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Effect of Mahogany Bark Extract on Growth, Feed Utilization and Proximate Composition in Catfish (*Clarias gariepinus*)

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ABSTRACT

This study assessed the impact of mahogany bark extract in the diets of catfish (*Clarias gariepinus*) fingerlings. The effects of four diets supplemented with mahogany bark extracts on growth performance, feed utilization and proximate composition was evaluated. Four diets were prepared using mahogany bark extract as a supplement at 0ml (Trt 0), 10ml (Trt 1), 20ml (Trt 2) and 30ml (Trt 3) per 100g of feed. One hundred fingerlings of *Clarias gariepinus* with initial weight of 1.25g were stocked in four treatments with a replicate each in 60 litre bowls at 20 fingerlings per bowl. The results showed a significant difference amongst the four treatments with respect to final weight, weight gain, daily weight gain, condition factor, feed conversion ratio and specific growth rate ($P<0.05$). It was observed that the least value for feed intake occurred in fish fed diet Trt 3. Group fed diet supplemented with 20 ml mahogany bark extract (Trt 2) was significantly higher in final weight (26.10±0.88), weight gain (24.77±0.88), daily weight gain (1855±66.20) and specific growth rate (3.26±0.03) and also lower at feed conversion ratio (1.26±0.04). This study therefore recommends 20ml mahogany bark extract (Trt 2) per 100g of feed as appropriate supplement for *Clarias gariepinus* diets.

Introduction

The demand for fish is increasing globally due to the popularity of its dietary value (Yaakob *et al*., 2014). Intensification of aquaculture to meet the global demands of sea foods has resulted in an increased occurrence of diseases and low survival of fish (Sukumaran *et al*., 2016).

Antibiotics have been traditionally used to treat diseases and have been reported to improve growth and disease resistance of fish (Alderman and Hastings, 1998; Rashidian *et al*., 2018).

However, the use of antibiotics in aquaculture has negative impacts on the fish, the aquatic environment and human health (Terzi and Isler, 2019). This has resulted in calls for safe and cost-effective alternatives.

Medicinal plants are considered suitable alternatives to antibiotics because they are cheap or cost-effective, environmentally friendly, and natural; hence they have been widely used in aquaculture production (Abdel Rahman *et al*., 2018; Kaleo *et al*., 2019). These plants could be applied in aquaculture as either parts (seed, fruit, leaf, or root) or as a whole and could also be applied in its fresh state or as extracts (Reverter *et al*., 2017).

Bioactive compounds existing in numerous plants are used in animal nutrition to influence feed intake, increase secretion of digestive enzyme, and trigger immune responses. These plants are also recognized to have antibacterial, antioxidant and antiviral properties (Citarasu, 2010). In aquaculture many herbs are included in the fish diet to cure diseases, promote growth, reduce stress, stimulate appetite, boost immunity, and prevent infections in culturing healthy fishes (Shakya, 2017).

Mahogany (*Meliaceae*), one of such plants comprises more than fifty genera with about 1400 species (Oyedeji *et al*., 2020) which is distributed in tropical and subtropical regions. Many species of this family were utilized in traditional drugs for treatment of numerous diseases and additionally in pest control (Coll *et al*., 2010).

The objective of the study was to examine the growth rate, feed utilization and proximate composition of catfish, fed with varying inclusion levels of mahogany bark extract.

Materials and methods

Preparation of Extract

The neem extract was prepared according to protocols as

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previously described by Cross *et al*. (2004) with modifications. The bark of mahogany was freshly harvested, cut into pieces and washed with distilled water. 500g of mahogany bark was grounded into fine particles and mixed with 500ml of distilled water (1:1) for the extraction. A separating funnel was used to separate the extract. The liquid extract was stored in a refrigerator in airtight plastic container until uses.

Formulation of Diets with Extract

Commercial diet for Catfish was purchased from Ranaan Feeds. Except the control which had no mahogany bark extract, 10ml, 20ml, and 30ml of the extract was added to 100g of the commercial diet (Trt 0, Trt1, Trt 2, and Trt 3). Table 1 shows proximate composition of the commercial diet.

Experimental Fish and Design

One hundred catfish fingerlings were purchased from Pilot Aquaculture Centre (PAC) Kumasi in the Ashanti region. The fish was stocked into two 60-L tanks and fed a commercial diet purchased from Raanan feed twice daily for two weeks to adapt them to the experimental facilities and conditions.
The experiment was conducted in triplicates in four (4) treatments. Fish were stocked at20 fish per tank and fish fed their respective diets to apparent satiation four times a day (9:00am, 12:00am, 2:00am and 4:00pm) for eight weeks (2 months).

