performance and condition factor of *Clarias gariepinus* fed *Psidium guajava* and *Mangifera indica* leaf extracts

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Abstract
The growth performance and condition factor of Clarias gariepinus fed Psidium guajava and Mangifera indica leaf extracts was assessed in this study. Experimental feed was formulated with 40% crude protein with Psidium guajava and Mangifera indica at 4%, 6%, and 8% for each extract with a control diet having no extract inclusion. Clarias gariepinus with initial body weight of 12.5 g and total length of 9 cm was allotted at 20 fish/tarpaulin tank measuring 4 m×4 m× 4 m in a complete randomized design for each treatment in triplicate. Body weight and length was measured biweekly, and the growth performance study was assessed with data on specific growth rate, weight gain, survival rate, food conversion ratio, protein efficiency ratio, and condition factor. The best weight was recorded in fish fed 4% Psidium guajava (T_2 - 441.41±10.48) while the least was recorded in fish fed 4% Mangifera indica (T_5 - 376.15±9.19).

Keywords: Aquaculture, experimental feed, leaf extract, growth

1. Introduction
Aquaculture which is a fast growing food sector where fish meal is a primary protein source in fish diet has become an important part of food security. Feeding in aquaculture is the most essential factor that must be regarded. Fish like other animals have a requirement for essential nutrients in order to grow properly (Olele, Onyema, and Odiko, 2013) [22]. High nutritional diet plays a vital role in health maintenance of fish. Feed formulation accounts for over 50% of total intensive aquaculture production costs, making it the biggest cost factor in aquaculture (Olusola and Olorunfemi, 2017) [23]. Sustainable aquaculture can be achieved with good and less expensive nutritional diet. Fish feed has been reported to have less supply than its demand (Abdelhamid, 2013) [2]. The importance of nutrition cannot be phased out in aquaculture because nutrient and energy sources are essential for growth, health, and reproduction of cultured fish (Shubha, 2017) [28]. Plants are natural sources of safe and cheap additives to fish feed (Samson, 2019) [27]. Plants as feed additives promote growth and stimulate immune system against diseases of cultured fish (Nwabueze, 2014 and Ekelemu, Akpotor, Eriegha and Munu-Komi 2022) [20, 7]. The World Health Organisation (WHO) encourages the use of medicinal herbs and plants to reduce the use of chemical and synthetic products as fish feed additives (Funda, Emre, and Ugras, 2016) [11]. The use of extract in producing highly nutritional fish feed has been reported as a way of curbing aquaculture environmental pollution, and also producing quality feed which will be highly consumed by fish and lead to improved growth (Olusola and Olorunfemi, 2017) [23].
Psidium guajava also called guava is used for many medicinal purposes even long before modern medicine recorded the specific chemical compounds in the plant. It is known for its antioxidant, antibacterial, and anti-inflammatory properties. Guava leaves have phenolic compounds and flavonoids with high antioxidant activity. *Mangifera indica* (Mango) leaf does not have commercial value, though it has been reported to possess antimicrobial, anti-inflammatory, antioxidant, and medicinal properties because of the various phytochemicals especially Tannin (Adu, Gbore, Oloruntola, Falowo and Olarotimi, 2020) [1].

The extracts from mango leaves (MLs) have been studied for their biological activities, including anti-cancer, anti-diabetic, anti-oxidant, anti-microbial, anti-obesity, lipid-lowering, hepato-protection, and anti-diarrheal (Batool, Ilyas, Shabir, Saeed, and Mazhar, 2018) [5].

C. gariepinus is a freshwater fish species of African origin and is one of the most cultured species in the world. This fish species is valuable for fish farming (aquaculture) due to the fact that it is easy to farm especially in warm climates and has fast growth rate, better resistant to diseases, and has high stocking density

Research has shown that *Psidium guajava* and *Mangifera indica* leave extract as plant immuno stimulants are used to promote growth and manage health, but information on the action of these plants in aquaculture is not adequately documented. There is need to source for means of producing high quality feed using natural plant extracts to increase fish yield, build immunity of the fish and make fish resistant to diseases without appreciably increasing cost of feed. The study focused on the growth performance and condition factor of *Clarias gariepinus* fed *Psidium guajava* and *Mangifera indica* dietary extracts.

