



Botanical Specifications, Chemical Composition and Pharmacological Applications of Tartara (*Digera muricata* L.) – A Review

Abdul Ghaffar¹, Bui Thanh Tung², Rafia Rahman¹, Farwa Nadeem^{1*} and Muhammad Idrees Jilani³

¹Department of Chemistry, University of Agriculture, Faisalabad-38040-Pakistan, ²Department of Pharmacology and Clinical Pharmacy, School of Medicine and Pharmacy, Vietnam National University, Hanoi, Vietnam and ³Department of Chemistry, University of Sahiwal, Sahiwal, Pakistan

Abstract

Tartara (*Digera muricata* L.) is an annual herb having approximate height ranging from 20-70 cm. It is an important medicinal herb belongs to the Amaranthaceae family that is found as a weed in various regions of India. 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 prophylactic, 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 also 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

Full length article *Corresponding Author, e-mail: farwa668@gmail.com

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 India. 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 also 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]. Flowers are hairless, white mixed with pink to carmine or red, usually becoming greenish-white in fruit. In Kenya, they are particularly popular as a cooked vegetable between coastal tribes. In India, the leaves are made into curries or the whole plant is boiled in water and seasoned with salt and chili. The whole plant is also commonly grazed as forage, particularly by sheep and goats. The flowers are rich in nectar which is sometimes sucked by children in Kenya. The leaves and spikes are used as a vegetable. Flowers and seeds used in the treatment of urinary discharges. For the last few decades or so, extensive research work has been done to

prove its biological activities and pharmacology of its extracts. Analysis of various fractions of the Tartara indicated the presence of flavonoids, alkaloids, terpenoids, saponins, coumarins, tannins, cardiac glycosides and anthraquinones [1].

2. Demographic Locations

Tartara is widespread in southern Asia from tropical Arabia and Yemen to Afghanistan, India, Malaysia and Indonesia, as well as in northeastern and eastern tropical Africa and Madagascar. The occurrence of the species is usually relative to gram crop and human activity in Pakistan, we consider that this species was likely introduced to Taiwan 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. Tartara was native to northeastern and eastern tropical Africa and Madagascar, also widespread in southern Asia from tropical Arabia and the Yemen to Afghanistan, India, Malaysia and Indonesia. Recently, this species was found as an alien species in central Taiwan. This is a new record of genus and species of the Amaranthaceae in Taiwan. Tartara is most commonly disturbed on waste ground, but occurs in many kinds of habitat, from dry savanna and semi-desert to moist localities on deep clay and mud soils, from sea-level upto 1500 m altitude. It also occurs as a weed in fields, sometimes being troublesome. Its cultivation occurs in northeast tropical regions.

3. Morphological Features and Ecological Specifications

Tartara is an annual herb that can be upto 70 cm tall its stem is simple or branched, sub-glabrous and ridged. Leaves alternate, simple, petiole upto 5 cm long; blade linear to ovate, 1–9 cm×0.2–5 cm, base narrowed, apex acuminate, margin entire, sub-glabrous. Inflorescence a long-pedunculate (upto 14 cm long), axillary, spike-like bracteate raceme upto 30 cm long, each bract subtending a sub sessile partial inflorescence with a central fertile flower and 2 sterile lateral flowers. Flowers are borne on slender spike-like racemes, which can be as large as 30 cm long. Flowers are hairless, white mixed with pink to carmine or red, usually becoming greenish-white in fruit. Flowering occurs in month of August and September. Fertile flower with 2 firm, boat-shaped outer perianth segments 3–5 mm long 2–3 inner, slightly shorter, hyaline segments; stamens usually 5, free or slightly connate at base; ovary superior, 1-celled, style filiform, upto 4 mm long, stigmas 2, divergent; lateral flowers consisting of accrescent antler-shaped scales. Fruit is sub-globose, hard, 2 mm in diameter, ridged, enclosed by the persistent perianth and falling together with the sterile flowers and bracteoles. Tartara comprises only 1 species. Based on the venation of the outer tepals 2 subspecies of Tartara have distinguished subspecies. Tartara with outer tepals 7-12 veined, mainly occurring in Asia, but also in eastern Africa and Madagascar with outer tepals 3–5-veined, mainly occurring in Africa. Based on hair ness of leaves and on form of scales in sterile flowers, several