Table 1. Proximate composition of the commercial diet purchased.

Nutrient	Percentage (%)
Protein	48
Fat	7
Fiber	2.5
Ash	12.5
Phosphorus	1.3
Lysine	1.5
Meth. + Cyst.	1.7
Calcium	1.7
Vitamins (added)	
Vitamin A	18000 IU/kg
Vitamin E	240 IU/kg
Vitamin C	600 mg/kg

Ethical statement

The standard operation procedure of the guide for the use of animals for research of University for Development Studies was used for this study. To minimize suffering and stress, fish were anesthetized with excess tricaine methane sulfonate (MS-222 at 200mg/L) before sampling.

Data Collection and Analysis

Growth and feed utilization

The weight of individual fish was taken with an electronic scale. Standard Length was taken with a measuring board. Growth performance and feed utilization parameters were determined as follows.
Weight gain (WG) = FW (g) - IW (g). FW and IW stand for the final weight and initial weight, respectively.
Specific growth rate (SGR) (%) = (ln FW (g) - ln IW) (g) /T × 100. T stands for total number of culture days
Condition factor (C) = [BW/TL 3] × 100%. BW and TL stands for body weight (g) and total length (cm) respectively
Feed intake (FI) is the total feed consumed (g) during the 56 days trial.
Feed conversion ratio (FCR) = FI (g)/WG (g)
% Weight gain = (final weight – initial weight)/ initial weight
Feed efficiency = fish weight gain (g) /total feed intake
Protein efficiency ratio = weight gain/ protein intake

Proximate composition

Moisture, ash, crude lipid, and protein were analyzed following standard methods of AOAC (2003). Samples were dried in an oven at 105 °C to a constant weight to determine moisture. Ash content was determined by incinerating samples in a muffle furnace at 550 °C for 12 h. the Crude protein content was analyzed using the Kjeldahl method. Nitrogen content was determined and subsequently multiplied by 6.25. Values are expressed as% dry weight. The Folch *et al*. (1957) method was used to analyze crude lipid content.

Statistical Analysis

Data was subjected to one-way analysis of variance (ANOVA) and the Tukey's multiple comparison used to test for the means at a significance level ($P<0.05$). The statistical package used for the analysis was the Graph Pad Prism V.5.03. The results are presented as mean ± SE (standard error).

Results

Growth Performance

The effects of the experimental diets on growth of *C. gariepinus* are shown in Table 2. The results showed significant difference in final weight (FW), weight gain (WG), percent weight gain (%WG), daily weight gain (DWG) and specific growth rate (SGR) ($P<0.05$).

Table 2. Growth performance of *Clarias gariepinus* fed diets supplemented with Mahogany bark extract.

Parameters	Trt 0	Trt 1	Trt 2	Trt 3	P-Value
Initial weight (g)	1.18±0.05	1.14±0.12	1.33±0.23	1.32±0.17	-
Final length(cm)	11.43±0.09	12.33±0.20	14.52±0.09	10.25±0.65	< 0.0873
Final weight (g)	14.21 ± 0.15^{a}	14.50 ± 0.15^{ab}	26.10 ± 0.88^{c}	15.15 ± 0.55^{b}	< 0.0001
Weight gain (g)	13.03 ± 0.15^{a}	13.36 ± 0.15^{ab}	24.77 ± 0.88^{c}	13.83 ± 0.55^{b}	< 0.0001
% Weight gain	1099 ± 13.01^{a}	1172 ± 13.40^{abc}	1855 ± 66.20^{b}	1043 ± 41.51^{c}	< 0.0001
Daily weight gain (g)	0.23 ± 0.00^{a}	0.24 ± 0.00^{abc}	0.44 ± 0.02^{b}	0.25 ± 0.01^{c}	< 0.0001
Specific growth rate (%)	2.65 ± 0.01^{a}	2.67 ± 0.01^{abc}	3.26 ± 0.03^{b}	2.71 ± 0.04^{c}	< 0.0001

Mean with the same letter in the same row is significantly different ($p<0.05$). Trt: Treatment; Mahogany bark extract supplemented at 0ml (Trt 0), 10ml (Trt 1), 20ml (Trt 2) and 30ml (Trt 3) per 100g of feed.

