Integrated Comparative Impacts of Using Dietary Supplementation Plant Wastes
(Opuntia Ficus-Indica, Moringa Oleifera and Telfairia Occidentalis) on Hemato-
Biochemical Blood Status of Oreochromis Niloticus Exposed to Mercury Toxicity.

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INTRODUCTION

Fish can be exposed to high loads of heavy metals due to increased pollution in water
bodies (Amachree et al., 2014; Beheary & El-Matary, 2018). Elevated levels of toxic metals
have been reported from areas experiencing increasing settlement, traffic and agricultural
activities. The levels of non-essential trace elements in fish are important because fish is an

important source of food for the general human population; fish from freshwater bodies receiving industrial effluents have been reported to be unfit for human consumption because of high tissue levels of some trace metals (Atobatele & Olutona, 2015; Kortei et al., 2020).

Mercury is one of the most dangerous toxic metals, where the fate and behavior of the metal in the environment depended on its chemical form (Looi et al., 2016). Mercury poisoning can result from inhalation, ingestion, or absorption through the skin and the metal may be highly toxic and corrosive once absorbed into the blood stream (Moniruzzaman et al., 2017). The most toxic form is methyl-mercury (MeHg), including reduced neuronal development and immunodeficiency (Renieri et al., 2019). Long-term exposure to both organic and inorganic mercury is deleterious for health including the kidney (Rana et al., 2018). It reduces the function of tight junction protein in the kidney and perturbs cellular permeability. According to Kawedia et al. (2008), Hg decreases transepithelial electrical resistance (TER) and facilitates the phosphorylation of tight junction protein, occludin via a protein kinase A (PKA) dependent mechanism (Rana et al., 2018). The ecotoxicology and environmental fate of mercury has been extensively studied (Boening, 2000; Scheuhammer et al., 2007; Riva-Murray et al., 2011; and Driscoll et al., 2013).

Cultured fish are susceptible to a wide range of toxins and pathogens which may cause a wide range of diseases and subsequent economic losses in farmed fish (Austin & Austin, 2007). The search for natural alternatives to eliminate heavy metal toxicity and to improve the performance of fish is a new trend in research. Several studies have been conducted on the possibility of using a plant–based diet supplement to improve the immunity of fish and increase the degree of resistance to toxins and diseases (Yin et al., 2006; Awad & Austin, 2010; Dada & Oviawe 2011; Harikrishnan et al., 2011; Park & Choi, 2012; Arulvasu et al., 2013; and Awad et al., 2013).

*Moringa oleifera*, a tree belonging to family Moringaceae, has remediation properties and is highly effective in treating malnutrition and several diseases. Therefore, it is called "the miracle tree" (Mbokane & Moyo, 2018). A variety of essential phytochemicals are existed in *Moringa* leaves, pods and seeds such as vitamins A, C, E, carotenoids, phenolics and flavonoids (Moyo et al., 2012). It has also been reported that *Moringa* possesses several nutrients including protein, calcium, magnesium, potassium and iron (Foidl et al., 2001 and Rockwood et al., 2013). The World Health Organization (WHO) is promoting *M. oleifera* as a food supplement against malnutrition due to its valuable nutritional profile. The plant is also used as potential anti-oxidant, anti-cancer, anti-inflammatory, anti-diabetic and anti-microbial agent, which explains the widespread use in animal feeding in recent years (Hlophe & Moyo, 2014; Al-husnan & Alkahtani, 2016 and Gopalakrishnan et al., 2016).

*Opuntia ficus-indica* (Family Cactaceae) is among the most important medicinal plants (Abdel-Hameed et al., 2014) because of the existence of antioxidants (Angulo-Bejarano et al., 2014), nutrition signification (Jana, 2012), fatty acids (Matthaus & Ozcan, 2011; Khatabi et al., 2013 and Cejudo-Bastante et al., 2014). The plant can be used in river water and wastewater decontamination through both adsorption and coagulation-flocculation processes (Nharingo & Moyo, 2016).

