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A critical review on *Cordia dichotoma*: Its therapeutic value

Vikas, Anisha and Mukul Kumar

Abstract
Hectic schedule of people pushing them to different types of diseases such as hypertension, diabetes, obesity, migraine etc., to tackle these types of problems now we are focusing on Ayurveda. *Cordia dichotoma* is a medicinal fruiting tree which is edible from its root to tip and has different types of medicinal and health benefits. It is found in semi-arid areas of our country as well as found in many other countries. It is known as Indian cherry and Lasora in local language. *Cordia dichotoma* fruits shown many nutritional values, different types of studies shows that *Cordia dichotoma* contain different types of phytoconstituents like phenols, triterpenoids, pyrrolizidine, alkaloids, coumarins, and bioactive compounds. Many of them have shown to be germicidal, antifungal, hypoglycemic, and act on inflammation, lipid disorders, parasiticidal, injury recovery, and anticancer activities. Many different clinical trials and studies are done and it is found that *Cordia dichotoma* have antifungal, antidiuretic, anti-cerebrovascular insufficiency activity, antidiabetic, antibacterial, antiulcer, wound healing and can be used as astringent, expectorant, hepatoprotective and beneficial in digestion and skin problems. From some studies it is found that the gum of the fruit can be used for making biodegradable packaging material.

Keywords: *Cordia dichotoma*, expectorant, hepatoprotective, antidiuretic, anti-cerebrovascular insufficiency activity

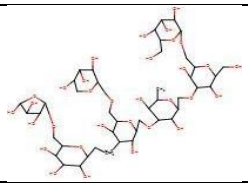
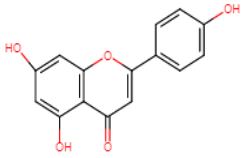
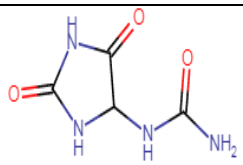
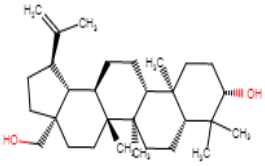
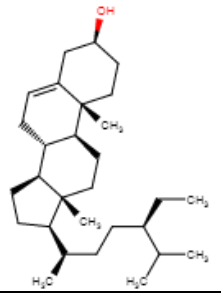
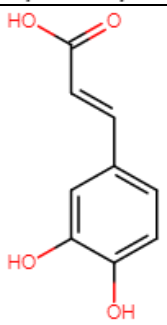
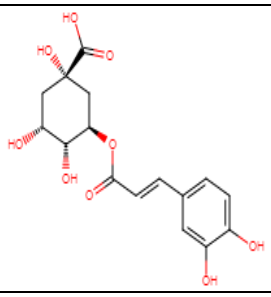
Introduction
Nowadays food habits are changing due to hectic schedules which affect our body system and leads to several health issues such as hypertension, diabetes, obesity, migraine etc. To overcome these problems now we are focusing on Ayurveda in place of allopathic and homeopathy. *Cordia dichotoma* is a medicinal tree which is commonly found in arid and semi-arid areas of our country such as north-west and central India (Sooraj., 2018). This plant is also found in Northern Australia, Sri-Lanka and also in Egypt where it is called as Makhate (Ibrahim *et al*., 2019). The fruits of *Cordia dichotoma*, usually known as sebesten, Indian cherry (Hussain & Kakati., 2013) [10] and in local language it is known as Lasora and Gonda.
Cordia genus consists of more than 3000 species and many of them are used for medicines (Ozal and Kullkarni., 2017). The *Cordia dichotoma* tree is small to medium in size (85-100cm in girth) with small, crumbled branches and the outer layer of the bark is generally wrinkled (Kuppast., 2006) [25]. From root to shoot the whole plant is edible and full of benefits and it shows various therapeutic applications such as it can be used as an astringent, expectorant, hepatoprotective and is also beneficial for digestion and skin (Usmani *et al*., 2018). Local people use *Cordia dichotoma* fruit as spices, vegetable, or pickle and also use it after fermentation (Priyanka and Shrikant., 2014).
Nowadays there is a massive increase in the use of non-biodegradable petroleum-based plastics which is a profoundly serious matter regarding our environment and also for our mother Earth (Gahrnie, Ziae, Eskandri and Hussain., 2017). According to the EPA report of 2015, municipal waste contains more than 40% of plastic packaging material from that we can get an idea of how much plastic we are using. to overcome this problem, we can also produce biodegradable packaging material from *Cordia dichotoma* (Ray and Rhim., 2020).

