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Botanical specifications, chemical composition, and pharmacological applications of Tartara (*Digera muricata* L.) – A review

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Abstract

Tartara (*Digera muricata* L.) is an annual herb having approximate height ranging from 20-70 cm. It is an important medicinal herb belonging to the Amaranthaceae family that is found as a weed in various regions of South Asia. The genus Tartara is known to contain 600 species widely distributed in tropical regions of the world. It is widespread in eastern tropical Africa from Sudan and Ethiopia south to Tanzania, Madagascar and tropical and subtropical Asia from Yemen to Afghanistan, Pakistan, India, Malaysia, and Indonesia. Tartara is an impressively aromatic plant that is used as herb of sweet taste and known to contain carbohydrates, proteins, lipids, phenols, chlorophylls, and amino acids as major chemical compounds in various parts of this plant. Some essential phytochemicals of *Digera muricata* L. include α-spinasterol, β-spinasterol, flavonoids, alkaloids, terpenoids, saponins, coumarins, tannins, cardiac glycosides, anthraquinones, rutin and hyperoside flavonoids along with vitamins such as ascorbic acid, thimine and β-carotene. Some of the well-known phytochemicals of *Digera muricata* L. are lycopene in tomatoes, iso-flavones in soy and flavonoid in fruit due to which they are known to possess prophylatic, anti-microbial, anti-oxidant, anti-diabetic, anthelmintic, anti-testicular, allelopathic and protective effects thus used to treat renal disorders, kidney stones, dysfunctional proteins, nephrotoxicity, increase level of urine creatinine, protein, nitrite, urobilinogen, red blood cells, leucocytes count and levels of blood urea nitrogen. It is also found effective against carcinogenicity in humans and cause glutathione depletion, resulting in intracellular oxidative stress.

Keywords: *Digera muricata* L., α-spinasterol, β-spinasterol, saponins, coumarins, thimine, β-carotene, anti-diabetic, anti-testicular, allelopathic effects, dysfunctional proteins

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1. Botanical perspective

Tartara (*Digera muricata* L.) is an annual herb growing upto 20-70 cm tall. It is an important medicinal herb belongs to Amaranthaceae family, found as a weed throughout South Asia. Though almost all of its parts are used in traditional systems of medicines, leaves, roots and shoots are the most important parts which are used medicinally [1]. The genus Tartara contains 600 species and is mainly distributed in tropical regions. This weed flower is known as false amaranth. It is widespread in eastern tropical Africa ranging from Sudan and Ethiopia south to Tanzania, Madagascar and tropical and subtropical Asia starting from Yemen to Afghanistan, Pakistan, India, Malaysia, and Indonesia. In India, this plant is widely distributed in Rajasthan, Maharashtra and Andhrapradesh. In English, it is typically called "false amaran". It is known as "latmahuria" and "lesua" in India and Bangali called it "latamouri ful", "gun gutiya" and in Pakistan it is known as "tandla". The stem is simple or branched, sub-glabrous and ridged. Leaves are alternate, simple; flowers are borne on slender spike-like racemes which can be as long as 30 cm [2].

The flowers of *Digera muricata* L. are white to pink in appearance and hairless in texture. During flowering stage, the colour of its flowers changes from carmine red to greenish white. In the coastal tribes of Kenya, the flowers of *Digera muricata* L. are popular as a vegetable. In some Indian dishes, leaves of the *Digera muricata* L. are used in making curries and sometimes, whole plant is boiled and seasoned to be used with red chili flacks and regular salt. This plant is also used by the grazing animals like goats and sheep as forage [3]. The floral part of this plant is full of nectar and this juice is also sucked by the children in Kenya. The spikes and leaves of *Digera muricata* L. are used as a very nutritive vegetable. Seeds and flowers are useful in

treatment of excessive urinary discharges [4]. Since past few decades, extensive research work has been conducted in order to explore the pharmaceutical potentials and biological activities of its extracts. Some recent investigations have confirmed the presence of anthraquinones, cardiac glycosides, tannins, coumarins, saponins, terpenoids, alkaloids and flavonoids in *Digera muricata* L. [1].