Final Weight

The effect of feeding *C. gariepinus* with mahogany bark extract on final weight is shown in Table 2. Mahogany extract levels had significant effect on final weight (P<0.05). Final weight (26.10±0.88) in Trt 2 (was significantly higher than Trt 0 (14.21±0.15), Trt 1 (14.50±0.15) and Trt 3 (15.15±0.55).

Final Length

Final length recorded in this study ranged between 10.25 and 14.52. Fish fed with Trt 2 diets recorded non-significantly higher value (14.52±0.09) than the other treatments (P>0.05) .

Weight Gain

Weight gain was significantly different amongst treatments (P<0.05). Fish fed with Trt 2 recorded the highest weight gain (24.77±0.88) and was significantly higher than fish fed Trt 0 (13.03±0.15), Trt 1 (13.36±0.15) and Trt 3 (13.83±0.55).

Daily Weight Gain

Daily weight gain was significantly influenced by the four experimental diets (P<0.05). Comparatively, fish fed Trt 0 (0.23±0.00) had a lower daily weight gain whilst the highest was recorded in group fed diet with Trt 2 (0.44±0.02). Groups fed diets Trt 1 and Trt 3 recorded daily weight gain of 0.24±0.00 and 0.25±0.01, respectively.

Percentage Weight Gain

Group fed diets Trt 2 recorded the highest percentage weight gain (1855±66.20) and was significantly higher than the other treatments (P<0.05). The least percentage weight gain (1043±41.51) was recorded in Trt 3. Groups Trt 0 and Trt 1 recorded percentage weight gain of 1099±13.01 and 1172±13.40 respectively.

Specific Growth Rate

Specific growth rate recorded in this study ranged between 2.65 to 3.26. Group Trt 0 recorded the lowest value (2.65±0.01) whilst Trt 1, Trt 2 and Trt 3 recorded SGR of 2.67±0.01, 3.26±0.03 and 2.71±0.03 respectively. There was significant different amongst the treatments (P<0.05).

Condition Factor and Feed Utilization

Table 3 shows condition factor and feed utilization parameters observed after 8 weeks of feeding.

Condition Factor

Supplementing catfish diets with mahogany bark extract significantly affected condition factor (P<0.05). The highest condition factor (1.43±0.21) was recorded in Trt 3 and the least (0.78±0.03) recorded in Trt 2. There was a significant difference among the four treatments (P<0.05).

Feed Conversion Ratio

Feed conversion ratio from recorded in this study ranged between 1.51±0.06 and 2.30±0.09. Feed conversion ratio of fish fed Trt 0 was significantly higher than Trt 1, Trt 2 and Trt 3. There was significant difference among the four treatments.

Feed intake

There was significant difference in feed intake amongst groups. Feed intake was lower in group fed diet Trt 3 whilst the highest was recorded in group fed diet Trt 0. Feed intake recorded ranged between 20.8 and 32.6.

Protein intake

Different levels of mahogany bark extract significantly influenced protein intake (P<0.05). The least protein intake (8.32±1.46) was recorded in group fed diet Trt 3 and was significantly lower that groups fed diet Trt 2 (12.41±1.05) and Trt 0 (13.04±1.14). Group fed diet Trt 3 was however non-significantly lower than group fed diet Trt 1 (8.73±1.33).

Protein efficiency ratio (PER)

Protein efficiency ratio ranged between 0.99±0.13 to 1.99±0.17 and was significantly influenced by different levels of mahogany bark extract. The highest PER (1.99±0.17) was recorded in group fed diet Trt 2 whilst the least (0.99±0.13) was recorded in group fed diet Trt 0. Groups fed diets Trt 1 and Trt 3 recorded PER of 1.53±0.21 and 1.66±0.24 respectively.

Table 3. Condition factor and feed utilization of *C. gariepinus* after 60 days of feeding diets supplemented with Mahogany bark extract.