2. Materials and Methods

2.1 Experimental site

This study was carried out in the Department of Fisheries and Aquaculture, Delta State University, Abraka. Abraka is located in the South-South zone of Nigeria. It is located in latitudes 05^0 47^1 and 05^0 50^1 North of the equator and longitudes 06^0 00^1 and 06^0 08^1 East of the Greenwich Meridian. It is situated at the Eastern bank of river Ethiope in Ethiope East Local Government Area of Delta State, Nigeria.

2.2 Duration of study

The feeding experiment lasted 6 months during which fish samples were fed to satiation, with experimental diet.

2.3 Collection and acclimatization of fish samples

Four hundred and twenty, 8 weeks old post fingerlings of pure hatchery bred *Clarias gariepinus* with average weight and length of 12.5 g and 9 cm respectively was purchased from Rex Agro farms, Asaba, Delta state, and used for this study.

2.4 Tank preparation

Twenty 0ne tarpaulin tanks measuring 4 × 4 × 4 feet were constructed with wooden fame work, filled with water, and cured using poultry droppings which were bagged and dropped into the tanks, to reduce the lime content in the water. After 8days the bags of poultry droppings were removed, and the tanks were washed with salt and filled with clean water.

2.5 Collection and processing of leaves

Fresh leaves of *Psidium guajava* and *Mangifera indica* were obtained from Dennis Osadebey University, Asaba, and Delta state. Aqueous extract was used in extracting *Psidium guajava* and *mangifera indica* plant according to Keta, Suberu, Shehu, Yahayya, Mohammad and Gudu (2019) [17]. Both plants were plucked fresh, removed from the stem, thoroughly washed with running water and rinsed in distilled water to remove dirt. Twenty five gram (25 g) of each plant was measured using an electric top loading balance, SF-400C with the leaves in a beaker. This was pounded in a laboratory mortar and further crushed in 500 ml distilled water using an electric blender. The blended mixture was filtered through Whattman No 22 filter paper placed on a Buckner funnel to avoid any contamination. The filtrate was poured in a can and refrigerated till when it was needed for compounding the feed.

2.6 Experimental diet

Feed with 40% crude protein was formulated for this experiment using Pearson's square method (Lukram, 2020) [16]. *Psidium guajava* and *mangifera indica* extract was included at varying levels of 0%, 4%, 6%, 8% each, after which, it was mixed thoroughly alongside other ground and measured ingredients and extruded with an extruding machine to produce floating feed. Feeds were extruded in sizes, ranging from 2 mm to 6 mm for the purpose of this study. The extruded diets were sun-dried, packed in 50kg sack bags and labelled, T_1 (0%), T_2 (Guava 4%), T_3 (Guava 6%), T4 (Guava 8%), T_5 (Mango 4%), T_6 (Mango 6%), T7 (Mango 8%) and stored in a cool and dry place.

Table 1: Feed formulation (g/100 g) of Psidium guajava and Mangifera indica at various inclusion levels

Control		PGLE			MILE		
Ingredients	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**
Fish Meal	33.93	33.93	33.93	33.93	33.93	33.93	33.93
GNC	16.97	16.97	16.97	16.97	16.97	16.97	16.97
Yellow Maize	31.10	31.10	31.10	31.10	31.10	31.10	31.10
Vitamin Premix	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Palm Oil	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Salt	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Starch	7.55	7.55	7.55	7.55	7.55	7.55	7.55
BHT/BHA	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Chromic Trioxide	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	100	100	100	100	100	100	100
Psidium Guajava	-	4.0	6.0	8.0	-	-	-
Mangifera Indica	-	-	-	-	4.0	6.0	8.0

PGLE-*Psidium guajava* leaf extract
MILE-*Mangifera indica* leaf extract
T_1-T_7-Treatment 1-7
GNC-Groundnut cake
BHT/BHA- Butylated hydroxytoluene/butylated hydroxyanisole