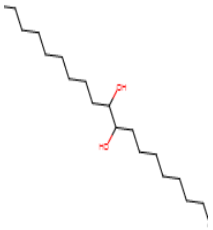
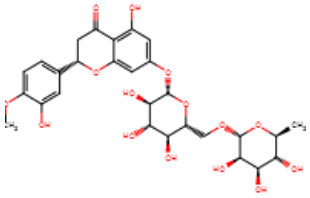
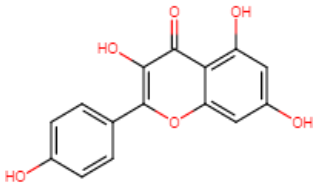
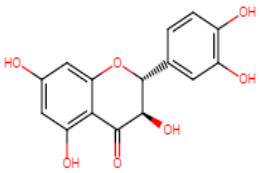
Scientific Classification
Cordia dichotoma is medicinal tree which is classified into scientific division such as it falls in Kingdom Plantae and followed by other scientific divisions like its division is Magnoliophyta, class is Dicotyledon, subclass is Asteriidae, order is Lomiates and family is Boraginaceae, Genus is Cordia, species is Dichotoma forst.

Different Names of Cordia dichotoma

Cordia dichotoma is known by many names in different languages, In English we call it Sebesten clammy cherry or Indian cherry, in Hindi it is known as Lasora, in Sanskrit it is called as Shelu, Bahuvarka, Shleshmatak, whereas in Tamil it is known as Kalvirusu vidi. In different countries it has different common names, in Egypt it is known as Makhate whereas in Japan it is known as Kendal (Rapisarda, A lau. L).

Table 1: Show the bioactive compounds plant

Name of Bioactive compounds	Part of Plant (*Cordia dichotoma*)	Extraction Solvent	Health Benefits	Structure	References
Arabinoglucon	Fruits	Water	Immunity booster, it enhances the macrophages and pro-inflammatory secretion of cytokines.		A Rahman, J Akhtar 2016.
Apigenin	Bark, leaves	Methanol, Ethanol	It induces muscle relaxation and sedation, antioxidant, anti-inflammatory and neuroprotective.		Jamkhande *et al*.,2019, MH Ghante and SR Barde; Ganjare *et al*., 2011 [36] Bhattacharya and Saha, 2013
Allontoin	Bark	-	Wound healing property, anti-aging property, good exfoliant		Jamkhande *et al*., 2013 [13], Hussain and Kakoti, 2013
Betulin	Seeds	Ethanol	Reduces blood lipids, promotes metabolism		Rudrapal, *et al*., 2021
β-sitosterol	Twigs	Dichloro methane	Lowering cholesterol Anti-inflammatory		Ragasa *et al*., 2015
Caffeic acid	Seeds	Ethanol	Reduce inflammation, prevent diabetes and give relief from fatigue		KF Mahmoud *et al*.,2021
Chlorogenic acid	Seeds	Ethanol	Lowers blood sugar, improves mood, weight loss		Hameed *et al*.,2022

Hentricontanol	Seeds, leaves	Ethanol	Analgesic, Antipyretic, Anti-inflammatory		A Nithaniyal Stalin *et al*.,2020
Hesperidine	Seeds	Methanol	It is beneficial to us in many ways its effect is on blood vessels, including allergies also		A Nithaniyal Stalin *et al*.,2020
Octacosanol	Seeds, Leaves	Methanol	Improves cells efficiency, strength.		S Usmani *et al*.,2018
Kaempferol	Fruits	Butanol	Reduce risk of chronic diseases, Antioxidant		SM Osman *et al*.,2019
Taxifolin	Seeds	Methanol	It shows Anticancer activity		A Ganjare, *et al*., 2019

Arabinoglucon

The aqueous extract of *Cordia dichotoma* fruit is found to be a reliable source of arabinoglucon. Arabinogalactan bonds relate to the fifth carbon part. It increases our immunity and enhances the macrophages and inflammatory secretion of cytokines (Sung Ho yoon *et al*., 2008)

Apigenin

Apigenin is a trihydroxy flavone, a flavone with hydroxy groups presents at positions 4', 5', and 7. It stimulates autophagy in leukemia cells. Found in the bark of *Cordia dichotoma*. It gives relaxation in muscles and helps in recovery and formation of new cells in the brain. It also stops the generation of free radicals in our body.