Parameters	Trt 0	Trt 1	Trt 2	Trt 3	P-Value
Condition factor	0.95 ± 0.03^{abc}	0.78 ± 0.04^{a}	0.85 ± 0.04^{b}	1.43 ± 0.22^{c}	0.0006
Feed conversion ratio	2.30 ± 0.09^{d}	1.64 ± 0.02^{c}	1.26 ± 0.04^{a}	1.51 ± 0.06^{b}	< 0.0001
Feed intake (g)	32.6 ± 2.45^{c}	21.84 ± 1.94^{a}	31.04 ± 3.05^{b}	20.80 ± 2.41^{a}	0.0057
Protein intake	13.04 ± 1.14^{c}	8.73 ± 1.33^{a}	12.41 ± 1.05^{b}	8.32 ± 1.46^{a}	0.0072
PER	0.99 ± 0.13^{a}	1.53 ± 0.21^{b}	1.99 ± 0.17^{d}	1.66 ± 0.24^{c}	0.0004

Mean with the same letter in the same row is significantly different (p<0.05). PER: Protein Efficiency Ratio. Trt: Treatment; Mahogany bark extract supplemented at 0ml (Trt 0), 10ml (Trt 1), 20ml (Trt 2) and 30ml (Trt 3) per 100g of feed.

Table 4. Proximate composition of *C. gariepinus* fed diets with different levels of mahogany bark extract.

Parameters	Trt 0	Trt 1	Trt 2	Trt 3	P-Value
Protein	58.96±2.18	58.94±4.07	58.88±4.39	58.47±3.16	0.2184
Lipid	19.59 ± 3.19^{a}	21.53 ± 2.15^{b}	21.73 ± 2.27^{b}	21.72 ± 1.89^{b}	0.0271
Ash	19.25 ± 1.07^{b}	18.90 ± 1.49^{a}	18.97 ± 2.13^{a}	18.92 ± 1.48^{a}	0.0327
Moisture	74.63 ± 2.19^{b}	73.93 ± 2.24^{a}	73.86 ± 2.77^{a}	73.89 ± 3.08^{a}	0.0235

Mean with the same letter in the same row is significantly different (p<0.05). Trt: Treatment; Mahogany bark extract supplemented at 0ml (Trt 0), 10ml (Trt 1), 20ml (Trt 2) and 30ml (Trt 3) per 100g of feed.

Proximate composition

The effects of mahogany bark extract on proximate composition of *C. gariepinus* are shown in Table 4. Moisture content was significantly altered by different levels of mahogany bark extract ($p<0.05$) Group fed Trt 0 recorded the highest moisture content (74.63±2.19) and was significantly higher than all other groups.

There was no significant difference in protein content of fish fed different levels of mahogany bark extract. There was however, a decrease in protein content and mahogany bark extract increased in diets. Protein content ranged between 58.47±3.16-58.96±2.18. Ash content was significantly different among treatments ($p<0.05$). The highest ash content was recorded in group fed diet Trt 0 whilst the least was observed in group fed diet Trt 3.

Lipid content ranged between 19.59±3.19 and 21.73±2.27. Group fed diet Trt was significantly higher that group fed diet Trt 0.

Discussion

The aim of this study was to evaluate the effects of mahogany bark extract as supplements in diets of *C. gariepinus*. The potential use of feed additives in fish feed are evaluated by two important parameters; growth performance and feed conversion (Hoseinifar *et al*., 2018; Rashidian *et al*., 2018). The study showed that increasing mahogany bark extract in diets of *C. gariepinus* affected the final body weight, weight gain and specific growth rate of *C. gariepinus* significantly. The result of the study revealed that mahogany bark extract can be used as a supplement to enhance the positive effect of *C. gariepinus* growth and is in agreement to previous studies, which reported improved growth when plant extracts were used as supplements in diets of fish (Giri *et al*., 2015; El-Mesallamy *et al*., 2015; Sun *et al*., 2018). Also, other studies have reported improved growth performance when different plant extracts were added to fish diets (Abdel-Tawwab *et al*., 2010; Ahmad and Abdel-Tawwab, 2011; Abdel-Tawwab, 2012; Abdel-Tawwab and Abbass, 2017; Adeshina *et al*., 2017; Abdel-Tawwab *et al*., 2018). The result of this study is however in contrast to previous study by Jiang *et al*. (2012) and Xu *et al*. (2015). Differences in plant species use, animal species (fish), plant extract component as well as amount of plant extract applied could be the reason for variation in results as shown above (Motamedi-Tehrani *et al*., 2016).

FCR observed in this study was significantly altered by different levels of mahogany bark extract. This agrees to previous reports (Munglue, 2014). The result is however contrary to other reports (Bohlouli *et al*., 2016; Bohlouli and Sadeghi, 2016), which reported no significant difference in FCR when plant extracts were used as feed additives.

