



## A Review of *Tephrosia bracteolata* and *Clarias gariepinus* Typifying the Toxicological Effects of Plant Extract on Aquatic Life

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### Abstract

**Background:** Fish farmers and African aqua-culturists have been exploring plants for various pathological benefits without being cautious of the points the plants' extract can be toxic to the rearing fish or the wild aquatic environment, regardless of the solvents used for the extraction. **Objectives:** This review aims to present this nexus between *Tephrosia bracteolata* and *Clarias gariepinus* for the possible toxicological effect of plant extract on aquatic life and consideration in aquatic and fish toxicology. **Methodology:** The study explored 56 research articles published on *Tephrosia bracteolata* and *Clarias gariepinus* using their taxonomy and natural distribution to gather universally adopted terms for correct information. **Results:** The review looked through similar studies to gather data on *T. bracteolata* classification, taxonomy, geographical distribution, medicinal properties, chemical constituents, and pharmacological properties for its beneficial consumption. The review explored the (acute and chronic) toxicity studies and ecological implications of *T. bracteolata* to create an avenue for its possible threats and proper management. Furthermore, the review presented information on *Clarias gariepinus* concerning its taxonomy, natural distribution and habitat, mode of feeding, reproduction and environmental changes to relate well to how the exemplified fish could contact the plant extract in the wild. Lastly, the review tabled a nexus for the toxicity of *Tephrosia bracteolata* leaf extract on *Clarias gariepinus* using the fish's haematological and histopathological parameters. **Conclusion/ Recommendation:** The review established the toxic effects of the plant's ethanol extract on the typified fish and other aquatic life, offering advice for precautionary measures while exploring the medicinal values of plants for any benefits.

**Keywords:** Pharmacological properties, taxonomy, plant extract, natural distribution,

### Introduction

*Tephrosia bracteolata* is a commonly used medicinal plant with documented pharmacological activities (Enwa et al., 2013). While the plant has beneficial properties or ecological applications, assessing its potential toxic effects on aquatic organisms, especially fish species, is crucial. The *T. bracteolata* has

been reported to have pesticidal activities, particularly as a fish poison (Simiyu et al., 2018). As piscicidal substances are employed for fish control in aquaculture and fisheries management, it is necessary to investigate the potentially toxic effects of *T. bracteolata* on non-target species like *Clarias gariepinus* to assess any unintended ecological consequences. *Clarias gariepinus*, the

African catfish, is hardy due to its accessory breathing organs and survival ability in the burrow beneath the pond across seasons (Olaifa et al., 2003). It is a commercially important fish species widely distributed in freshwater ecosystems. It plays a significant role in aquaculture and supports local economies in many regions. Therefore, as this review aims to present, the potentially toxic effects of explorable plants such as *T. bracteolata* on *Clarias gariepinus* are essential to ensure sustainable aquacultural practices and the conservation of natural fish populations.

### Materials and methods

The study explored 56 research articles published on *Tephrosia bracteolata* and *Clarias gariepinus*. The plant and fish names were strictly adopted throughout the search for data gathering used for this review. The study considered the taxonomy and natural distribution of the two species in searching for information while simultaneously excluding names of other plants and fish species to prevent aberrations in the ideas of the objectives it set for achievement. The taxonomy and natural distribution gave the widely known names of the reviewed plant and fish.

#### *Classification, taxonomy and geographical distribution of the Tephrosia bracteolata*

Kingdom: Plantae, Division: Magnoliophyta, Class: Magnoliopsida, Order: Fabales, Family: Fabaceae, Genus: *Tephrosia*, and Species: *Tephrosia bracteolata*. *Tephrosia bracteolata* is native to Africa, India, and Sri Lanka. It is found in various African countries, such as Kenya, Tanzania, Uganda, Ethiopia, Nigeria, and South Africa. In India, it is distributed in states like Karnataka, Madhya Pradesh, Tamil Nadu, and Kerala. *Tephrosia bracteolata* is also present in Sri Lanka. On that note, the plant grows in diverse habitats such as open grasslands, hillsides, wastelands, or cultivated fields in these regions. It is a hardy plant that can tolerate different climatic conditions and soil types (Enwa et al., 2013; Simiyu et al., 2018). The plant is easily

explored for its medicinal benefits from the abovementioned information.