Alpha-amyrin

It has five fused rings of ursane with basic structure in the 2-methylbuta-3-dene alpha, a hydroxyl group substituting the hydrogen at the 3-beta position. It is extracted with methanol from the seeds of the *Cordia dichotoma.* It helps in reducing the swelling of cells. (N Hussain *et al*.,2013) [10]

Allantoin

Allantoin is a 5-aminohydantoin imidazolidine-2,4-dione with a carbamoyl group connected to the exocyclic nitrogen which is majorly found in the bark of the plant. It functions as a vulnerary, and metabolite for humans, E coli etc. It behaves as a fermenter and performs the same function as bacteria which are present in our small intestine. (E Tiam *et al*., 2020)

β-sitosterol

β-sitosterol (SIT) can be found in cell membranes of plants. It is found in the bark of *Cordia dichotoma*. They are also present in food plants which are rich in lipids e.g. nuts, legumes, seeds and olive oil, and it is acquired by consuming by these plant diet. According to the European Authority taking 1500-2400mg/day of unsaturated steroid alcohol can help to decrease triglycerides in blood and this thing is also recommended by the FDA.(BB kakoti *et al*., 2013) [10]

Rutin

Rutin is a 15-carbon chain of flavonoids which is in 3-ring system ie.C6-C3-C6. Rutin shows a covalent bond in carbon ring. After oxidation of carbon-hydrogen results in reaction which lead to the carbon hydroxyl bond which form three hydroxy flavones i.e., Kaempferol. It shows anti-inflammatory, anticarcinogenic, antiproliferative, antimetastatic and antioxidative stress effects. It helps in blood circulation and helps to relieve arthritis pain. (S.M. Samuel *et al*., 2019) [38]

Luteolin

It is flavonoid which can be found in several types of vegetables Luteolin (3,4,5,7-tetrahydroxy flavone) that we can found in diverse types of plants which includes vegetables, fruits, medicinal herbs and also present in *Cordia dichotoma.* It works as an anticancer drug against many distinct types of human cancer drugs such as glioblastoma, prostate, colon, and pancreatic cancer. (Bhattacharya and Saha *et al*, 2013)

Hesperidin: Hesperidin is a hesperetin -7-rutinoside composed of an aglycone, hesperetin, and a disaccharide, rutinose. Hesperidin and hesperetin have anticancer and cancer chemopreventive. It is beneficial to us in many ways; its effect is on blood vessels, including allergies also (A Nathanial Stalin *et al*., 2020). It is found in the seeds of *Cordia dichotoma*. *It* helps in the allergy problems.

Taxifolin (C15H12O)
Taxifolin has structure of hydrogenated oxygen atom group with carbon ring that is attached to benzene ring in the second carbon atom. Taxifolin has mass of 304.25 g/mo. Taxifolin helps in prevention of cancer. Taxifolin present in the seeds of *Cordia dichotoma* (A Ganjare *et al*., 2019)

Betulin (C30H50O2**)**
Betulin, also called as betulinic alcohol, is a lupane-type pentacyclic triterpene that was one of the first natural compounds recognized and extracted from trees as a purified chemical substance in 1788 by Lowitz. (Lowitz, J.T *et al*., 1788).It helps in reduction of blood lipids and promotes metabolism of the body. (N Hussain *et al*., 2021) [21]

Caffeic acid
Caffeic acid is a phenolic molecule which we can find in simple forms ie. monomers or in the form of esters, Complicated form of caffeic acid as phytochemicals. It is found in the seeds of *Cordia dichotoma*. It helps to reduce inflammation, prevent diabetes, and give relief from fatigue. (El-Massry *et al*., 2021)