varieties have been distinguished in subspecies. It seems most suitable as a leafy vegetable because it has large leaves. Tartara is most common on disturbed and waste ground, but occurs in many kinds of habitat, from dry savanna and semi-desert to moist localities on deep clay and mud soils, from sea-level upto 1500 m altitude. It also occurs as a weed in fields, sometimes being troublesome. 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 100% to light and darkness at 35°C but continuous light increases inhibitory effects [3].

4. Essential Chemical Constituents

Tartara is an impressively aromatic plant that is used as herb of sweet taste. Tartara ecotypes have been described on the basis of their taste, flavor and other phenotype. Tartara leaf colour is green and flower colour is purple and plant may grow 70 cm 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. The primary metabolites like carbohydrates, proteins, lipids, phenols, chlorophylls and amino acids of this plant in different solvent extracts have been investigated. The plant contains α -spinasterol and β -spinasterol. Analysis of various fractions of Tartara indicated presence of flavonoids, alkaloids, terpenoids, saponins, coumarins, tannins and cardiac glycosides and anthraquinones.

Rutin and hyperoside flavonoids have been identified in hexane extract of this plant. Tartara has explicit aromatic odor because of the existence of essential or volatile oil, which is largely confined in green leaves. Tartara contain 54-58 mg edible portion, ash value 3.52-3.56mg, mineral contents in Tartara contain calcium 506mg/100g, potassium 604mg/100g, magnesium 232mg/100g, phosphorus 63mg/100g. Some trace minerals like iron 17.72mg/100g and zinc 0.57mg/100g are also found. Tartara contain vitamin contents ascorbic acid 49mg/100g, thimine 0.10mg/100g and β -carotene 3-30mg/100g. Detailed chemical structures of rutin (fig 1), anthraquinone (fig 2), hyperoside (fig 3) and coumarin (fig 4) are shown and nutrient level (table 1), mineral contents (table 2), trace mineral elements (table 3) and vitamins contents (table 4) of *Digera muricata* L. are also listed in this review.

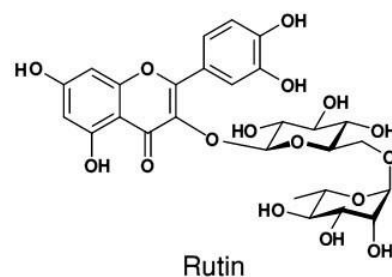


Fig 1 Chemical structure of rutin

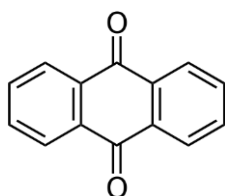


Fig 2 Chemical structure of anthraquinone

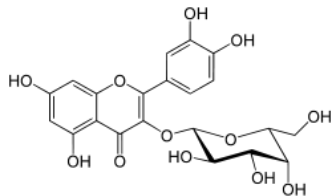


Fig 3 Chemical structure of hyperoside

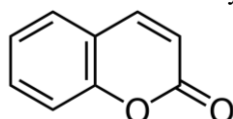


Fig 4 Chemical structure of coumarin

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

Analysis of various fractions of *Digera muricata* L. indicated presence of flavonoids, alkaloids, terpenoids, saponins, coumarins, tannins, cardiac glycosides and anthraquin. It is well-known that plant produces these chemicals to protect them but recent research demonstrates