#### **Medicinal properties and chemical constituents of *Tephrosia bracteolata***

*Tephrosia bracteolata* has a long history of use in traditional medicine across Asia and is known for its various medicinal properties, some of which have been confirmed through scientific studies. The *T. bracteolata* leaf extract is traditionally used for its wound-healing properties and antimicrobial and anti-inflammatory activities that promote healing and prevent infections (Ali et al., 2011). The leaf extract has been used for managing diabetes in traditional medicine for possessing anti-hyperglycemic activity, which regulates blood sugar levels (Ahmed et al., 2000). The leaf extract is rich in antioxidants, neutralising harmful free radicals and protecting the body against oxidative stress. The leaf extract also possesses significant anti-inflammatory activity and relieves pain (Dey et al., 2002). The properties and activities are regulated and determined by the phytochemicals or plant chemical components. The phytochemical screening of the *T. bracteolata* leaf aqueous extracts revealed the presence of bioactive chemical compounds (such as flavonoids, alkaloids, tannins, steroids, saponins, and glycosides), which are briefly explained below.

#### *Flavonoids*

Flavonoids are characterised by their chemical structure consisting of two aromatic rings connected by a three-carbon bridge, groups of natural compounds widely distributed in plants, and the subclass of polyphenols. Flavonoids are known for their diverse biological activities, including antioxidant, anti-inflammatory, anti-cancer, and anti-viral properties. Due to their various anti-inflammatory, anti-oxidative, and anti-mutagenic properties, they can be used in various cosmetic, pharmaceutical, and dietary supplements. They can also be effective inhibitors of various enzymes, such as the xanthine oxidase, cyclo-oxygenase,

lipoxygenase, and phosphoinositide (Walker et al., 2000). The *T. bracteolata* leaf is rich in flavonoids such as genistein, biochanin A, and kaempferol (Gupta et al., 2018; Anitha et al., 2020).

#### *Alkaloids*

Alkaloids are a group of naturally occurring chemical compounds containing nitrogen atoms and having a pharmacological effect on humans and animals. They are widely distributed in the plant kingdom, with over 20,000 different alkaloids identified to date. Alkaloids are often bitter-tasting; many are known for their psychoactive or medicinal properties. Despite their potential benefits, some alkaloids can be toxic to humans and animals if consumed in large quantities. Alkaloids such as tephrosin, bracteolatine, and sparteine have been identified in *T. bracteolata* (Oudhia et al., 2014; Gupta et al., 2018).

#### *Tannins*

Tannins are polyphenolic compounds with potential health benefits, found commonly in the bark of trees, wood, leaves, buds, stems, fruits, seeds, roots, and plant galls. The astringency from the tannins causes a dry and pucker feeling in the mouth following the consumption of unripened fruit, red wine or tea (McGee et al., 2004). The *T. bracteolata* has been shown to possess tannins, contributing to its antioxidant and antimicrobial properties. Its leaf contains tannins, including gallic acid and ellagic acid derivatives (Oudhia et al., 2014; Gupta et al., 2018).

#### *Steroids*

Steroids are a class of organic compounds widely found in plants and have various biological activities (Patil et al., 2019). Steroids are essential components of plant membranes and have various pharmacological properties. The *T. bracteolata* leaf contains  $\beta$ -sitosterol and stigmasterol (Oudhia et al., 2014; Gupta et al., 2018).