Extraction techniques of bioactive compounds
The qualitative and quantitative analysis of bioactive chemicals derived from plant materials are mostly dependent on the choice of an accurate extraction process (Sasidharan *et al*., 2011). The initial stage in every medicinal plant study is extraction of bioactive compounds, which has a substantial and critical impact on the ultimate result and conclusion. Extraction procedures are often known as "sample preparation techniques". Plant components such as leaves, stems, flowers, and fruits can be used to identify and describe bioactive isolate properties. Different strategies can be used to extract primary and secondary metabolites from plants. For non-volatile substances, the simplest method is to merely immerse the part of these plant chemicals in solution (water, alcohol, oil). This method is known as solid liquid extraction.
With the technological advancement in the recent years, the soxhlet extraction process has even aided with ultrasonic waves, pressure, microwaves etc. The communication of these techniques has been found to significantly reduce the process time, energy consumption, amount of solvent being used and changed extraction yield.
The isolation of bioactive substances is influenced by numerous factors, including the extraction process, raw materials, and extraction solvent utilized (Tiwari, 2015).
Conventional procedures are different compound procedures like extreme heat, and include techniques such as Soxhlet, exfoliation, and water distillation.
Non-conventional Methods, also familiar as modern methods, are ecological or pure processes as they use fewer power and biological liquids, most of which are environmentally favorable (Rodriguez Perez *et al*., 2015). It includes techniques, such as supercritical extraction, pulsed electric field and high hydrostatic pressure.

Ethanol Extraction
Cordia dichotoma leaves (100 g) were pulverized into a fine powder using a stainless-steel grinder and immersed in 100% ethanol (200 mL) overnight at a temperature >78-degree Celsius. The ethanol portion was segregated by clean cotton fabric and filtered with filter paper. The filtered substance was again clarified using a circular film evaporator.

Extraction of Alkaloids
In a soxhlet device, 100 g of pulverized leaves were placed to which 150 ml of 90% ethanol was added and placed for four hours in greater than 50 degrees. After this time, the pure extract was filtered. 4N HCL was used to acidify it to pH=2(according to the PH-meter. Chloroform was then poured, and the aqueous was collected. Sodium hydroxide was used to neutralize the reaction). The organic solvent was evaporated, and the alkaloid was recovered.

Chloroform Extraction
To make the chloroform extract, a pulverized plant sample (100 g) was mixed with chloroform and placed at room temperature overnight. The samples were isolated by using sanitized wet cloth and Whatman filter paper. (John Odiyo *et al*., 2018)

Scientific Bioactive Compounds of *Cordia dichotoma* & their extraction
There are researchers who conducted the evaluation of chemical constituents and compositions of whole components of *Cordia dichotoma*. The roots, cortex, leaflets, and fruits, which have been found to contain various phytoconstituents like phenols, triterpenoids, pyrrolizidine, alkaloids, coumarins, and bioactive compounds. Many of them have shown to be germicidal, antifungal, hypoglycemic, and act on inflammation, lipid disorders, parasiticidal, injury recovery, and anticancer activities (Jamkhandi *et al*., 2013).
There is the existence of niacin bases, secondary metabolites of plants which contain nitrogen, phytochemicals, saponins, and phytosterols, in various parts of plants. (Jamkhande *et al*, 2013) [13].
From another study it is clear apigenin (0.005 g/kg, p.m.) from *C. dichotoma* shows good recovery properties as well as it helps lower swelling enzymes during inflammatory bowel disease (Ganjare *et al*., 2011) [36]. Seeds of Cordia dichotoma containing oil rich in oleic, stearic, and linoleic acids are present at the rate of 7.60 percent (Rameshwar *et al*., 2006**)**.
Out of the numerous studies conducted, one has reported the ethanol extract having phenols (1%), isopentenyl pyrophosphate oligomers (.075%), amino acids (1.39%), and rosmarinic acid (0.0028%) (Tian *et al*., 2014).
At a dose of 100 g/mL, the kernel of Cordia dichotoma demonstrates taxifolin DPPH free radical scavenging action (Mahasweta., 2014). The existence of alkaloid, coumarins, flavonoids, saponins, terpenes, and sterols in the leaf extract was identified in the phytochemical study. Six flavonol derivatives and two phenolic compounds were recovered from a butanol extract of C. dichotoma leaflets, with rosmarinic acid being a prominent ingredient. Three flavonoids, *et al* kaempferol, quercetin, and isorhamnetin, were isolated from the butanol part of the fruits of. C. dichotoma *et al*. (Kuppast, 2006) [25]