2.7 Experimentation

The experiment was a complete randomized block design (CRDB) where 420 fish samples were randomly distributed in twenties into 21 tarpaulin tanks, measuring 4 × 4 × 4 feet each half filled with clean borehole water. These tanks were distributed in threes to form 7 treatments in triplicates labeled $T_{1\ A-C}$, $T_{2\ A-C}$, $T_{3\ A-C}$, $T4_{\ A-C}$, $T5_{\ A-C}$, $T_{6\ A-C}$ and $T_{7\ A-C}$, where T1 was the control, T_2 -T_4 was fed 4%, 6%, 8% *Psidium guajava* and T_5-T_7 was fed 4%, 6%, 8% of *mangifera indica*. Pond water was renewed bi-weekly and was half renewed by reducing the water halfway and topping up.

2.8 Morphometric measurement

The weight and length of fish was measured biweekly with calibrated meter rule and a measuring scale respectively. Length and weight measurement were used as indices of growth such as specific growth rate (SGR), weight gain (WG), survival rate (SR), feed conversion ratio (FCR), protein efficiency ratio (PER), condition factor were calculated:

Specific growth rate (SGR)

$$\frac{\text{Ln (final weight)} - \text{ln (initial weight)}}{\text{Time interval in days /days of feeding}} \times 100$$

Halver (1972) [13]

Weight gain (WG)

Final weight-initial weight

Halver (1972) [13]

Survival rate (SR)

$$\frac{\text{No of fish at the end of the experiment}}{\text{No of fish at the beginning of experiment}} \times 100$$

Halver (1972) [13]

Feed conversion ratio (FCR)

$$\frac{\text{Weight of feed given}}{\text{Weight gain of fish}}$$

Halver (1972) [13]

Protein efficiency ratio (PER)

$$\frac{\text{Weight of fish}}{\text{Protein feed}} \quad \frac{\text{(percentage of protein in diet} \times \text{total diet consumed feed)}}{100}$$

Hamid (2009) [14]

Condition factor (K)

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

Where;
W= Weight of fish in g
L= Length of fish in cm
Froese (2006) [10]

2.9 Water parameter

Water samples were collected on the days of sampling and water renewal which was bi weekly, between the hours of 7.00am-8.00am. Water samples were collected with a 250 mL sampling bottles from the various experimental tanks (T_1-T_7). Water samples were analysed according to Parra *et al*., (2018) [25] the pH was measured with a pH meter, model PHS-25, techmel and techmel USA, temperature was measured with mercury in glass thermometer, the dissolved oxygen was determined using the Winkler technique.

2.10 Statistical Analysis

All data obtained from the experiment were subjected to descriptive statistics and one way analysis of variance (ANOVA) and Duncan's multiple range test was used to separate means at a significant level of $p<0.05$ (Duncan, 1955) [6], with the aid of IBM statistical package (SPSS) version 22.