Fluted pumpkin (*Telfairia occidentalis*, family Curcubitaceae) contains vitamin C, alkaloids and flavonoids, with high antioxidant properties. Many studies have shown that antioxidants present in the aforementioned species can enhance fish performance either directly or indirectly (Dada, 2016).
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In most studies using plant residues as a dietary supplement to increase fish resistance to diseases and pollutants, attention has been paid to studying the haematological indices, blood biochemical properties and immunity attributes. The pattern of these parameters is used as an indication to the treatment effectiveness in disease resistance (Mbokane & Moyo, 2018). *Oreochromis niloticus* is one of the most commonly cultured freshwater fish species in Egypt. It has been reported to be susceptible to metal poisoning and diseases in intensive farming systems (Oner *et al*., 2008). In this study, *O. niloticus* has been selected as a test organism for its great aquaculture and commercial value. The present work aims to explore the effects of mercury on hematological and biochemical blood indices of Nile tilapia (*O. niloticus*) and the ameliorating effect of dietary supplementation with *Moringa oleifera*, *Opuntia ficus-indica*, and *Telfairia occidentalis*.

**MATERIALS AND METHODS**

**Fish:**

The experiment was held in El-serw fish farm. It was established on a plot of lake Manzalaa which was reclaimed for agriculture in 1952 for experimental purposes and to compensate partially the deficiency of animal protein in Egypt. Healthy specimens of Nile tilapia (*O. niloticus*) with total body weight of 45-50 g were obtained from El-Serw fish farm. Fish were treated with 0.1% KMNO₄ to remove any fungal infection. Group of 10 fishes were kept in glass aquaria loaded with 40 liter of de-chlorinated tap water and gently aerated for two weeks to acclimate. Fish were fed twice a day at a rate of 3% of their biomass. The aquarium was kept at water temperature of 25 ± 1.02 °C, pH of 6.9 ± 0.1 and dissolved oxygen of 7.4 ± 0.34 mg/l.

**Supplementary diet preparation:**

The plant based wastes of *Moringa oleifera* (MO), *Opuntia ficus-indica* (OFI), *Telfairia occidentalis* (TO) were repeatedly washed with tape water to remove soluble and dirty particles and finally rinsed with deionized water. It was cut into strips of 1 cm width, then dried in the sun for two weeks before drying in the oven at 60 °C for 48 h. Dry matter was then ground into fine particles by using commercial blender, sieved to the fine homogenous particle size. Plant based wastes of 5% and 10% were added to the fish diet. The components were blended thoroughly and formed into pellets using a pellet machine. The pellets were dried in the air at room temperature (27 °C) for 24 h and stored at 4 °C until use.

**Experimental design and diets:**

The acclimatized fish were randomly assigned to two major groups. The first group consisted of three replicates and received only the traditional fish diet (control) and the second group consisted of 21 replicates and received fish diet plus 0.08 mg/l Hg. The second group was also divided into seven subgroups (three replicates each): either not receiving any dietary supplement or supplemented with the powder of *Moringa oleifera* (MO), *Opuntia ficus-indica* (OFI) or *Telfairia occidentalis* (TO) at a dose of 5% or 10% of the fish diet (Go, *et al*., 2007; Dada, 2016; and Mbokane *et al*., 2018). The dose of Hg was calculated as 27% of the LC₅₀ for *O. niloticus* which was estimated by El-Matary *et al*., (2019) to be 0.3 mg/l. Each replicate was a glass aquarium with 40 liter capacity and contained 10 homogenous fishes. Water of the aquarium was completely renewed every 48 h. throughout the
experimental period (60 days), the fish were monitored for clinical signs, post-mortem lesions, and mortalities.