that they can also protect humans against diseases. There are more than thousand known phytochemicals. Some of the well-known phytochemicals are lycopene in tomatoes, iso-flavones in soy and flavonoid in fruit. The plant has shown anti-oxidant activity in different investigations. Mety and other scientists analysed free radical scavenging and anti-oxidant activity of different solvent extracts like hexane, petroleum ether, chloroform, methanol, ethanol and aqueous media. The maximum activity was recorded in methanol and least activity was recorded in hexane. The methanolic crude extracts of *Digera muricata* L. was screened for their free radical scavenging properties by DPPH (1,1-diphenyl-2-picryl hydrazyl) radical scavenging assay. The methanolic extract of *Digera muricata* L. (MEDM) leaves exhibited anti-diabetic activity in alloxan induced diabetic rats. Extract of this plant is administered daily in kidney stone treatment. Nephrotoxicity is a poisonous effect of some substances on kidneys. The n-hexane and methanolic extract of *Digera muricata* L. shows protective role against tetrachloride which is induced nephrotoxicity in rats. The maximum activity was observed in roots of *Digera muricata* L. Phytochemicals are naturally present in many foods but it is expected that through bioengineering, new plants will be developed, which will contain higher level. *Digera muricata* L. is considered as an electron rich source of calcium, iron, phosphorus, potassium and magnesium [4].

5. Commercialized Value Added Products

Digera muricata L. is desert annual, which appears only after rains at high temperatures. When plant matures and dies down, the leachates enter the soil, which with the passage of time undergo degradation and level of phenolics declines thus allowing the germination of numerous other plants, in the field next year after monsoon showers. The distribution of allelochemicals phytotoxic substances and the amount of these substances depend upon the number of donor plant [5]. *Digera muricata* L. like other herbal plants is consumed in variety of ways for various purposes. The whole plant of *Digera muricata* L. was collected from local area. The leaves of *Digera muricata* L. were washed and dried under shade for 3 weeks [6]. The properly dried leaves were crushed and ground to fine powder. The powder was extracted three times for 72 h with five different solvents (100 ml each) in ascending order of polarity i.e. hexane, chloroform, acetone, methanol and water. The extracts were filtered and solvents were evaporated to dryness under temperature below 50°C to yield a crude extracts. The extracts were stored at 80°C till further use. The percentage yield of plant extract obtained was 0.072%, 1.67%, 1.68%, 7.42% and 18.01% in hexane, chloroform, acetone, methanol and water respectively.

The extracts were further tested for anti-bacterial activity against gram positive and gram negative bacteria by micro both dilution test. It was found that the hexane extract exhibited highest activity against all tested pathogens. Chloroform and acetone extracts exhibited moderate

activity. Hexane extract showed least MIC of 195µg/ml towards *Staphylococcus aureus* and *Bacillus subtilis* as compared to other bacterial strains. Anti-oxidant and anti-microbial activity of *Digera muricata* L. against tested organisms provides the platform for its utilization as herbal drug [7]. Tartara plant is edible and medicinal plant. In Kenya, they are particularly popular as cooked vegetables amongst costal tribes, the plant are rich in nectar which is sucked by children in Kenya. In India, leaves are made into curries the entire plant is boiled in water and seasoned with salt and chili. The whole plant is commonly grazed as forage, particularly by sheep and goat. Tartara is used as a both folk and traditional system of medicine.

This plant is used as an alternative for secondary infertility. Secondary infertility is found to be associated with hepatic disorders. In Ayurveda, herb is considered as a cooling, astringent to bowels and also used as laxative. The flowers and seeds are used to treat urinary discharges. Boiled root infusion given to mother after child birth for lactation purpose. Generation of reactive radicals has been implicated in carbon tetrachloride-induced nephrotoxicity, which are involved in lipid peroxidation, accumulation of dysfunctional proteins, leading to injuries in kidneys. *Digera muricata* L. treatment augments the anti-oxidants defense mechanism against carbon tetrachloride induced toxicity and provides evidence that it may have a therapeutic role in free radicals. Some investigations were performed to standardize plant by pharmacognostical and phytochemical analysis [8]. Anti-oxidant properties of *Digera muricata* L. against CCl₄-induced toxicity for kidneys and testis had been documented. The models created by the use of CCl₄ to induce liver injuries can be best suited to study the hypogonadism in rat.