Table 2: Bioactive Compounds and Pharmacological Behaviour

Plant parts	Bioactive Compounds	Pharmacological Behaviour	References
Leaves	Apigenin	Sores curing	Ganjare A B *et al*.,2015
Leaves	Apigenin, luteolin	Anti-inflammatory	Bhattacharya P, Saha *et al*.,2013
Seeds, Leaves	Alpha-amyrin	Anti-inflammatory	Jamkhandi PG, *et al*.,2013
Seeds	Hentriacontane Hesperetin,	Anti-inflammatory activity,Varicose	Mahasweta R *et al*,2014
Seeds	betulin, Octacosanol, flavonoids. taxifolin	Anti-inflammatory Strengthen Stamina Atherosclerosis	Singh R *et al*.,2010
Seeds	Phytosterols	Breast Cancer	Awad AB, *et al*., 2007
Leaves	4-hydroxy-transcinnamate Ester	Free radical scavengers	Consolacion YR, *et al*.,2015
Leaves	α-Sitosteryl-3α-glucopyranoside-6'-O-palmitate	Skin Cancer (Breast) cancer cell	Nguyen AT *et al*.,2004
Leaves	Quercetin	Antioxidant activity and Anti-inflammatory	Hussain A *et al*., 2011 [36]

Pharmacological behaviour of bioactive compound

Therapeutic importance

Cordia dichotoma is a medicinal tree which has been used since ancient times. It has been reported to be helpful in curing diseases including diabetes and glycemia.

Study was done on Wistar rats to check the impact of *Cordia dichotoma* on normoglycemic and alloxan -induced. It has been investigated. The extract was given in three dosages and the dosages are 250 mg/kg ;500 mg/kg and 1000 mg/kg were evaluated for research, route taken orally. The *Cordia dichotoma* extract at 500 mg/kg had no major effect on the blood sugar quantity of normal blood sugar rats. When the comparison was done with raw control with the dosage of 250mg/kg having the same outcomes. Remarkable change is noticed when the dosage of *Cordia dichotoma* extract changed to 500mg/kg and 1000mg/kg after 4hours,8hours and 24hours the level is decreased to (P< 0.5).In normal blood sugar rats when the dosage of 1000mg/kg *Cordia dichotoma* is given and observation is done then it is found that there is considerably reduction in blood glucose level (P< 0.05) after 8 hours and 24 hours. This clear that dosages of *Cordia dichotoma* exhibit (P< 0.05) low blood sugar level and antidiabetic effects in rats. (Basu *et al*., 2020) [3].

Generation of Free Radicals

Oxygen ($O_2^{\bullet}$)

The source of this radical is through the oxidation process which occurs at room temp by enzymatic process. It serves as reductant for iron compounds by cytochrome-c

Hydroperoxyl Radical (HO_2)

The source of Hydroperoxyl Radical is protonation of oxygen, which is the addition of a proton i.e., a hydron or a hydrogen cation to, (H*) to an atom, molecule or ion which leads to the formation of a complex acid which initiates the fatty acid peroxidation.

Nitric Oxide ($NO^{\bullet}$)

NO is the second carrier within the cells that activates lyase enzyme, serine, and threonine which help in the loosening of cardiac muscle

Peroxynitrite ($ONOO^{\bullet}$)

When there is reaction between oxygen with nitric oxide takes place, it will result into peroxynitrite. Peroxynitrite is a powerful reactant, which combine with nitric acid through amino acid like methionine and tyrosine, which react with DNA to generate guanine (nitroguanine).

Antioxidant activity

Antioxidant

These are the chemicals that extinguish free radical cell damage. (J.V. Woodside, *et al*., 2001). It is of two types enzymatic and non-enzymatic.

This classification is done on the behalf of their actions

Enzymatic antioxidant function by decomposing free flowing radicals. This whole conversion is done in the presence of compounds such as Zn, Cu, Mn etc. It converts harmful oxidants to dihydrogen dioxide stepwise into water.