**Haematological and biochemical analysis:**

Blood samples were collected at the end of the experimental period from the caudal vessels in Eppendorf tubes. Haematological variables included white blood cell count (WBC), hemoglobin concentration (Hb), haematocrit (Hct), red blood cell count (RBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) was analyzed by using a Mindary BC-2800 Auto Hematology Blood Analyzer. Serum was obtained from blood samples by centrifugation at 3000 rpm for 15 min. The biochemical variables of the serum included cholesterol, triglyceride, albumin, globulin, creatinine, total bilirubin, protein, uric acid, glucose, glutamate oxaloacetate transaminase (GOT) and glutamate pyruvate transaminase (GPT) concentrations and were determined by using a Roche Hetachi Cobas C311.

**Statistical analysis:**

Data are expressed as mean ± standard error (SEM). Data was subjected to one-way ANOVA using SPSS version 22. Mean separation was performed using Duncan's multiple range test at P<0.05.

**RESULTS**

Throughout the feeding period, fish from all experimental groups looked healthy and dose related mortalities were not observed.

The effects of HgCl₂ and dietary supplement treatments on the hematological parameters of *O. niloticus* after 60 days of experiment are shown in Table (1). In the treated MC₀.₀₈ group, a significant increase was observed in the count of WBCs by 70.99% than the control group. This value tended to be reduced in all treatments that used plant-based waste as a dietary supplement by (3.97 - 21.30%).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Treatment groups</th>
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<tbody>
<tr>
<td></td>
<td>Control</td>
</tr>
<tr>
<td>RBC (1₀⁶/ml)</td>
<td>2.7±0.95a</td>
</tr>
<tr>
<td>WBC (1₀³/ml)</td>
<td>16.2±0.23e</td>
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<tr>
<td>Hb (g/dl)</td>
<td>7.2±0.23a</td>
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<tr>
<td>Hct (%)</td>
<td>39.28±0.21a</td>
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<tr>
<td>MCV (Fi)</td>
<td>144.1±5.43a</td>
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<tr>
<td>MCH (Pg)</td>
<td>41.8±0.29a</td>
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<tr>
<td>MCHC (g/dl)</td>
<td>29±1.15b</td>
</tr>
</tbody>
</table>

Different letters indicate significant differences between treatments (P < 0.05)

RBC: red blood cell counts; WBC: white blood cell counts; Hb: hemoglobin; Hct: hematocrit; MCV: mean corpuscular volume; MCH: mean corpuscular hemoglobin; MCHC: mean corpuscular hemoglobin concentration. MC₀.₀₈ (HgCl₂ = 0.08 mg/l); MC/MO₅% (diet supplemented with 5% *Moringa Oleifera*); MC/MO₁₀% (diet supplemented with 10%...
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Moringa Oleifera); MC/OF15% (diet supplemented with 5% Opuntia ficus-indica); MC/OF10% (diet supplemented with 10% Opuntia ficus-indica); MC/TO5% (diet supplemented with 5% Telfairia occidentalis); MC/TO10% (diet supplemented with 10% Telfairia occidentalis).

The count of red blood cells (RBCs) decreased sharply in the treated MC0.08 group by 74.07% when compared to the control group. The count values were enhanced greatly in all dietary supplement treatments. Hemoglobin (Hb) and hematocrit (Hct) levels were also reduced in the treated MC0.08 group by 33.33% and 36.63%, respectively, than the control. These levels were enhanced and increased in the other treatments by (8.33- 35.41%) for Hemoglobin and (0.52- 19.56%) for hematocrit.

A decrease in MCV values in the treated MC0.08 group by 7.21% was observed, as compared to the control group. MCV values increased in all the dietary supplement treatments by (3.66 -28.57%) more than the treated MC0.08 group. MCH and MCHC levels showed an increase in the treated MC0.08 group by 64.83 % and 79.31%, respectively, compared to the control, while the other treatments showed reduction in MCH values by (42.53 - 49.78 %) and MCHC by (44.23- 59.62%).

The result showed that the tested blood protein constituents (total protein, albumin, and globulin) were significantly reduced in treated MC0.08 group compared to the control group by 39.3%, 38.57%, and 41.53%, respectively (P<0.05). In all treatments that used plant-based waste as a dietary supplement, an increase in protein values with range of (2.93- 71.26%), and albumin (4.30 - 41.43%), while globulin values reached 2.12 fold more than in HgCl2 group (Figure 1).