2. Demographic locations

The occurrence of the species is usually relative to gram crop and human activity in Pakistan. It is considered that this species was likely introduced to many countries by agricultural activities. Several populations were recently found in a short time in central Taiwan, and this species has the potential to be an invasive plant. The *Digera muricata* L. was found native to the eastern tropical and northeastern areas of the Madagascar and Africa. It is also found in some areas of Indonesia, Malaysia, India, Afghanistan and Yamin. This plant is mostly distributed to the waste grounds in a variety of habitats starting from the dry savanna to semi-deserted moisture localities on the mud soils and deep clays at the depth of fifteen hundred meters. Sometimes, this plant also creates troubles as it grows as a weed in the fields. *Digera muricata* L. is mostly cultivated in the northeast tropical regions of the world [5].

3. Morphological features and ecological specifications

The *Digera muricata* L. is an annual herbaceous plant attaining the approximate height of seventy centimeter with small, rigid, sub-glabrous and branched stems [6]. Its leaves have alternate venation with simple petioles ranging upto five centimeters. Leaf blades are linear to ovate in shape with narrowed base, acuminating apex and almost sub-glabrous shape. Its flowers contain long-pedunculate having the approximate length of fourteen centimeters and bracteate raceme upto thirty centimeters. Its inflorescence contains sub-sessile partial flowers with one central fertile flower and two lateral sterile flowers. The flowers of *Digera muricata* L. are found attached on spike-like cylindrical raceme having the length of thirty centimeters [6].

The hairless flowers of *Digera muricata* L. show light pink to carmine red colour and become greenish white during fruiting season. Flowers are usually grown in August and September. Fertile flowers contain boat shaped, firm outer perianth having three to five millimeters length. Within larger petiole, there are two to three smaller and longer hyaline segments with five stamens. These stamens are free to move and slightly connate at the base with superior ovary and one celled style. Its filiform style is four millimeters long and has two stigmas with lateral flowers constituting accrescent antler-shaped scales [6].

The fruit of *Digera muricata* L. is hard in texture and sub-globose in shape with two millimeter diameter. It is enclosed by the rigid and persistent perianth along with small bracteate and sterile flowers. The *Digera muricata* L. consist of only one species. However, based on the venation of outer tepals, there are two recognized sub-species of this plant. The outer tepals of *Digera muricata* L. found in Asia have seven to twelve veins. The same species when found in Madagascar and eastern Africa, contain three to five veins in outer tepals. Depending upon the different scales of sterile flowers and hairiness of leaves, various sub-species have been identified. It is mostly used as leafy vegetable due to its larger leaves [6].

Digera muricata L. is commonly found distributed on waste grounds, dry savanna and some semi-deserted to moist localities on mud soils and deep clays upto the altitude of fifteen hundred meters. It is also grown as wild plant and cause number of problems for regular crops and vegetables. Its cultivation occurs in northeast tropical Africa (Ethiopia) and in Indian subcontinent (India). Seed of Tartara vary with response of temperature, depending on light, dark condition. Seed of Tartara germinated hundred percent to light and darkness at 35°C but continuous light increases inhibitory effects [7].

4. Essential chemical constituents

Tartara is an impressively aromatic plant that is used as herb of sweet taste. Tartara ecotypes have been described based on their taste, flavor, and other phenotype. Tartara leaf color is green and flower colour is purple and plant may grow seventy centimeter tall, depending on the type of species. The distinctiveness of fragrance and aroma in many Tartara species/cultivars is due to the presence of essential oils in leaves and other part of plant. Different solvent extracts of *Digera muricata* L. have been found to contain appreciable concentrations of amino acids, phenols, chlorophylls, lipids, proteins and carbohydrates. In addition to these primary metabolites, this plant also contains the β-spinasterol and α-spinasterol. The chemical analysis of various fractions of *Digera muricata* L. constitutes large number of anthraquinones, cardiac glycosides, flavanoids, tannins, alkaloids, coumarins, terpenoids and coumarins.