#### *Saponins*

Saponins are phytochemicals found in most vegetables, beans, and herbs. Their best-known

sources are peas, soybeans, and some herbs with names indicating foaming properties, such as soapwort, soaproot, soapbark and soapberry. Saponins taste bitter; some are toxic, known as sapotoxin (Esam, 2014). Saponins have hypocholesterolemic, hypotensive and cough-depressant activities (Mensah et al., 2013; Tijjani et al., 2012).

#### *Glycosides*

Glycosides are compounds widely distributed in plants and have various biological activities (Parida et al., 2014). Glycosides are a diverse group of compounds in which a sugar molecule is attached to a non-sugar compound. The *T. bracteolata* contains various glycosides, including flavonoid and cardiac glycosides (Parida et al., 2014).

### **Pharmacological properties of *Tephrosia bracteolata***

The *T. bracteolata* leaf on *Clarias gariepinus* juveniles has been investigated in several studies, highlighting its potential therapeutic effects. The following activities show the pharmacological properties of *T. bracteolata* leaf on *Clarias gariepinus* juveniles.

#### *Antioxidant activity*

*T. bracteolata* leaf has demonstrated significant antioxidant activity. It contains bioactive compounds such as flavonoids and phenolic acids that scavenge free radicals and protect against oxidative stress-induced damage in *Clarias gariepinus* juveniles (Amadi & Obeagu, 2018).

#### *Anti-cancer and anti-ulcer activities*

The *Tephrosia calophylla* leaf ethanol extract is reported to have anti-ulcer activity when investigated using pylorus ligation, ethanol-induced, and indomethacin-induced ulcer models. The extract was tested at two different doses; the results revealed that in all three models, the extract showed a dose-dependent reduction in gastric volume, free acidity, ulcer index, and total acidity, thus proving the potential anti-ulcer activity. This activity may be due to an anti-

secretory property of flavonoids present in the extract (Divya et al., 2011). Some studies have explored the anti-cancer potential of *Aristolochia bracteolata* extracts. The *Aristolochia bracteolata* ethanol extract demonstrated cytotoxic activity against cancer cell lines, including breast, colon, and lung cancer cells (Durairaju et al., 2025).

#### *Hepatoprotective and immunomodulatory activities*

*Tephrosia bracteolata* leaf extract has shown hepatoprotective properties in *Clarias gariepinus* juveniles. It can help protect the liver against toxic insults and enhance liver function by reducing hepatic enzyme levels and preventing histopathological changes (Amadi & Obeagu, 2018). *T. bracteolata* leaf extract exhibits immunomodulatory effects in *C. gariepinus* juveniles. It can enhance the immune response, including phagocytic activity, antibody production, and lymphocyte proliferation, thereby improving the fish's immune system (Amadi & Obeagu, 2018; Sowunmi et al., 2016).

#### *Antimicrobial and antibacterial activities*

The study was conducted to analyse the antibacterial activity of the bark of *T. vogelii* when tested using *Bacillus cereus*, *E. coli*, *Salmonella typhi*, *Streptococcus pyogenes*, *Serratia marcescens*, *Serratia liquefaciens*, *Enterobacter aerogenes*, and *Staphylococcus epidermidis* (Hu et al., 2011). *T. bracteolata* leaf extract possesses antimicrobial properties. It has shown inhibitory effects against various pathogenic bacteria and fungi, reducing the risk of microbial infections in *C. gariepinus* juveniles (Amadi & Obeagu, 2018; Sowunmi et al., 2016).

#### *Anti-inflammatory and analgesic properties*

The *T. sinapou* ethyl acetate extract was evaluated for its anti-inflammatory activity, which was proven by inhibiting the recruitment of total leukocytes and neutrophils induced by various inflammatory stimuli; this action may be attributed to the presence of flavonoid and phenolic components in the extract (Martinez et al., 2012). The *T. bracteolata* has been traditionally used in Ayurvedic medicine for its

anti-inflammatory and analgesic properties. It treats rheumatism and arthritis (Sakat et al., 2010). *T. bracteolata* leaf extract also exhibits anti-inflammatory activity in *C. gariepinus* juveniles. It can reduce inflammation by inhibiting pro-inflammatory mediators and modulating inflammatory pathways, thereby alleviating inflammatory conditions (Sowunmi et al., 2016).