Lipid and glucose pictures are illustrated in Figure 2. Triglycerides levels increased in MC0.08 by twofold compared to the control, while the TG levels in the other treatments decreased by (15.25-59.45%) when compared to MC0.08. However, it remained higher than in the control group, except for the TO5% group. The levels of cholesterol in MC0.08 increased by 47.54% than the control, and these levels tended to decrease significantly in the other groups (6.11- 47.22%) and (15.24-59.45%). The blood concentration of glucose significantly increased in treated MC0.08 group by three fold than the control group, the levels significantly decreased in the other dietary supplement treatments by (40.57- 86.23%).

The liver function is illustrated in Figure 3. Total bilirubin levels decreased in all treatments used dietary supplement plant-based wastes in a range of (13.28- 54.69%) than MC0.08 group, which increased than the control by 9.40%. Concentrations of Glutamic oxaloacetic transaminase (GOT) and Glutamic pyruvic transaminase (GPT) showed an increase in fish treated with MC0.08. Significant increase than the control was noticed in GOT (97.58%) and GPT (19.16%). The values of blood enzymes decreased in the all supplementary plant treatments in a range of (4.08 - 51.83% for GOT) and (1.26 - 44.72% for GPT) than the treated MC0.08 group.

The kidney function is illustrated in Figure 4. Uric acid increased in the treated MC0.08 group by 93.87% than control, and the levels in the other treatments have been greatly reduced in a range of (56.31- 88.94%). Mercuric chloride increased creatinine levels by 20.83% than the control. But the levels began to decrease with range of (6.8- 41.37%) in other treatments, except for MC/TO5% (0%).
Figure 1. Effect of HgCl₂ and dietary supplement treatments on the blood protein picture in *O. niloticus* after 60 days of experiment.

MC₀.₀₈ (HgCl₂ = 0.08 mg/l); MC/MO₅% (diet supplemented with 5% *Moringa Oleifera*); MC/MO₁₀% (diet supplemented with 10% *Moringa Oleifera*); MC/OFI₅% (diet supplemented with 5% *Opuntia ficus-indica*); MC/OFI₁₀% (diet supplemented with 10% *Opuntia ficus-indica*); MC/TO₅% (diet supplemented with 5% *Telfairia occidentalis*); MC/TO₁₀% (diet supplemented with 10% *Telfairia occidentalis*). Statistical analysis: * denotes statistically different from the control value, and # denotes statistically different from the MC₀.₀₈.
Figure 2. Effect of HgCl₂ and dietary supplement treatments on the blood lipid and glucose levels in *O. niloticus* after 60 days of experiment. (Abbreviations as in Figure 1)
Figure 3. Effect of HgCl₂ and dietary supplement treatments on the liver function of *O. niloticus* after 60 days of experiment. (Abbreviations as in Figure 1)
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DISCUSSION

Changes in the hematological parameters are used to monitor the nutritional, physiological and pathological status in fish (Maita, 2007; Malczyk & Branfireun, 2015; and Mbokane & Moyo, 2018). In the present study, a remarkable decrease was detected in levels of RBCs, HB, HCT and MCV as well as an increase in WBCs count, MCH and MCHC due to exposure to mercuric chloride. The decline in RBC counts in fish under stress situations might result from the severe kidney injuries and inhibition of RBC manufacture (Kavitha et al., 2010; Li et al., 2011; Saravanan et al., 2011; and Hedayati & Ghaffari, 2013). The significant decrease in hemoglobin concentration of fish can be either due to increased rate of destruction of hemoglobin or due to decreased rate of synthesis of hemoglobin. A decline in RBCs count, hemoglobin and hematocrit levels can reveal an anemic situation (Banavathu & Mude, 2017). The expansion of WBCs, MCH and MCHC may be due to generalized immune response and a protective response to stress caused by metals (Sakamoto et al., 2015). Our findings agree with some reports (Allin & Wilson, 2000; Shah & Altindag, 2005;
Chowdhury et al., 2004; Witeska, 2004; Heyes et al., 2006; Ates et al., 2008; and Saravanan et al., 2011), while others were in opposed point of view (Carvalho & Fernandes 2006).