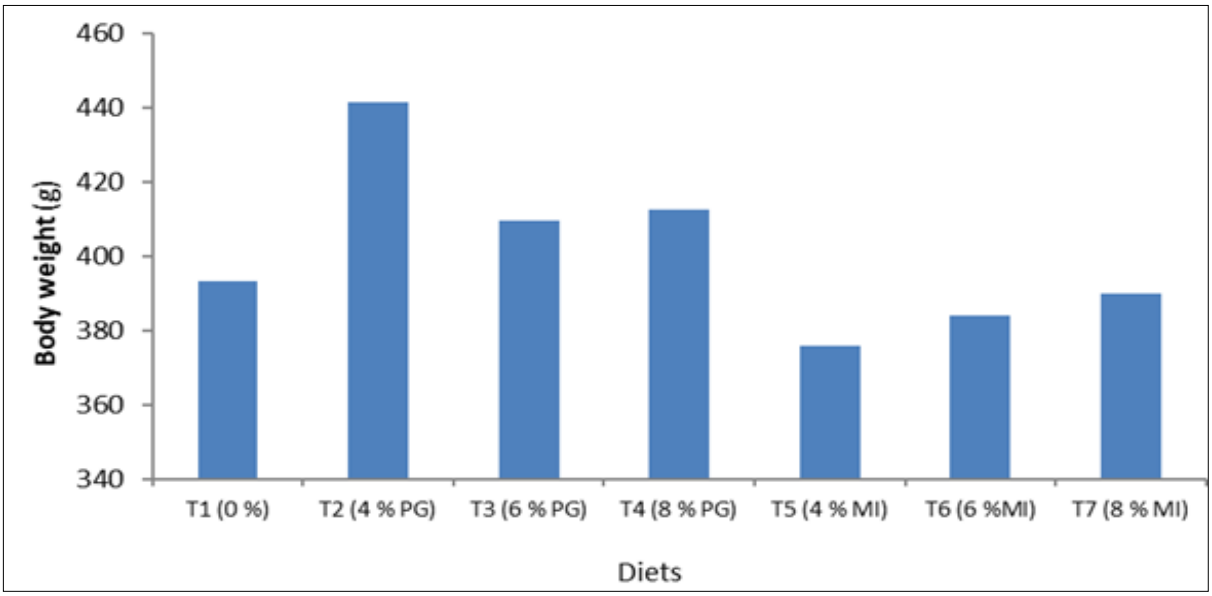
The fish fed supplemented diets had better weight gain than those fed control diet, which could be as result of the presence of growth stimulants or constituents in the M. oleifera and P. guajava leaves as reported by Akinyeye *et al*. (2014). These phytochemical properties could contribute to improving the digestion and nutrient absorption with a subsequent increase in the fish-weight. This result is in agreement with the report of Bello *et al*. (2012a) who obtained high growth performance in C. gariepinus with 1.5% walnut leaves and onion bulb extracts as well as that of Shalaby *et al*. (2006), who obtained the highest growth performance in O. Niloticus with 3

3. Results

3.1 Effect of *Psidium guajava* and *Mangifera indica* diets on mean body weight of *Clarias gariepinus*.

The effect of *Psidium guajava* and *Mangifera indica* on mean body weight of *Clarias gariepinus* is shown in Figure 1. Body weight was significantly different amongst the treatments at $p<0.05$. The highest mean body weight was recorded in T_2 (4% PG) as $441.41g \pm 10.48^a$, which was higher than other treatments. This was followed by T_4 (8% PG) with mean body weight of $412.74g \pm 9.87^b$ which was not significantly different from mean body weight recorded in T_3 (6% PG) as $409.84g \pm 9.53^b$.

The least mean body weight was recorded in T_5 (4% MI) as $376.15g \pm 9.19^c$ and this was not significantly different from T_1, T_6, and T_7 which had $393.43g \pm 9.75^c$, $383.99g \pm 8.76^c$, $389.92g \pm 9.62^c$ respectively. Also, the ANOVA for the variation in body weight with experimental diets is presented in Table 2.



Key: PG (*Psidium guajava*), MI-(*Mangifera indica*), T_1 (control), T_2-T_7 (treatments).