There was no significant difference in condition factor when common carp (*Cyprinus carpio*) fed diet containing willow herb, *Epilobium hirsutum* (Pakravan *et al*., 2012). A similar observation was observed by Beyraghdar *et al*. (2011) when diets containing propolis extract were fed to rainbow trout (*Oncorhynchus mykiss*). Contrary to these observations, there was significant difference in condition factor in this present study. Pezeshk *et al*. (2019) observed significant differences in condition factor of electric yellow cichlid fed plant extracts and is in agreement to this present study.

Group fed diet Trt 0 recorded the highest feed intake. There was however a decrease in feed intake as mahogany bark extract increased in diets and could be attributed to the presence of tannin and limonoid in mahogany bark.

Toxicological effects and pathological processes could be well understood using proximate composition as an index (Sudova *et al*., 2008). Except for protein, there was significant alteration in moisture, lipid and ash content of *C. gariepinus* fed different levels of mahogany bark extract. There was significant difference in moisture content of this study and is contrary to results of previous studies (Abdel-Zaher *et al*., 2009; Pakravan *et al*., 2012; Yu *et al*., 2019). The result of this study is however in agreement to the results of Ramezanzadeh *et al*., (2020).

Contrary to this study which recorded increase in lipid content as mahogany bark extract increased, there was a decline in lipid content in previous studies (Cho *et al*., 2007; Pakravan *et al*., 2012).

Conclusion

This study documents that mahogany bark extract can be used as supplement in diets of catfish (*Clarias gariepinus*) without adversely altering growth performance and feed utilization. In addition, for optimum growth and better feed utilization, addition of mahogany bark extract in diets of *Clarias gariepinus* should be at 20 ml per 100 g.

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Conflict of interest

The authors declare no conflict of interest.

References

Abdel Rahman, A.N., Khalil, A.A., Abdallah, H.M., El-Hady, M., 2018. The effects of the dietary supplementation of *Echinacea purpurea* extract and/or vitamin C on the intestinal histomorphology, phagocytic activity, and gene expression of the Nile tilapia. Fish and Shellfish Immunology 82, 312–318.

Abdel-Tawwab, M., 2012. The use of American ginseng (*Panaxquin quefolium*) in practical diet for Nile tilapia (*Orechromis niloticus*), growth performance and challenge with Aeromonas hydrophilla. Journal of Applied Aquaculture 24, 366–376.

Abdel-Tawwab, M., Abbass, F.E., 2017. Turmeric powder (*Curcuma longa* L.) in common carp, *Cyprinus carpio* L., diets: Growth performance, innate immunity, and challenge against pathogenic Aeromonas hydrophila infection. Journal of the World Aquaculture Society 48, 303-312.

Abdel-Tawwab, M., Adeshina, I., Jenyo-Oni, A., Ajani, E.K., Emikpe, B.O., 2018. Growth, physiological, antioxidants, and immune response of African catfish, *Clarias gariepinus* (B.), to dietary clove basil, *Ocimum gratissimum*, leaf extract and its susceptibility to Listeria monocytogenes infection. Fish and Shellfish Immunology 78, 346–354.

Abdel-Tawwab, M., Ahmad, M.H., Seden, M.E.A., Sakr, S.M.F., 2010. Use of green tea, *Camellia sinensis* L. in practical diets for growth and protection of Nile tilapia, *Oreochromis niloticus* (L.) against *Aeromonas hydrophila* infection. Journal of the World Aquaculture Society 41, 203–213.

Abdel-Zaher, A., Mostafa, Z.M., Ahmad, M.H., Mousallamy, A., Samir, A., 2009. Effect of using dried Fenugreek seeds as natural feed additives on growth performance, feed utilization, whole-body composition and entropathogenic Aeromonas hydrophila-challinge of monsex Nile tilapia *O. niloticus* (L) fingerlings. Australian Journal of Basic and Applied Science 3, 234-1245.

Adeshina, I., Adewale, Y. A., Tiamiyu, L.O., 2017. Growth performance and innate immune response of *Clarias gariepinus* infected with Aeromonas hydrophila fed diets fortified with Curcuma longa leaf. West Africa Journal of Applied Ecology 25, 79–90.

Ahmad, M. A., Abdel-Tawwab, M., 2011. The use of caraway seed meal as a feed additive in fish diets: Growth performance, feed utilization, and whole-body composition of Nile tilapia,

Orechromis niloticus (L.) fingerlings. Aquaculture 314, 110–114.