Rutin and hyperoside flavonoids have been identified in hexane extract of this plant. Tartara volatile oil is largely confined in green leaves. Tartara contain fifty four to fifty eight milligrams edible portion, ash value 3.52-3.56 milligrams, mineral contents in Tartara includes: calcium 506mg/100g, potassium 604mg/100g, magnesium 232mg/100g and phosphorus 63mg/100g. Some trace minerals like iron 17.72 mg/100 g and zinc 0.57mg/100g are also found. Tartara contain vitamin contents ascorbic acid 49mg/100g, thymine 0.10mg/100g and β-carotene 3-30mg/100g. Detailed chemical structures of rutin (Figure 1), anthraquinone (Figure 2), hyperoside (Figure 3) and coumarin (Figure 4) are shown in figures 1-4 and nutrient levels (Table 1), mineral contents (Table 2), trace mineral elements (Table 3) and vitamins contents (Table 4) of *Digera muricata* L. are also listed in tables 1-4.

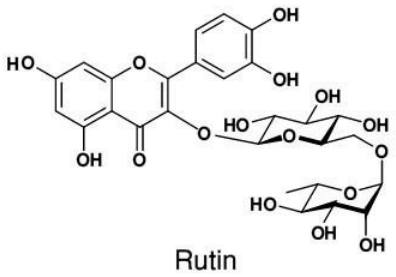

Figure 1: Chemical structure of rutin

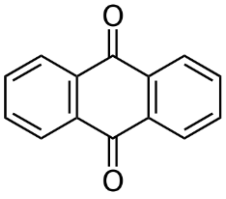

Figure 2: Chemical structure of anthraquinone

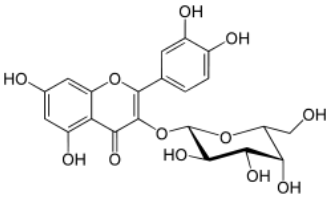

Figure 3: Chemical structure of hyperoside

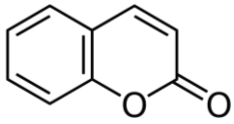

Figure 4: Chemical structure of coumarin

Table 1: Nutrients levels of *Digera muricata* L.

Parameter	Concentration (g/100g)
Edible portion	56
Ash value	3.54
Moisture	83.8
Protein	4.3

Table 2: Mineral contents of *Digera muricata* L.

Parameters	Concentration (mg/100g)
Calcium	506
Potassium	604
Magnesium	232
Sodium	232
Phosphorus	63

Table 3: Trace minerals of *Digera muricata* L.

Parameters	Concentration (mg/100g)
Iron	17.72
Zinc	0.57
Copper	0.16
Chromium	0.243
Manganese	0.23

Table 4: Vitamin contents of *Digera muricata* L.

Parameters	Concentration (mg/100g)
Ascorbic acid	49
Thimine	0.10
Total-Carotene	17.93
B-Carotene	3.36

Complete chemical characterization of different fractions of *Digera muricata* L. have indicated the presence of saponins, anthraquinone, flavanoids, cardiac glycosides, alkaloids, tannins, coumarins and terpenoids. All these secondary metabolites are produced for the purpose of defence in plants. However, some recent studies have shown that these metabolites are not only used by the plants but also by the human beings for the treatment of number of ailments. Thousands of phytochemicals are found in different parts of plants. Few well-known chemicals in fruits and vegetables are: (i) lycopene of tomatoes (ii) iso-flavanoids of soy and (iii) flavanoids of fruity plants. Number of researches and scientific investigations has proved the anti-oxidant potentials of *Digera muricata* L.

Anti-oxidant activities and free radical scavenging potentials of different solvent extracts of *Digera muricata* L. such as aqueous extracts, ethanolic extract, methanolic extract, chloroformic extract, etheric extract and hexane based extracts have been analyzed by various scientists. Methanolic extracts showed the maximum and hexane base extracts showed the minimum activity. The methanolic extracts of the leaves of *Digera muricata* L. also exhibited anti-diabetic potentials in alloxan induced diabetic rats when used in a dose dependent manner. Similarly, n-hexane base extracts are excellent nephroprotective agents in rats having artificially induced nephrotoxicity by using tetrachloride. Maximum positive effects were shown by the roots of this plant. The *Digera muricata* L. is also a rich source of magnesium, calcium, potassium, phosphorous and iron [8].