Fig 1: Variations in Body Weight with experimental diets

Table 2: ANOVA for the variation in body weight with experimental diets

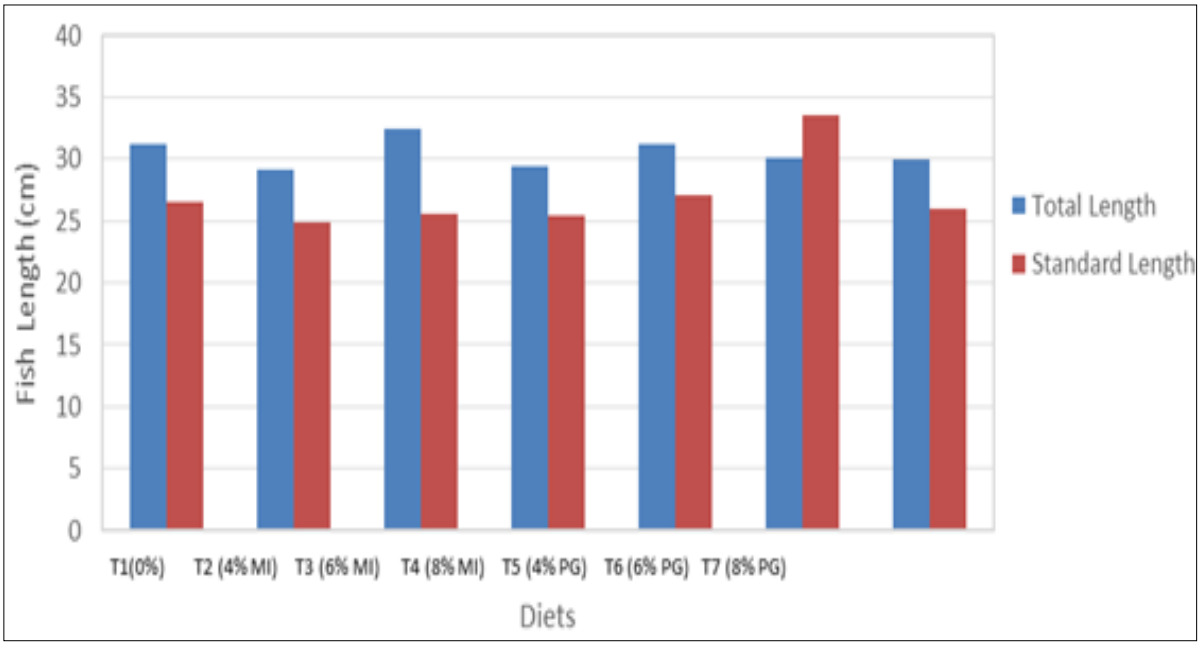
			PGLE			MILE	
Parameters	**T_1 (0%)**	**T_2 (PG 4%)**	**T_3 (PG 6%)**	**T_4 (PG 8%)**	**T_5 (MI 4%)**	**T_6 (MI 6%)**	**T_7 (MI 8%)**
Body weight(g)	393.43 ± 9.75^{c}	441.47 ± 10.48^{a}	409.84 ± 9.53^{b}	412.74 ± 9.87^{b}	376.15 ± 9.19^{c}	383.99 ± 8.76^{c}	389.92 ± 9.62^{c}
Standard length(cm)	26.49 ± 0.32^{b}	27.09 ± 0.38^{b}	33.61 ± 4.35^{a}	26.05 ± 0.38^{b}	24.95 ± 0.37^{b}	25.58 ± 0.37^{b}	25.39 ± 0.38^{b}
Total length(cm)	31.19 ± 0.55^{a}	31.18 ± 0.42^{a}	30.09 ± 0.41^{b}	30.03 ± 0.41^{b}	29.12 ± 0.40^{b}	32.46 ± 2.71^{a}	29.39 ± 0.41^{b}

PGLE: Psidium guajava leaf extract
MILE: Mangifera indica leaf extract

3.2 Effect of *Psidium guajava* and *Mangifera indica* on mean standard length and total length of *Clarias gariepinus*

The effect of *Psidium guajava* (PG) and *Mangifera indica* (MI) on mean standard length and total length of *Clarias gariepinus* is show in Figure 2. The highest mean standard length was 33.61 ± 4.35^{a} cm recorded in T6 (6% PG) and this was significantly different from other treatments having the following results 26.49 ± 0.32^{b} cm (T_1 - 0%), 24.95 ± 0.37^{b} cm (T_5 - 4% MI), 25.58 ± 0.37^{b} cm (T_6 - 6% MI), 25.39 ± 0.38^{b} cm (T_7 - 8% MI), 27.09 ± 0.38^{b} cm (T_2 - 4% PG), and 26.05 ± 0.38^{b} cm (T_4 - 8% PG).