#### *Anti-diabetic activity*

The anti-diabetic activity of *T. calophylla* methanol extract was carried out using in-vitro and in-vivo methods against alloxan-induced diabetes in albino Wistar rats. The result showed a significant reduction in blood glucose levels compared to the diabetic control group. The extract also effectively reduced serum concentrations of serum glutamic oxaloacetic transaminase, triglycerides (TG), total cholesterol (TC) and urea and increased insulin levels. *Tephrosia calophylla* could also inhibit the in-vitro  $\alpha$ -glucosidase and  $\alpha$ -amylase activity (Ramesh & Rani, 2018). Some studies have suggested that *T. bracteolata* may possess anti-diabetic properties. It has been used in traditional medicine to help manage diabetes (Panda et al., 2016)

#### **Toxicity studies of the *Tephrosia bracteolata***

Several studies have investigated the toxicity of *T. bracteolata* leaf extracts on various organisms, as typified by the study of Singh & Singh (2015), who conducted an experiment using *T. bracteolata* leaf extract on *Daphnia magna*, revealing its toxic effects on the organism survival and reproduction. Additionally, Kumar et al. (2018) examined the toxicity of *T. bracteolata* leaf extract on *Artemia salina* and found significant mortality rates at higher concentrations; this established that dose is one of the various mechanisms contributing to the toxic effects of *T. bracteolata* leaf extract. Studies by Ahmed et al. (2016) and Gupta et al. (2018) elucidated bioactive compounds

(phytochemicals) such as alkaloids, flavonoids, and tannins, which are responsible for the *T. bracteolata* leaf toxic properties. These phytochemicals can disrupt cellular processes, impair vital organ functions, and induce oxidative stress in aquatic organisms. Among the toxicity possibly exhibited by and conducted in toxicological studies are acute and chronic, with their various subcategories such as subacute and subchronic premising of testing duration.

#### *Acute toxicity studies*

Acute toxicity studies have revealed varying toxicity in *T. bracteolata* leaf extract's exposed fish. For instance, a study by Sharma et al. (2018) conducted acute toxicity tests on *C. gariepinus* exposed to different concentrations of *T. bracteolata* leaf extract in mg/ L. The results indicated a dose-dependent mortality rate, with a calculated LC<sub>50</sub> after 96 hours of exposure.

#### *Chronic toxicity studies*

Chronic toxicity studies provide insights into the long-term effects, such as the *T. bracteolata* leaf extract on fish, which examines growth patterns, reproductive parameters, and biochemical changes in exposed organisms. A study by Singh et al. (2020) investigated the chronic toxicity effects of *T. bracteolata* leaf extract on *C. gariepinus* juveniles for 30 days.

#### *Ecological implications of the T. bracteolata*

The toxicity effects of *T. bracteolata* leaf extract on *C. gariepinus* have significant ecological implications. Nduka & Enyoh (2017) examined the potential impact of *T. bracteolata* leaf extract on non-target aquatic organisms. They emphasised the need for proper dosage regulation to mitigate adverse effects on the aquatic ecosystem. The study established that understanding the ecological consequences is crucial for developing effective management strategies. A typical example of aquatic life is the *Clarias gariepinus*, whose features are discussed below.

#### ***Clarias gariepinus*: Taxonomy**

Kingdom: Animalia, Phylum: Chordata, Class: Actinopterygii, Order: Siluriformes, Family:

Clariidae, Genus: *Clarias*, and Species: *C. gariepinus*. *C. gariepinus* is a species of catfish commonly known as the African catfish or the sharp-tooth catfish. It belongs to the family Clariidae and is native to various African freshwater habitats. This species is widely cultured for food and used for research due to its hardiness, adaptability, and ease of maintenance in captivity (Food and Agriculture Organization of the United Nations, 2012).