5. Commercialized value added products

The *Digera muricata* L. is an annual deserted plant that grows only after heavy rainfall at high temperature [3]. After the maturation and death of these plants, all the organic matter enters the soil as leachates and releases huge amount of phenolic contents allowing the various other plants to grow after monsoon. The amount of soil chemicals and allelopathic phytotoxic compounds depend on the number of donor plants in close vicinity [3].

Like many other herbaceous crops, *Digera muricata* L. is also grown for the number of purposes. In a

recent research investigation, the leaves of *Digera muricata* L. were collected from the plant grown in wild areas. The collected leaves were washed and dried under shade for about three weeks. These dried leaves were crushed to fine powder prior to the solvent extraction. For the solvent extraction, five different chemicals such as water, methanol, acetone, chloroform and hexane were used. The plant material was extracted three times during seventy two hours to extract essential phytochemicals. After the completion of extraction, extracts were filtered and the solvents were evaporated using rotatory evaporator at the approximate temperature of about 50 ˚C [9].

For the further use, these extracts were stored at 80 ˚C and percentage yield was calculated for each different solvent. The results showed following yields: (i) water (18.01 %) (ii) methanol (7.42 %) (iii) acetone (1.68 %) (iv) chloroform (1.67 %) and (v) hexane (0.072 %). All these extracts were further tested for anti-bacterial potentials using different types of gram positive and gram negative bacteria by micro-dilution method. The results indicated that all the hexane based extracts showed maximum activity against all tested pathogens. Acetonic and chloroformic extracts only showed moderate results against pathogens. The "minimum-inhibitory-concentration" (MIC) of hexane base extracts was one hundred and ninety five micrograms per milliliters towards *Bacillus subtilis* and *Staphylococcus aureus* as compared to all other bacterial strains. The anti-microbial and anti-oxidant activity of *Digera muricata* L. provide the platform for its excessive utilization in herbal system of medicines [10].

Digera muricata L. is an edible and medicinal plant having number of applications in traditional and folk system of medicines. Various parts of this plant are used in treatment of secondary infertility most commonly found in the patients suffering from hepatic disorders. In Ayurvedic system of medicines, this herbaceous plant is considered as a cooling agent, astringent to bowels and used as a laxative agent. The seeds and flowers of *Digera muricata* L. are used to treat urinary obstructions. The infusion of boiled roots is helpful in lactating mothers, immediately after childbirth.

In the carbon-tetrachloride-induced-nephrotoxicity, free radicals are generated and involved in the accumulation of dysfunctional proteins and lipid peroxidation resulting in the injured kidneys. The treatment of all these diseases is possible by the use of *Digera muricata* L. as it augments the removal of free radicals. In some recent articles, researches were conducted to standardized the phytochemical and pharmacognostical analysis [11]. The anti-oxidant properties of *Digera muricata* L. were found to be effective against carbon-tetrachloride-induced-nephrotoxicity in testis and kidneys. These model animals can also prove to be the best for studying the hypogonadism in rats.

6. Pharmacological applications

Medicinal plants and Ayurvedic system of medicines is getting renewed attention with the advent of modern chemical drugs as people are moving from marginal use of herbs to the pharmaceutical uses for better healthcare management. In Pakistan, there are around three thousand different plant species known for their therapeutic potentials and medicinal uses. According to some estimates, almost six thousand plants are used in traditional and folk system of medicines in Pakistan. There are different systems of treatment in Pakistan including: (i) Ayurvedic system of medicines (ii) homoeopathic system of medicine (iii) unani system of medicines and (iv) siddha system of medicines.