The total length recorded in this study revealed the highest to be 32.46 cm in T_3 which was not significantly different from T_1 (31.19 ± 0.55^{a} cm), T_2 (31.18 ± 0.42^{a}cm), but significantly different from T5 (29.12 ± 0.40^{a} cm), T_7 (29.39 ± 0.41^{a} cm), T_3 (30.09 ± 0.41^{a} cm), and T_4 (30.03 ± 0.41^{a} cm).



Key: PG (Psidium guajava), MI-(Mangifera indica), T_1 (control), T_2-T_7 (treatments)

Fig 2: Variations in Total length and Standard length with diets

3.3 Growth performance indices of *Clarias gariepinus*

Table 3 shows that the highest Specific growth rate (SGR) value was 4.38 recorded in T_5 while the least was recorded in T_2 with the value, 2.33.

The highest mean weight gain (WG) was recorded in T_5 (431 g), followed by T_7 (402), and the least value was recorded in T_2 (365 g).

The survival rate varied amongst treatments and the rate of mortality was minimal in all treatments. There was 100% survival rate for *Clarias gariepinus* at T_6 and T_7 respectively while the least survival rate was recorded in T_2 (70%).

Data obtained at the end of the experiment showed that the highest feed conversion ratio (FCR) was recorded in T_3 (1.04) while T_5 (1.02) recorded the least value.

Values recorded showed that the highest performance efficiency ratio (PER) was obtained in T5 (11.03) and the least value obtained in T_2 (9.40), T_1, 2, 4, 6, and 7 recorded 1.03 as FCR. The condition factor (K) of the fish samples in various treatments had values greater than 1 which indicates a good level of feeding and appropriate environmental state.

Table 3: Mean of growth performance studies of *Clarias gariepinus* fed *Psidium guajava* and *Mangifera indica*

	SGR	WG	SR	FCR	PER	K
T1 (0%)	3.30	383	85	1.03	9.83	2.12
T2 (PG 4%)	4.38	431	90	1.02	11.03	2.22
T3 (PG 6%)	3.25	399	100	1.03	10.23	1.08
T4 (PG 8%)	3.83	402	100	1.03	10.30	2.33
T5 (MI 4%)	2.33	365	70	1.03	9.40	2.42
T6 (MI 6%)	3.28	369	80	1.04	9.58	2.29
T7 (MI 8%)	3.22	376	90	1.03	9.73	2.38

Percentage means value from each treatment

Key: T-Treatment, PG-*Psidium guajava,* MI-*Mangifera indica*, SGR-Specific Growth Rate, WG-Weight Gain, SR-Survival Rate, FCR-Feed Conversion Ratio, PER-Protein Efficiency Ratio, K-Condition Factor.

3.4 Water quality

The water quality parameters as affected by varying levels of the leaf extract is presented in Table 4. The result showed that the temperature varied between 26.00 °C-29.05 °C, dissolved oxygen was between 5.8-7.4 mg/l and pH varied between 5.7-8.0 throughout the duration of this research. The leaf extracts, however, did not have a negative effect on the quality of the water as all parameters checked were in the normal range for fish production.

Table 4: Water quality parameters

Parameters	T_1 (control)	T_2 (PG 4%)	T_3 (PG 6%)	T_4 (PG 8%)	T_5 (MI 4%)	T_6 (MI 6%)	T_7 (MI 8%)
Temperature ^{0}C	26.00	29.05	28.51	28.57	29.00	27.01	27.00
Dissolved oxygen (mg/l)	6.03	7.4	6.2	7.2	6.1	7.3	5.8
pH	6.00	8.01	6.80	6.71	7.00	6.60	5.7