6. Pharmacological Applications

Medicinal herbs are moving from marginal to typical use with a greater number of people seeking remedies and health approaches free from side effects caused by synthetic chemicals. India officially recognizes over 3000 plants for their medicinal value. It is generally estimated that over 6000 plants are used as traditional, folk and herbal medicine in India. Indian traditional medicine is based on various systems including ayurveda, siddha, unani and homoeopathy. The evaluation of these drugs is primarily based on pharmacological and allied approaches including various instrumental techniques as chromatography, microscopy and others. With the emerging worldwide interest in adopting and studying traditional systems and exploiting their potential based on different health care systems, the evaluation of the rich heritage of traditional medicine is essential. In this regard, one such plant is *Digera muricata* L. Tartara is a genus having one species only *Digera muricata* L. from Amaranthaceae family. The root, leaf, stem, seeds and flowers of this plant have medicinal properties and traditionally used as medicinal

plant. All parts of plant have been used as crude drug for treatment of kidney stone and urinary disorders.

Digera muricata L. ethno pharmacologically has been used in renal disorders, aperients and refrigerant. This plant is also used as an alternative for secondary infertility. Anti-oxidant properties of *Digera muricata* L. against CCl₄-induced toxicity for kidneys and testis had been documented [9]. The leaves and young shoots of this plant are locally used as a vegetable and given to relieve constipation. *Digera muricata* L. is used internally against digestive system disorders and in India seeds and flowers are used to treat urinary disorders. Leaf paste is applied locally to prevent pus formation [9]. Tartara is a wild edible herb used by village people. It is popularly known for herbal remedy for various ailments. In Ayurveda, this herb is considered as cooling, astringent of bowels and also used as a laxative agent. The leaves are used for treatment of diabetes. But the scientific basis for its medicinal use especially for boiled root infusion given to mother after child birth to increase lactation purpose is to be evaluated. The flower and seeds are used to treat urinary discharges. Ethyl alcohol extract of plant is diuretic in action.

6.1 Prophylactic Agent

Digera muricata L. contain many phytochemicals and each works differently. These are some possible actions. Most phytochemicals have anti-oxidant activity and defend our cells against oxidative damage and reduce the risk of evolving certain types of cancer. Phytochemicals with anti-oxidant activity, allyl sulfides (onions, leeks, garlic), carotenoids (fruits, carrots), flavonoids (fruits, vegetables), polyphenols (tea, grapes). Iso-flavones, found in soy, imitate human estrogens and help to reduce menopausal symptoms and osteoporosis [10].

6.2 Anti-Microbial Activity

The different solvent extracts show anti-fungal and anti-bacterial activity against selected bacteria and fungi. The organic successive soxhlet extracts of *Digera muricata* L. is petroleum ether, chloroform, ethanol and distilled water, have shown significant zone of inhibition of growth at the concentrations of 200 and 400 µg/well against test pathogens. It is also reported that the methanol extract shows maximum activity against test bacteria and fungi [11].

6.3 Anti-Oxidant Potential

The plant has shown anti-oxidant activity in different investigations [12] analysed free radical scavenging and anti-oxidant activity of different solvent extract like hexane, petroleum ether, chloroform, methanol, ethanol and aqueous extracts. The maximum activity recorded in methanol and least activity was recorded in hexane. The methanolic crude extracts of *Digera muricata* L. was screened for their free radical scavenging properties by DPPH (1,1-diphenyl-2-picryl hydrazyl) radical scavenging assay. The maximum activity was observed in roots of *Digera muricata* L. Anti-oxidant properties of

Digera muricata L. methanol extract against the CCl₄-induced toxicity in kidneys and testis had been well known [2].

6.4 Anti-Diabetic Effects

The methanolic extract of Tartara (MEDM) leaves exhibited anti-diabetic activity in alloxan induced diabetic rats. These results suggested that MEDM (200mg/kg) showed anti-hyperglycemic activity in diabetic rats. The other parameters like blood glucose level, HDL level in serum decreases and body weight increases [13].