The evaluation of all these plant based drugs is dependent on some allied and pharmacological approaches involving the use of various separation techniques and characterization equipments such as the microscopy and chromatography. With the increasing interest and global attention, serious efforts are being made to adopt and study the traditional system of medicines for the exploration of their potentials in healthcare system. Similarly, evaluation of the conventional medicinal remedies is of great importance. The detailed study and comprehensive assessment of *Digera muricata* L. is of great importance as the flowers, seeds, stems, leaves and roots of this plant are known to contain large number of medicinal components. Therefore, all the parts of this plant are used as medicinal remedies. The crude drugs are obtained from this plant and used to treat urinary disorders and kidney stones.

The ethnopharmacological uses of *Digera muricata* L. have been found to treat number of renal disorders and to act as a refrigerant and aperients. Some secondary infertility problems are also solved by the use of this plant. The anti-oxidant potentials of *Digera muricata* L. have also been documented against carbon-tetrachloride-induced-toxicity for testis and kidneys [12]. The young shoots and leaves of this plant are used as vegetable and as a medicine to treat the severe constipation. Different parts of *Digera muricata* L. are used for internal stomach disorders and its seeds are found to be effective in urinary disorders in Pakistan and India. Leaf paste is also locally applied to prevent the formation of pus cells and severe infections [12].

Digera muricata L. commonly known as "Tartara" is an annual medicinal herb widely used in herbal medicines for the treatment of number of diseases. In Ayurvedic system of medicines, this plant acts as a cooling agent and astringent of bowels. It is also used as laxative agent under severe conditions. The leaves of *Digera muricata* L. are used for the treatment of diabetes. The most pronounced use of this medicinal plant is the uptake in form of root infusion for the enhancement of lactation period in feeding mothers. The seeds and flowers of this plant are used to treat number of problems related to urinary discharge. The ethanolic extract of *Digera muricata* L. is diuretic in action.

6.1 Prophylatic agent

The *Digera muricata* L. is known to contain large number of phytochemicals having different modes of actions and pharmaceutical potentials. Every chemical compound has its possible effect as many bioactive compounds acts as an anti-oxidant to defend our body against oxidative stress and reduces the risk of certain types of cancer (cancer is an uncontrolled cell division). The allyl sulfides (obtained from garlic, leeks and onions), carotenoids (obtained from carrots and other fruits), flavanoids (obtained from vegetables and fruits) and polyphenols (obtained from grapes and tea plant) are some of the potential anti-oxidants of nature. Similarly, iso-flavones is found in soy plant and helps to imitate the estrogen level in human beings to reduce the symptoms of osteoporosis and menopause [13].

6.2 Anti-microbial activity

Different solvent extracts of *Digera muricata* L. has shown strong anti-bacterial and anti-fungal effects against some selected groups of bacteria and fungi. The soxhlet extraction of *Digera muricata* L. by using distilled water, ethanol, chloroform and petroleum ether, has very pronounced effects on the inhibition of growth of pathogens in a concentration dependent manner. The optimum values have been obtained by using two hundred to four hundred micrograms of plant extracts. The methanolic extract of the *Digera muricata* L. has shown maximum effects against all the tested fungal and bacterial species [14].

6.3 Anti-oxidant potential

Large numbers of scientific studies are in support of strong anti-oxidant potentials of *Digera muricata* L. In a recent research, the anti-oxidant activities of this plant are determined by the free radical scavenging potentials using different solvent extracts including aqueous extracts, ethanolic extracts, methanolic extracts, chloroformic extracts, etheric extracts and hexane based extracts [15]. The maximum activity was exhibited by the methanolic extracts and hexane based solvent extracts showed negligible effects among all. Methanolic extracts of this plant were screened for free radical scavenging potentials using DPPH (1,1-diphenyl-2-picryl hydrazyl) radical scavenging assay. The roots of this plant showed maximum anti-oxidant potentials and methanolic extracts were more potent for carbon-tetrachloride-induced-nephrotoxicity in testis and kidneys of experimental animals [2].