#### *Natural distribution and habitat*

The *C. gariepinus* is a freshwater fish species widely distributed, according to De Graaf & Janssen (1996), in freshwater systems throughout Africa, from Senegal and Gambia in the west to the Zambezi River system in the East. The species is also present in some parts of the Nile River system in Egypt, Sudan, and Ethiopia. Regarding habitat, *C. gariepinus* is a euryhaline species that can tolerate various environmental conditions. The species is found in rivers, streams, lakes, swamps, and artificial habitats such as reservoirs and aquaculture ponds. *C. gariepinus* prefers slow-moving or stagnant water with dense vegetation, although it can also tolerate fast-flowing water.

#### *Mode of feeding*

The *C. gariepinus* is an omnivorous species that feeds on various food items, including insects, crustaceans, molluscs, algae, plants, and other small fishes. The *C. gariepinus* is a nocturnal and opportunistic predator that feeds on a wide range of prey, including fish, crustaceans, insects, molluscs, and aquatic plants (Adite et al., 2017). The fish takes commercial feeds formulated explicitly for omnivorous fish and feeds on live or frozen foods such as bloodworms, brine shrimp, and other tiny aquatic organisms.

#### *Reproduction*

*Clarias gariepinus* exhibits various breeding behaviours, with some species engaging in courtship rituals and nesting activities. The male often establishes territories and constructs nests, while females lay their eggs in these nests (Jensen et al., 2008). Most catfish species practise external fertilisation; the female releases

eggs, and the male releases sperm to fertilise them. The process usually takes place within the nest prepared by the male. Male catfish construct nests by clearing debris and creating depressions in the substrate. They may use their mouths to shape the nest and defend it from other fish. After fertilisation, the males guard the eggs to protect them from predators and maintain favourable conditions. They fan the eggs with their pectoral fins to ensure oxygen circulation. Once the eggs hatch, catfish larvae typically remain close to the nest. They rely on their yolk sacs until they can feed independently (Reig et al., 2012). According to Hogendoorn & Van der (1995) on the reproductive biology of *C. gariepinus*, the study noted that *C. gariepinus* exhibits high fecundity, with females producing up to 20,000 eggs per spawning event. The eggs hatched within 36 to 72 hours, and the larvae remained in the nest for several days before swimming away to find food.

#### *Environmental changes*

*Clarias gariepinus* is a highly adaptable species and can tolerate various environmental conditions. However, drastic or prolonged environmental changes can still pose significant challenges to their survival and overall population dynamics. Changes in water temperature can influence the fish's various physiological processes, including growth, metabolism, reproduction, and survival (Od Mwahiti et al., 2014). Also, fluctuations in dissolved oxygen, pH levels, and the presence of pollutants can impact its health and behaviour. Poor water quality can lead to decreased feeding activity, growth inhibition, and increased disease susceptibility (Adeogun et al., 2021). Changes in the structure and availability of aquatic habitats can affect fish behaviour and distribution; alteration of wetland habitats, such as dam construction and land-use changes, may disrupt the species' natural breeding and migration patterns (Iwanowicz et al., 2009).

#### **The toxicity of *Tephrosia bracteolata* leaf extract on *Clarias gariepinus***

The toxicological impacts of *T. bracteolata* leaf extract on *C. gariepinus* have been studied in detail. Akintola & Faturoti (2017) investigated the acute toxicity effects of *T. bracteolata* leaf extract on *C. gariepinus* fingerlings and reported adverse effects on mortality, behaviour, and physiological parameters. Similarly, Omitoyin et al. (2019) explored the sublethal effects of *T. bracteolata* leaf extract on *C. gariepinus*, observing alterations in liver enzymes, haematological parameters, and histopathological changes.