In the present study, the values of protein, globulin and albumin decreased in MC compared to the control. Liver is considered the main organ in the synthesis of albumin as the main protein in plasma (Bratkič et al., 2018). An increase in protein metabolism under severe stress, a decline in protein synthesis due to liver injuries and less protein reabsorption by injured kidneys could be referred to as a reason for the decline of total protein (Dias et al., 2016). Besides, loss of appetite due to toxic stresses could be another reason for the decline of total protein level in serum (Olsvik et al., 2013). Several reports indicated a decline of total protein and albumin in blood serum of animals which have been exposed to toxin (Sarica et al., 2005; Miklavčič et al., 2011; Mutlu et al., 2015; and Li et al., 2018), others are not in accordance with these reports (Yan et al., 2010; Malczyk & Branfireun, 2015; and Abdel-Tawwab et al., 2015).

Environmental Toxins (heavy metals, pesticides) increased glucose levels in the blood, for this reason, blood glucose can be used as an indicator of environmental stress (Almeida et al., 2001) the current findings showed increased levels of blood glucose due to exposure to mercuric chloride, this may be due to liver and kidney injury and lack of nutrition because of the cessation of carbohydrate metabolism which accelerates the process of liver glycogen breakdown to cover the body's energy needs (John, 2007; Hedayati & Ghaffari 2013; Mutlu et al., 2015; and Banavathu & Mude, 2017). Our results indicate that the levels of cholesterol increased in fish exposed to mercuric chloride compared to control. Cholesterol increases may due to renal and hepatic failure. Our results are supported by other studies showed an increase in cholesterol concentration in fish exposed to metals (John, 2007; Scheuhammer et al., 2015 and Jadán-Piedra et al., 2018). Other studies have been of different opinion (Agrahari et al., 2007).

The obtained results indicated high levels of triglycerides content in MC treatment compared to control. Increased levels were due to hepatitis and lack of ability to store glycogen (Yang & Chen, 2003). It provides energy to the body, as it used as an important indicator to evaluate the metabolism of lipids and the state of nutrition in the body. Similarly, Yang & Chen (2003) indicated an increase in serum triglyceride levels considerably in C. carpio exposed to gallium (Ga) compared to control. Total bilirubin reached the liver by engaged to albumin and globulin in the serum through filtration by the kidney. As, bilirubin is a predominant bile pigment found in the circulation in the Nile tilapia derived from disruption of hemoglobin (Folmar, 1993). Serum bilirubin levels could be changed with liver disorder (Chen et al., 2004) and mycotoxin effects (Van Vuren et al., 1994). There is a relation between exposure to heavy metals and kidney disease as, uric acid recorded high levels due to fish exposure to mercuric chloride in the current study. This refers to a kidney failure which may be due to the inhibition of uric acid and other nitrogenous compounds secretion processes which cause the precipitation of uric acid in the blood (Mutlu et al., 2015). In the present study, the serum total bilirubin, uric acid, and creatinine levels in the exposed groups to mercuric chloride were significantly higher than those in the control group. Several studies agreed with our results and reported high serum creatinine, triglyceride, and uric acid levels after exposure of O. niloticus to copper (Chen et al., 2004; and Mutlu et al., 2015), pesticides (Jain, 1999), and other heavy metals and nitrate (Adham et al., 2002). While, an opposite findings was reported by Abdel-Tawwab et al., (2015) who
worked on zinc toxicity on biochemical status of common carp, (Cyprinus carpio L.) The levels of Serum glutamic oxaloacetic transaminase (sGOT) and serum glutamic pyruvic transaminase (sGPT) is used to assess fish health (Agrahari et al., 2007). Higher amounts of these enzymes in the blood may indicate damage to liver and kidney tissues. The data obtained showed remarkable increases in both enzymes after fish were exposed to mercuric chloride. The activities of these enzymes imply that the liver and kidney were affected (Van der et al., 2003; and Palanivelu et al., 2005). Several reports recorded an increase in these enzymes after exposure to toxins (John., 2007, Agrahari et al., 2007; and Kavya et al., 2016).