6.5 Anthelmintic Activity

The crude extract from leaves was preliminary screened for anthelmintic activity when tested against earthworms (*Pheretima posthuma*) [14].

6.6 Anti-Testicular Toxicity

The study suggested the protective potential of hexane of *Digera muricata* L. against the CCl₄-induced liver and testicular toxicity. CCl₄ can rapidly lead to both oxidative stress and acute liver injuries. Liver cirrhosis causes hypogonadism in male rats which are cured by hexane extract of *Digera muricata* L. DMH treatment ameliorated the hepatic injuries with consequent increase in the anti-oxidant status of various enzymes and compounds. Level of testosterone was elevated with DMH in addition to the repairing of testis and accessory organs. These effects of DMH against the CCl₄ toxicity may be attributed due to the presence of various bioactive groups and specifically the rutin and hyperoside in DMH. *Digera muricata* L. is used in renal disorders in folk system of medicines. The extract of this plant is administered daily in treatment of kidney stone. Generation of reactive radicals has been implicated in CCl₄-induced nephrotoxicity, which are involved in lipid, accumulation of dysfunctional proteins, leading to injuries in kidneys. Nephrotoxicity is poisonous effect of some substances on kidneys. The n-hexane and methanolic extract of *Digera muricata* L. shows protective effects against carbon tetrachloride in rats [6].

6.7 Allelopathic Effects

The aqueous extract of stem, root and leaf of *Digera muricata* L. shows allelopathic effect on in vitro seed germination of *Pennisetum typhoideum* (bajra). Different concentrations of various parts of weed showed inhibitory effects on shoot and root growth of *Pennisetum typhoideum*. The leaf extract proved inhibitory in nature than stem and root [5].

6.8 Protective Effects

The methanolic and hexane extract of *Digera muricata* L. shows protective effect against oxidative stress caused by CCl₄ in rat. The protective potential may also involve the preventive effects of *Digera muricata* L. methanolic extract by the inhibition of CCl₄ metabolism. This study further supports the scientific evidence in favor of its pharmacological use in oxidative stress diseases [15].

6.9 Renal Disorders

Digera muricata L. is used in renal disorders in folk medicine. The extract of this plant is administered daily in kidney stone treatment. Generation of reactive radicals has been implicated in CCl₄-induced nephrotoxicity, which are involved in lipid peroxidation, accumulation of dysfunctional proteins, leading to injuries in kidneys. Nephrotoxicity is a poisonous effect of some substances on kidneys. The n-hexane and methanolic extract of *Digera muricata* L. shows protective role against carbon tetrachloride which is induced nephrotoxicity in rats [9].

7. Summary and Conclusions

Tartara (*Digera muricata* L.) is an annual herb growing upto 20-70 cm tall is belonging to family Amaranthaceae. Mostly tartara contain flavonoids, alkaloids, terpenoids, saponins, coumarins, tannins, cardiac glycosides and anthraquinones. The leaves and young shoots of this plant are locally used as a vegetable and given to relieve constipation. *Digera muricata* L. used internally against digestive system disorders and in India, its seeds and flowers are used to treat urinary disorders. Before the introduction of modern medicines, disease treatment was entirely managed by herbal remedies. It is estimated that about 80% of the world population residing in vast rural areas of the developing and under developed countries still rely mainly on medicinal plants. Phytochemical and pharmacological investigations were carried out for this plant which reveals its multidisciplinary usage. It is quite obvious that the plant is widely used in traditional medicinal system of India and has been reported to possess anti-bacterial, anti-fungal, anti-diabetic, hepato-protective, nephron-toxicity protective, anthelmintic and free radical scavenging properties. It is known as a rich source of phenols, tannins, terpenoids, flavonoids and glycosides present in *Digera muricata* L. that might be medicinally important and/or nutritionally valuable. The plant is rich in carbohydrates, calcium, potassium, ascorbic acid, iron and magnesium. The present review summarizes some important pharmacological studies on *Digera muricata* L. and phytochemical investigations and isolated principles from them, which can be investigated further to achieve lead molecules in the search of novel herbal drugs.