#### **Haematology of fish**

Haematology studies the bone marrow, lymph nodes, and spleen as a branch of medicine that focuses on diagnosing, treating, and preventing disorders related to the blood and blood-forming tissues. The main components of blood are red blood cells, white blood cells, and platelets. The primary functions of blood are oxygenation of tissues, nutrition of tissues, maintenance of acid-base balance and removal of metabolic waste products from tissues. Thus, any blood dysfunctions can severely affect the body's physiological activities. Also, specific physiological dysfunctions in the body are reflected as alterations in the blood constituents, which can be used as diagnostic indicators. The history of applying haematological methods as diagnostic aids in episodes of noninfectious and infectious diseases in confined and free-living fish populations is relatively meagre (Adebayo et al., 2007). Blood analysis is valuable for calculating the physiological condition of cultured fish, diagnosing diseases, and determining the effects of toxic substances and other environmental factors. Blood participates directly or indirectly in almost all biochemical processes in the body, and its composition is usually altered during diseases, malnutrition and even in toxic environments. Feed quality and the level of toxicant (such as the *Tephrosia bracteolata* leaf extract in this review) present in the fish culture influences the fish's haematological and biochemical blood

components. The biochemical component is sensitive to elements of toxicity in the environment (Adeyemo, 2007). Examples of the haematological components are erythrocytes (red blood cells: RBC), thrombocytes, and lymphocytes (white blood cell: WBC).

#### *Erythrocytes*

Erythrocytes, or red blood cells (RBC), are essential to fish blood. The fish erythrocytes generally have an oval or ellipsoidal shape and lack a nucleus and other organelles, allowing for more space to carry oxygen. Erythrocytes may vary in size, shape, and presence of specific structures, such as nucleoli in different fish species (Arellano et al., 2002). The erythrocyte count refers to the number of RBCs per unit blood volume. Hematocrit is the volume percentage of packed RBC to the total blood volume (Teimouri et al., 2016). An ESR is the rate at which erythrocytes settle in a vertical column of blood over a specific period, indicating fish's inflammation or disease (Mohammadi et al., 2019). Fish erythrocytes can change in size, shape, and haemoglobin content in response to environmental stressors, such as temperature, pollutants (such as the *Tephrosia bracteolata* leaf extract in this review), and handling stress (Kumar et al., 2016).

#### *Thrombocytes*

Thrombocytes, or platelets, are essential cellular components in fish blood clotting and wound healing. It consists of small, non-nucleated cells that play a role in hemostasis; they contain granules that contain factors involved in blood clotting. Fish thrombocytes also exhibit adhesive properties that assist in clot formation Boudreau & Zielinski (2018). Thrombocyte count refers to the number of platelets in a given volume of fish blood; the activation can be assessed by monitoring changes in their morphology and function (Abdo et al., 2020). Fish thrombocytes play a role in the immune response, including phagocytosis and the release of immune-related factors. They are involved in the defence against pathogens and contribute to the clearance of foreign particles (Chi et al., 2007). Under stress

conditions, such as handling, transportation, or exposure to pollutants, fish thrombocytes may show changes in their numbers, activation status, or adhesive properties (Xu et al., 2017).

#### *Lymphocytes*

Lymphocytes are a type of white blood cell (WBC) that plays a key role in fish's immune system. They recognise and respond to foreign substances (such as the *Tephrosia bracteolata* leaf extract in this review) and pathogens, producing specific immune responses. They recognise specific antigens presented by antigen-presenting cells and initiate immune responses, including the production of antibodies or the activation of immune cell-mediated defences (Zhang et al., 2010).

### **Histopathology of fish**

The histopathology of fish refers to examining and analysing tissue samples from fish to detect any abnormalities or lesions that may indicate disease or injury (Bernet et al., 2001). Histopathology is an essential tool in aquatic toxicology studies, as it allows researchers to evaluate the effects of environmental stressors, such as pollution or toxins (such as the *Tephrosia bracteolata* leaf extract in this review) on the fish health and population (Stentiford et al., 2003).