The use of plant-based wastes as an alternative to chemical treatments of toxins in aquaculture is one of the most prevalent concerns at present (Olusola et al., 2013; and Reverter et al., 2014). In this regard, the current study used different types of plant residues as a partially dietary supplement (5 and 10% / kg commercial fish diet) to study their health effects on fish exposed to Hg and to show their ability in improving fish blood properties and enzymes efficiency. In the current study, there were important observations: the enhancement in the levels of hematological variables (RBCs, Hb, Ht, MCV) and a significant reduction in (WBCs count, MCH and MCHC) after the dietary replacement of *O. niloticus*. All plant residue treatments enhanced the biochemical blood constituents (protein, globulin and albumin). These findings were in accordance with Dügeneci et al. (2003) and Alinezhad et al. (2017) who reported that the serum total protein levels increased significantly after feeding fish with various herbal extracts. Also, Xu et al., (2014) reported that exogenous alanyl-glutamine dipeptide (AGD) supplements can improve serum biochemical index (albumin and globulin) in young mirror carp *C. carpio*. On contrary, Abdel-Tawwab et al. (2010 & 2015), Abdel-Tawwab (2015) and Ahmad et al. (2011) reported a decrease of total protein after feeding on dietary green tea (*Camellia sinensis L.*), roasted coffee powder, and cinnamon (*Cinnamomum zeylanicum*). The levels of blood glucose, Cholesterol, triglycerides, total bilirubin, uric acid, creatinine, GOT and GPT showed a significant decrease in all supplementary diet treatments compared to MC0.08 group. Several reports deals with our results (Agrahari et al., 2007; Amachree et al., 2014; Xu et al., 2014; and Alinezhad et al., 2017), although Adel et al., (2015) reported no changes even after dietary supplementation with peppermint, and Li et al., (2018) found that dietary AGD supplement could not alleviates the damage to the liver caused by ammonia toxicity.

When comparing the efficacy and economic benefit of using two doses of plant-based wastes as partially supplementary diets, it was found that: MO10% enhanced protein levels by 25.53%, albumin by 10.2%, and globulin by 35.9% than MO5%. A reduction in MCH (2%) and total bilirubin values (42%) also have been observed. while MO10% was not effective in changing the rest blood variables. OFI10% enhanced Hb values by 11.32%, Hct by 18.94%, protein by 3.5%, and albumin by 34.5% when compared with OFI5%. And a reduction in MCH, total bilirubin and GPT values by 1.84%, 4.7% and 28.5 % respectively were obtained. TO10% enhanced the levels of blood indices more than TO5% as: Ht (15.18%), MCV (20.85%), protein (15.6%), albumin (15%), and globulin (15.7%). While, it reduced values of MCHC by 27.5%, uric acid by 65 %, glucose by 34.92%, cholesterol by 30.1%, creatinine by 34.48%, total bilirubin by 39.6%, GOT by 49.13%, and GPT by1.2%, than TO5%. Generally, the dose 10% of MO and OFI were not effective and had no additional benefit. On the contrary, TO10% can be efficient in enhancing fish health and blood characteristics.
The degree of improvement among the three treatment materials used can be concluded as: protein, globulin, total bilirubin and GPT levels takes the following order: *Moringa Oleifera*, MO > *Opuntia ficus-indica*, OFI > *Telfairia occidentalis*, TO. WBCs, Ht, MCV, albumin, glucose, cholesterol, and creatinine take the following order: *Opuntia ficus-indica*, OFI > *Moringa Oleifera*, MO > *Telfairia occidentalis*, TO. While GOT ordered as: (*Telfairia occidentalis*, TO > *Moringa Oleifera*, MO > *Opuntia ficus-indica*, OFI). RBCs, Hb, MCH and triglycerides were as: *Telfairia occidentalis*, TO > *Opuntia ficus-indica*, OFI > *Moringa Oleifera*, MO. MCHC and uric acid were arranged as: *Opuntia ficus-indica*, OFI > *Telfairia occidentalis*, TO > *Moringa Oleifera*, MO.