Alderman, D.J., Hastings, T.S., 1998. Antibiotic use in aquaculture: development of antibiotic resistance – potential for consumer health risks. International Journal of Food Science and Technology 33, 139-155.

Association of Official Analytical Chemists (AOAC), 2003. Official Methods of Analysis of AOAC International, 17th edn. Association of official analytical chemists, Arlington, Virginia.

Beyraghdar O.K., Dorcheh, E.E., Mahboobi-Soofiani, N., Samie, A., 2011. Long-term effects of propolis on serum biochemical parameters of rainbow trout (*Oncorhynchus mykiss*). Ecotoxicology and Environmental Safety 74, 315-318.

Bohlouli, S., Ghaedi, G., Heydari, M., Rahmani, A., Sadeghi, E., 2016. Effect of dietrary Persian oak (*Quercus brantii* var.persica) fruit extract on survival growth per foromance, hematological and immunological parameters in rainbow trout, *Oncorhynchus mykiss*, fingerlings. Aquaculture Nutrition 22,745-751.

Bohlouli, S., Sadeghi, E., 2016. Growth performance and haematological and immunological indices of rainbow trout (*Oncorhynchus mykiss*) fingerlings supplemented with dietary Ferulago angulata (Schlecht) Boiss. Acta Veterinaria Brno 85, 231-238.

Cho, S.H., Lee, S.M., Park, B.H., Ji, S.C., Lee J., Bae, J., Oh, S.Y., 2007. Effect of dietary inclusion of various sources of green tea on growth, body composition and blood chemistry of the juvenile olive flounder, Paralichthys olivaceus. Fish Physiology and Biochemistry 33, 49–57.

Citarasu, T., 2010. Herbal biomedicines: a new opportunity for aquaculture industry. Aquaculture International 18, 403–414.

Coll, M., Piroddi, C., Steenbeek, J., Kaschner, K., Lasram, F.B.R., Aguzzi, J., Danovaro, R., 2010. The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. PloS One 5, e11842.

Cross, C., Ax-Neto, J.G., Menezes M.L., 2004. Acute toxicity of metallic insecticide and azadiractin biopesticide of neem (*Azadirachta indica*) leaves for jewish and pacu youth (*Piaractus mesopotamicus*). Pesticidas: R. Ecotoxicol. e. 14, 93-102.

El-Mesallamy, A.M.D., El-Marakby, H.I., Souleman, A.M.A., Abd El-Nabyb, F.S., 2015. Evaluation of phenolic extract of licorice roots in diets of Nile tilapia (*Oreochromis niloticus*). Egyptian Pharmaceutical Journal 14, 117–122.

Folch, J., Lees, M., Stanley, G.H.S., 1957. A simple method for the isolation and purification of total lipids from animal tissues. Journal of Biological Chemistry 226, 497–509

Giri, S.S., Sen, S.S., Chi, C., Kim, H.J., Yun, S., Park, S.C., Sukumaran, V., 2015. Effect of guava leaves on the growth performance and cytokine gene expression of Labeo rohita and its susceptibility to Aeromonas hydrophila infection. Fish and Shellfish Immunology 46, 217-224.

Hoseinifar, S.H., Yousefi, S., Capillo, G., Paknejad, H., Khalili, M., Tabarraei, A., Van Doan, H., Spanò, N., Faggio, C., 2018. Mucosal immune parameters, immune and antioxidant defence related genes expression and growth performance of zebrafish (*Danio rerio*) fed on *Gracilaria gracilis* powder, Fish and Shellfish Immunology 83, 232–237.

Jiang, G., Liu, W., Li, G., Wang, M., Li, X., 2012. Effects of different dietary glycyrrhetinic acid (GA) levels on growth, body composition and plasma biochemical index of juvenile channel catfish, *Ictalurus punctatus*, Aquaculture 338–341, 167–171.

Kaleo, I.V., Gao, Q., Liu, B., Sun, C., Zhou, Q., Zhang, H., Shan, F., Xiong, Z., Bo, L., Song, C., 2019. Effects of Moringa oleifera leaf extract on growth performance, physiological and immune response, and related immune gene expression of *Macrobrachium rosenbergii* with Vibrio anguillarum and ammonia stress. Fish and Shellfish Immunology 89, 603–613.