#### *Gill histopathological alterations*

Histopathological alterations in gills can result from various factors, including exposure to pollutants, pathogens, and environmental stressors. Pollutants such as heavy metals, pesticides, and industrial chemicals (such as the *Tephrosia bracteolata* leaf extract's components in this review) can lead to histopathological changes in the gill tissues of aquatic organisms. These alterations may include hyperplasia, which is an abnormal increase in the number of gill cells; necrosis, which is cell death in gill tissues; oedema, which is Swelling and fluid accumulation in gill lamellae; gill filament fusion which is the adhesion of gill filaments, reducing the respiratory surface area, hyperplasia; an abnormal increase in the number of gill cells (Giari et al., 2007). Bacterial, viral, and parasitic

infections can cause gill alterations, including epithelial hyperplasia, which is the thickening of the gill epithelium; inflammatory cell infiltration, which is the presence of immune cells in gill tissues and mucus production; and an increase in mucus secretion as a defence mechanism (Woo & Bruno, 2011). Different fish diseases can result in specific gill alterations. For example, the parasitic disease *Ichthyophthirius multifiliis* (white spot disease) can cause cyst formation and cell damage in gill tissues. Thus, environmental stressors like hypoxia (low oxygen), temperature fluctuations, and salinity changes can lead to gill changes (Richards & Farrell, 2011).

#### *Liver histopathological alterations*

The liver plays a key role in essential body functions, including regulating metabolism, synthesising plasma proteins, storing energy and specific vitamins and trace metals, and transforming the excretion of steroids and xenobiotics. Histopathological alterations in the liver can result from various factors, including exposure to toxins, infections, metabolic disorders, and other pathological conditions. Hepatic steatosis is characterised by the accumulation of fat droplets in liver cells (hepatocytes). It can be caused by factors like excessive alcohol consumption or non-alcoholic fatty liver disease, often associated with obesity and metabolic syndrome (Kleiner et al., 2005). Viral hepatitis (e.g., hepatitis B or C) and autoimmune hepatitis can lead to liver inflammation, which may result in hepatocyte damage, inflammation, and fibrosis (Lefkowitz, 2015). Chronic liver injury, including hepatitis or alcohol abuse, can progress to liver fibrosis and cirrhosis; this involves the deposition of fibrous tissue, disruption of liver architecture, and functional impairment (Bataller & Brenner, 2005). Granulomas are organised collections of immune cells often seen in liver tissue in response to various infections and diseases, including tuberculosis or sarcoidosis (Porta et al., 2016). Hemochromatosis is a genetic disorder characterised by iron overload in the liver and other organs. Liver biopsies may reveal iron

deposits and damage (Pietrangelo, 2016). Various liver tumours can result from stressors or pollutants (such as the *Tephrosia bracteolata* leaf extract in this review), including hepatocellular carcinoma (HOC) and metastatic tumours, which can exhibit specific histopathological features. The HCC, for example, can show trabecular growth patterns (Ferrell, 2015).

#### **Conclusion and recommendations**

The review conceives the idea of beneficial plant exploration by the fish farmers to treat their culturing aquatic organisms without considering the likely effects the plant parts or their extracts could have on the cultured fish. It is on that this review collates information on the effects that *Tephrosia bracteolata* leaf (ethanol) extract might have on *Clarias gariepinus* for the plant's toxicity. The review methodologically considers the taxonomy and natural distribution of the two organisms (plant and fish), starting with the *Tephrosia bracteolata* medicinal properties and chemical constituents such as the flavonoids, alkaloids, tannins, steroids, saponins, and glycosides through which the plants might pose harmful threats to the aquatic lives if the fish cannot withstand the dose of the plant's extract. The review also considers the *Tephrosia bracteolata*'s pharmacological properties, ranging from antioxidant activity, anti-cancer and anti-ulcer activities, hepatoprotective and immunomodulatory activities, antimicrobial and antibacterial activities, anti-inflammatory and analgesic properties to anti-diabetic activity which plant's aforementioned chemical constituents can trigger. The review never neglects to account for various toxicity studies, such as the acute and chronic, which might give clues to the ecological implications of the *Tephrosia bracteolata* under consideration on the test fish, e.g., *Clarias gariepinus*. The review also accounts for the *Clarias gariepinus*' taxonomy and its natural distribution and habitat, mode of feeding, and reproduction to fully be aware of the likely environmental changes the plant and its extract can influence. The toxicity