References

- [1] N. Sharma, R. Vijayvergia. (2013). A Review on *Digera muricata* (L.) Mart-a great versatile medicinal plant. Int. J. Pharm. Sci. Rev. Res. 20(1): 114-119.
- [2] M.R. Khan, G.N. Khan, D. Ahmed. (2011). Evaluation of antioxidant and fertility effects of *Digera muricata* in male rats. African Journal of Pharmacy and Pharmacology. 5(6): 688-699.
- [3] C.C. Baskin, J.M. Baskin. (1998). Seeds: ecology, biogeography, and, evolution of dormancy and germination. Elsevier: pp.
- [4] N. Sharma, B.S. Tanwer, R. Vijayvergia. (2011). Study of primary metabolites and antimicrobial

- activities of *Digera muricata* (L.) Mart. J. Chem. Pharm. Res. 3(2): 424-431.
- [5] S. Aziz, S.S. Shaukat. (2014). Allelopathic potential of *Digera muricata*, a desert summer annual. Pakistan Journal of Botany. 46(2): 433-439.
- [6] B. Sharma, P. Jain. (2014). Barkha, and Dabur, R., "Antioxidant and antibacterial activity of *Digera muricata* (L.) Mart". Journal of Innovative Biology. 1(4).
- [7] B. Sharma, P. Jain, R.D. Barkha, R. Dabur. (2014). Antioxidant and Antibacterial activity of *Digera muricata* (L.) Mart. Journal of Innovative Biology December. 1(4): 181-188.
- [8] S. Usmani, A. Hussain, A. Farooqui. (2013). Pharmacognostical and phytochemical analysis of *Digera muricata* Linn. Growing as a weed in fields of Uttar Pradesh region of India. Int J. Pharm Sci. 5(1): 142-145.
- [9] M.R. Khan, W. Rizvi, G.N. Khan, R.A. Khan, S. Shaheen. (2009). Carbon tetrachloride-induced nephrotoxicity in rats: Protective role of *Digera muricata*. Journal of ethnopharmacology. 122(1): 91-99.
- [10] M.R. Khan, A. Memon, G.N. Khan, M. Shabbir, N. Saeed, N.A. Shah, J. Bokhari, U. Rashid. (2011). Protective effects of *Digera muricata* (L.) Mart. against carbon tetrachloride induced oxidative stress in thyroid of rat. African Journal of Biotechnology. 10(76): 17564-17570.
- [11] D. Muanza, B. Kim, K. Euler, L. Williams. (1994). Antibacterial and antifungal activities of nine medicinal plants from Zaire. International Journal of Pharmacognosy. 32(4): 337-345.
- [12] B.E. Ainsworth, W.L. Haskell, S.D. Herrmann, N. Meckes, D.R. Bassett Jr, C. Tudor-Locke, J.L. Greer, J. Vezina, M.C. Whitt-Glover, A.S. Leon. (2011). 2011 Compendium of Physical Activities: a second update of codes and MET values. Medicine and science in sports and exercise. 43(8): 1575-1581.
- [13] G. Jagatha, N. Senthilkumar. (2011). Evaluation of anti-diabetic activity of methanol extract of *Digera muricata* (L.) Mart in alloxan induced diabetic rats. INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH. 2(6): 748-752.
- [14] A. Hussain, M.N. Khan, Z. Iqbal, M.S. Sajid. (2008). An account of the botanical anthelmintics used in traditional veterinary practices in Sahiwal district of Punjab, Pakistan. Journal of ethnopharmacology. 119(1): 185-190.
- [15] M.R. Khan, D. Ahmed. (2009). Protective effects of *Digera muricata* (L.) Mart. on testis against oxidative stress of carbon tetrachloride in rat. Food and Chemical Toxicology. 47(6): 1393-1399.