T_1-T_7- Treatment 1-7

4. Discussion

The mean body weight of *Clarias gariepinus* fed *Psidium guajava* and *Mangifera indica* shows the highest significant body weight to be Treatment 2 (4% PG) - 441.41g and the least mean body weight was recorded in Treatment 5 (4% MI) - 376.15g. This means that the leaf extract of *Psidium guajava* performed better than that of *Mangifera indica.* Result of this study however disagrees with that of Jannatul *et al*., (2017) [15] who reported that tilapia fish fed 8% *P. guajava* leaf extracts showed better growth rate compared to 2%, 4%, and 6%. This may be because of the different fish species been studied. This present study agrees with Omitoyin *et al*., (2019) [24] who reported increased body weight of *Oreochromis niloticus* fed *Psidium guajava* though at 1% inclusion. Giri, Sen, Chi, Kim, Yun, Park, Sukumaran (2015) [22] reported that dietary supplementation with guava leaves (at 0.5% concentration) can promote growth performance and build up the immunity of *L. Rohita*. Guava leaves therefore represent a promising feed additive for carps in aquaculture. This present study revealed that fish fed with leaf extract performed better than the fish fed with no leaf extract which could be as a result of the growth stimulant present in the leaf extract. Also the phytochemicals present in the leaf could also be a contributing factor to improving the nutrient absorption and digestion of feed by the fish which results in corresponding increase in fish weight. Olaniyi, Ajani, and Adetomi (2013) stated that 12.5% *Moringa oleifera* leaf meal is potent in the diet of *Clarias gariepinus* because of the fact that it had a significant growth rate on *Clarias gariepinus*, as well as the best feed conversion rate and specific growth rate. Maroh and Ekelemu (2016) [19] reported a significant increase in weight of *Clarias gariepinus* fish fed 10g inclusion of *Ocimum gratissimum* compared to other treatments, stating also that an increment in the quantity of *Ocimum gratissimum* will deter the growth of *C. gariepinus,* also that there was a significant increase in length of fish fed 10g inclusion of *O. gratissimum* compared to other treatments. Nwabueze *et al*., (2020) [21] revealed that 3% inclusion of *Allium sativum* in *C. gariepinus* diet, promoted the highest growth rate whereas this present study reported 4% *P. guajava* inclusion as best for *C. gariepinus* fish growth. Attalla *et al*., (2021) [4] reported 2% inclusion of *Psidium guajava* and 1% mulberry as best for tilapia growth as it resulted to best body weight, though this does not agree to this present study. Several authors have dealt with immunity and fish nutrition in the past, suggesting that the nutritional status of fish is very important to determine the ability of fish to resist disease. So, there is a clear need for a proper and rich diet to improve health and to curb or prevent outbreaks of disease in fish also the proper dosage to administer for effective positive growth performance. The use of medicinal plants as natural growth promoters have been proven to significantly improve weight gain, survival and feed conversion rates in fish by about 50%.

The result from the study revealed that all fish samples from each treatment had a condition factor greater than 1 and this

met the criteria recommended by Sadauki *et al.*, (2023) [26], who also stated that a condition factor higher than or equal to 1 signifies a good level of feeding and appropriate environmental state. Ekelemu, Irabor and Anderson (2023) [8], and Maroh and Ekelemu (2016) [19] reported lower values of less than 1 for condition factor. The K factor value recorded in this study, had values ranging from 1.08-2.42 which is highly commendable for this study. This means that fish samples in this study were properly fed and had a stable environment which affected them positively. According to Kumolu-Johnson and Ndimele (2010) [18], condition factor is a useful index in monitoring the feeding intensity, maturity and age rate in fish and this is highly influenced by living and non-living environmental factors which can also be used to assess the fish habitat. Afolabi, Oladele, and olususi (2020) [3] also stated that the value of condition factor of fish is used to determine the physiological state of the fish and to know the health condition of the fish in the water. Suleiman and Solomon (2017) [29] reported 2.13-2.52 K value of *Clarias gariepinus* also reared in tanks which agrees with the K value from this study. Generally, the variations in condition factor of fish may likely be due to type/abundance of food and environmental adaptation.

Psidium guajava and *Mangifera indica* leaf extracts had no negative effect on tempeatue, dissolved oxygen and pH of water.

5. Conclusion

Psisium guajava leaf extract had a substantial effect on the weight gain and survival rate of the experimental fish, according to the findings. Conclusively, the 4% *Psidium guajava* leaf extract inclusion in fish feed boost fish growth when compared with *Mangifera indica*.

6. Acknowledgements

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