of *Tephrosia bracteolata* leaf (ethanol) extract on *Clarias gariepinus* was considered for haematology parameters: erythrocytes (the red blood cell), thrombocytes, and lymphocytes (the white blood cell). Lastly, the review examines the histopathology of the fish concerning gill and liver alterations, which can be triggered when the fish is exposed to plant extracts.

Thus, the review advises the fish farmers to consider dose-response of the plant's extract, which they are exploring for various benefits. The solvents (such as aqueous, ethanol, and methanol) for extraction should also be considered to secure the health of the fish and the ecological implications of their actions.

### **Toxicological implications of the study**

- ❖ *Understanding toxicity and safety:* Fish farmers need to know the potential toxic effects of *Tephrosia bracteolata* leaf (ethanol) extract on *Clarias gariepinus*; this knowledge helps ensure that the use of such plant extracts is safe for the cultured fish and does not lead to harmful consequences.
- ❖ *Informed decision-making:* The review provides comprehensive information on *Tephrosia bracteolata*'s pharmacological properties and chemical constituents; this allows fish farmers to make informed decisions about whether to use the plant's extract based on its potential benefits and risks.
- ❖ *Ecological considerations:* The review emphasises the importance of considering environmental impact by accounting for the ecological implications of using *Tephrosia bracteolata* extract. Fish farmers can thus avoid practices that may harm the broader aquatic ecosystem.
- ❖ *Optimising dosage and application:* The review's emphasis on dose response and the solvents used for extraction aids fish farmers in optimising the dosage and method of application of *Tephrosia bracteolata* extract; this ensures the health and well-being of the

fish while maximising the extract's beneficial properties.

- ❖ *Advancement of aquaculture practices:* The insights gained from the review contribute to the advancement of aquaculture practices by promoting the exploration of natural, plant-based treatments; this can lead to more sustainable and innovative approaches to fish farming, benefiting both the industry and the environment. for the betterment of aquaculture practices.

### **Limitations to the study**

- ❖ *Lack of comprehensive understanding:* The review focuses on the effects of *Tephrosia bracteolata* leaf (ethanol) extract on *Clarias gariepinus* but does not consider the full spectrum of possible plant parts and extracts; this narrow focus might limit the understanding of other potential beneficial or harmful plant-based treatments.
- ❖ *Generalisation of results:* The findings are specific to *Tephrosia bracteolata* and *Clarias gariepinus*; applying these results to other plants or fish species might not be valid, leading to potential misapplication or oversight in broader aquaculture practices.
- ❖ *Dose-response relationship complexity:* While the review advises considering dose-response relationships, it may not fully account for the complex interactions and variability in response among different fish populations or environmental conditions; this can lead to challenges in standardising safe and effective dosages.
- ❖ *Incomplete ecological impact assessment:* Although the review mentions ecological implications, it might not comprehensively assess *Tephrosia bracteolata* extracts' long-term and broad ecological impacts; this can result in unforeseen negative consequences on the aquatic ecosystem.
- ❖ *Potential oversight of synergistic effects:* The review might not fully explore the synergistic effects of *Tephrosia bracteolata*'s chemical

constituents when combined with other plant extracts or treatments. This oversight can affect the efficacy and safety of using multiple plant-based treatments simultaneously, necessitating further research and comprehensive evaluations to ensure the safe and effective use of plant extracts in aquaculture practices.

### **Ethical consideration**

The author did not conduct an experimental trial, so there was no need for ethical approval.

### **Conflict of interest**

The author declares no conflict of interest

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