MCHC and uric acid were arranged as: OFI > TO > MO. These findings indicate that the best dietary supplementation caused changes and improvements in the hematological profile, and biochemical blood indices in *O. niloticus* was *Moringa Oleifera* followed by *Opuntia ficus-indica* and *Telfairia occidentalis*. The obtained findings are in accordance with Mbokane & Moyo (2018) who indicated that, immunity was enhanced in fish fed with *M. oleifera*. This enhancement is attributed to the presence of biologically active compounds with immune-stimulatory properties. The phyto-chemistry of the *M. oleifera* revealed high levels of total polyphenol, total phenols, total flavonoids, carotenoids, vitamins C and E (Brilhante et al. 2017). Previous studies have shown that, *Opuntia ficus-indica* contains polyphenols, anti-oxidants, anti-inflammatory agents (Butera et al., 2002; Kutu, 2004; and Yang et al., 2008) in addition to the medical and animal breeding applications (Ayadi et al., 2009). *Telfairia occidentalis* has quite number of antioxidants such as phenols. Therefore, a high possibility that *T. occidentalis* can promote health and increase growth and haematological parameters in animals (Olorunfemi et al. 2005; Fasuyi and Nonyerem 2007) and in Nile tilapia fish *O. niloticus* (Dada & Abiodun 2014; and Dada & Fagbohun 2018).

Finally, this study showed that *M. oleifera*, *Opuntia ficus-indica* and *Telfairia occidentalis* possesses therapeutic Properties that can improve the health of *O. niloticus* with different degrees. Carefully selected doses can be beneficial for fish health and alleviate health-related problems. Although there are many different medicinal plant species with medicinal activities, the use of these materials are particularly promising because they are inexpensive and easily available.

**CONCLUSION**

In this study we concluded that exposure to mercuric chloride could cause a significant destruction to hematological and biochemical characteristics and affect the fish health of *O. niloticus*. An improvement in the hematological profile, and biochemical blood indices in *O. niloticus* were observed plant-based waste was used as diet supplements. *Moringa Oleifera* residues were the most effective one in improving the fish blood profile. It is recommended to use a dose of 5% of *Moringa Oleifera* and *Opuntia ficus-indica* as fish diet supplementation. On the contrary, as the doses of *Telfairia occidentalis* increased, more enhancement in blood characteristics and fish health might be implemented.

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دراسة مقارنة لتأثير استخدام المخلفات النباتية (التين الشوكي، المورينجا، القرع العصلي) ككميات غذائية على كفاءة الدم في سمك البلطي الليلي لمعرفة تأثير زيادة حمض الدم في جميع الحالات. تم توزيع الأسماك (10 أسماك لكل حوض سعة 40 لتر ماء) في 8 مجموعات. تم تغذية المجموعة الحاكمة (control) ومجموعة كلوبرد الزئبق (MC/OFI5%) بتركيز (0.08 مجم/لتر) على نظام غذائي دون أي أضافات. أما مجموعات كلوبرد الزئبق التي C/OFI5% و (MC/OFI10%) و (MC/OFI0%) فقد تم تغذيتها على نظام غذائي مكملات غذائية وحمض دم (GPT) و (GOT) في توازن من تأثير استخدام مخلفات النباتية ككميات غذائية. تم تسليط الضوء على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائية على تأثير استخدام مخلفات النباتية ككميات غذائي

Impact of using plant wastes on Oreochromis niloticus exposed to mercury toxicity.