6.4 Anti-diabetic effects

The methanolic leaf extracts of *Digera muricata* L. are known to show strong anti-diabetic potentials in number of alloxan induced experimental diabetic rats. The results of this experimental investigation are in strong support of use of dose upto two hundred milligrams per kilograms of body weight in diabatic rats during anti-hyperglycemic activity. Some other experimental parameters such as body weight was increased and high density lipoproteins (HDL) and blood glucose level in serum was significantly increased [16].

6.5 Anthelmintic activity

The leaf extract of *Digera muricata* L. was checked for its anthelmintic potentials in *Pheretima posthuma* (a species of earthworm) as experimental animal and the results were quite satisfactory [17].

6.6 Anti-testicular toxicity

In an experiment, protective potentials of hexane based extracts of *Digera muricata* L. were tested against carbon-tetrachloride-induced-testicular toxicity and carbon-tetrachloride-induced-hepatic toxicity. The results of this experiment showed that the leaf extracts have potential to reduce the liver injuries and oxidative stress. Similarly, the hypogonadism is caused by the liver cirrhosis in male rats and hexane based extracts of *Digera muricata* L. have full potential to treat this disease. These extracts ameliorated the severe hepatic injuries and increased the anti-oxidant potentials of various biochemical compounds including enzymes. In addition to the repairing of testis and various other accessory organs, these extracts increased the level of testosterone in experimental animals.

The positive effects of these hexanoic extracts against carbon-tetrachloride-induced-toxicities were mainly attributed to the presence of certain bioactive compounds more specifically hyperoside and rutin. Therefore, *Digera muricata* L. is used to treat renal disorders in folk system of medicines. These extracts are given to the patients suffering from kidney stones on daily basis. Large numbers of free radical species are produced by the carbon-tetrachloride-induced-nephrotoxicity involving the production of lipids, and accumulation of useless body proteins resulting in the severe kidney injuries. Nephrotoxicity is caused by the poisonous effects of various harmful chemical constituents on kidney. Methanolic and hexane based extracts of this plant are well-known for their nephron-protective effects in carbon-tetrachloride-induced-nephrotoxicity [9].

6.7 Allelopathic effects

The aqueous extracts of the leaf, root and stems of *Digera muricata* L. exhibit strong allelopathic effects on the seed germination in bajra (*Pennisetum typhoideum*). Variable concentrations of the different parts of this plant more specifically "weeds" show inhibitory effects on the proper growth and development of root and shoot of *Pennisetum typhoideum* as compared to the root and stem [3].

6.8 Protective effects

The hexane based and methanolic extracts of the *Digera muricata* L. show strong protective effects against severe oxidative stresses caused by the artificially induced

oxidative stress in experimental animals. This protective effect is also attributed to the involvement of methanolic extract in the treatment of carbon-tetrachloride-induced-toxicities by inhibiting metabolism of carbon tetrachloride. Hence, this study supports the pharmaceutical uses of this plant in treatment of number of diseases [18].

6.9 Renal disorders

As mentioned before, various extracts of *Digera muricata* L. are best known for their pharmaceutical potentials in number of diseases and so is the case of renal disorders. Therefore, this plant has long been used for the treatment of various ailments in folk system of medicines. The extracts of *Digera muricata* L. is used to treat kidney stones in patients through daily administration of doses. The production of large number of free radical species is also implicated in carbon-tetrachloride-induced-nephrotoxicity directly involving in collection of dysfunctional proteins, lipid per-oxidation and severe renal injuries [12].

7. Summary and conclusions

Tartara *(Digera muricata* L.) contain flavonoids, alkaloids, terpenoids, saponins, coumarins, tannins, cardiac glycosides and anthraquinones. *Digera muricata* L. used internally against digestive system disorders and in India, its seeds and flowers are used to treat urinary disorders. It poses anti-bacterial, anti-fungal, anti-diabetic, hepato-protective, nephron-toxicity protective, anthelmintic and free radical scavenging properties. It is a rich source of phenols, tannins, terpenoids, flavonoids and glycosides that is medicinally important and/or nutritionally valuable. The plant is rich in carbohydrates, Ca, K, ascorbic acid, Fe and Mg.

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