Motamedi-Tehrani, J., Ebrahimi-Dorcheh, E., Goli, S.A.H., 2016. Effect of pistachio (Pistacia vera) hull extract on growth performance, body composition, total phenolic compound and fillets peroxide value of common carp, *Cyprinus carpio*. Aquaculture Nutrition 22, 479-484.

Munglue, P., 2014. Effects of dietary *Nelumbo nucifera* (lotus) peduncle extract on growth performance of Nile tilapia (*Oreochromis niloticus*). Proceedings of the first Environment and Natural Resources International Conference (ENRIC 2014). Bangkok, Thailand: Mahidol Universitys. pp. 279–282

Oyedeji, Amusa, M.O., Van Wyk, B.E., Oskolski, A., 2020. Wood anatomy of South African Meliaceae: evolutionary and ecological implications. Botanical Journal of the Linnean Society 193, 165-179.

Pakravan, S., Hajimoradloo, A., Ghorbani, R., 2012. Effect of dietary willow herb, Epilobium hirsutum extract on growth performance, body composition, haematological parameters and Aeromonas hydrophila challenge on common carp, *Cyprinus carpio*. Aquaculture Research 43, 861-869

Pezeshk F., Babaei S., Kenari, A.A., Hedayati, M. Naseri, M., 2019. The effect of supplementing diets with extracts derived from three different species of macroalgae on growth, thermal stress resistance, antioxidant enzyme activities and skin colour of electric yellow cichlid (*Labidochromiscaeruleus*). Aquaculture Nutrition 25, 436-443.

Ramezanzadeh, S., Abedian Kenari, A., Esmaeili, M., 2020. Immunohematological parameters of rainbow trout (*Oncorhynchus mykiss*) fed supplemented diet with different forms of barberry root (*Berberis vulgaris*). Comparative Clinical Pathology 29, 177–187.

Rashidian, G., Bahrami Gorji, S., Farsani, M.N., Prokić, M.D., Faggio, C., 2018. The Oak (*Quercus Brantii*) Acorn as a Growth Promotor for Rainbow Trout (*Oncorhynchus mykiss*): Growth Performance, Body Composition, Liver Enzymes Activity and

Blood Biochemical Parameters. Natural Product Research 34, 17, 2413-2423

Reverter, M., Tapissier-Bontemps, N., Sasal, P., Saulnier D., 2017. Use of Medicinal Plants in Aquaculture. In: Diagnosis and Control of Diseases of Fish and Shellfish (Brian Austin, Aweeda Newaj-Fyzul, Eds), © 2017 John Wiley & Sons Ltd. pp. 223-261.

Shakya, S.R., 2017. Effect of herbs and herbal products feed supplements on growth in fishes: a review. Nepal Journal of Biotechnology 5, 58-63.

Sudova, E., Piackova, V., Kroupova, H., Pijacek, M., Svobodova, Z., 2008. The effect of praziquantel applied per as on selected haematological and biochemical indices in common carp (*Cyprinus carpio* L.), Fish Physiology and Biochemistry 35, 599-605

Sukumaran, V., Park, S.C., Giri, S.S., 2016. Role of dietary ginger Zingiber officinale in improving growth performances and immune functions of Labeo rohita fingerlings. Fish and Shellfish Immunology 57, 362-370.

Sun, Z., Tan, X., Ye, H., Zou, C., Ye, C., Wang, A. 2018. Effects of dietary Panax notoginseng extract on growth performance, fish composition, immune responses, intestinal histology and immune related genes expression of hybrid grouper (*Epinephelus lanceolatus* ♂ × *Epinephelus fuscoguttatus* ♀) fed high lipid diets, Fish and Shellfish Immunology 73, 234-244

Terzi, E., Isler, H., 2019. Antibiotic resistance genes of *Escherichia coli* in coastal marine environment of Eastern Black Sea, Turkey. In: Fresenius Environmental Bulletin. 28, 1594–1601.

Xu, H., Ai, Q., Mai, K., Xu, W., Wang, J., Zuo, R., 2015. Effects of dietary supplementation of glycyrrhizic acid on growth performance, survival, innate immune response and parasite resistance in juvenile large yellow croaker, *Larimichthys crocea* (Richardson), Aquaculture Research 46, 86–94.

Yaakob, Z., Ali, E., Zainal, A., Mohamad, M., Takriff, M.S., 2014. An overview: biomolecules from microalgae for animal feed and aquaculture. Journal of Biological Research Thessaloniki 21, 6.