Superoxide dismutase (SODs), which are found in the cytosol and mitochondria, act as a catalyst the transformation of oxygen and dihydrogen dioxide in the presence of metal ion compounds like copper, manganese, zinc, (T. G. Cotter *et al*.,2011).

Glutathione peroxidase (GPX)

Catalase

An interconnected system of antioxidant enzymes protects cells from oxidative damage. The univalent anion of O2 produced due to activities such as phosphate ion is first converted to per-hydrol oxydrol as well as in addition to its decreased yield of water. This purification route is the product of enzymes, with superoxide dismutase initiating the first step and catalases and different peroxidases eliminating hydrogen peroxide (Magnenat JL, Garganoam M, Cao J *et al*.,).

Non-enzymatic function by involving the free flowing radical bond, some examples of non-enzymatic antioxidants are ascorbic acid, tocopherol,triterpenoids,reduced glutathione Non-enzymatic antioxidants include vitamin C, vitamin E, plant polyphenols, carotenoids, and glutathione.

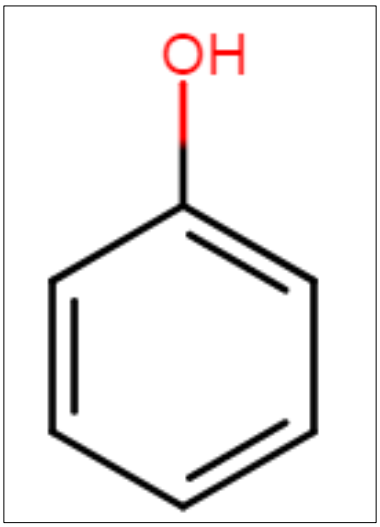
Tocopherol is a dominant acyl glycerol antioxidant work as a bond destroyer during phospholipid catabolism in cytoplasmic membrane and other phospholipid molecules like low-density lipoprotein (LDL). It stops the lipid peroxyl radicals' bonds.

Phenolic compounds present in *Cordia dichotoma* and their basic structure

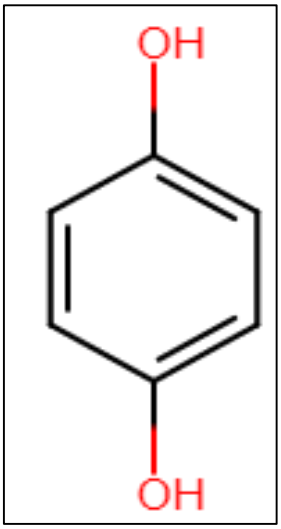
Whenever a Carbon atom is attached with any set of biological components with a hydroxyl (OH) radical in a pungent ring, it is called as phenol. The word monohydroxy benzene represents the term phenol, and it is called as benzenol or carbolic acid. Glycol and carbolic acid both are equivalent but carbolic acid makes more powerful connection of hydrogen. So, they are having more water solubility rather than glycols. Carbolic acids have more evaporating value. In

Normal temperature, carbolic acid appears colorless as fluids or as whitish solids. Carbolic acids could be immensely toxic and eroding (Wade, L. G. *et al*., 2018)

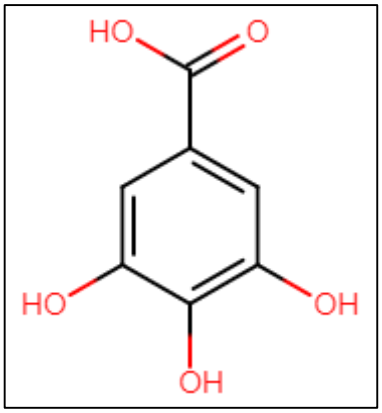
Structure



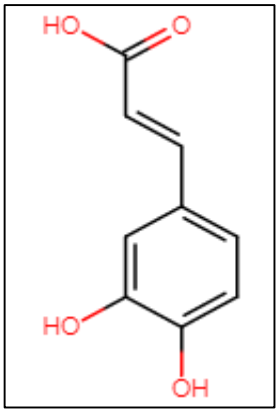
Hydroxybenzene



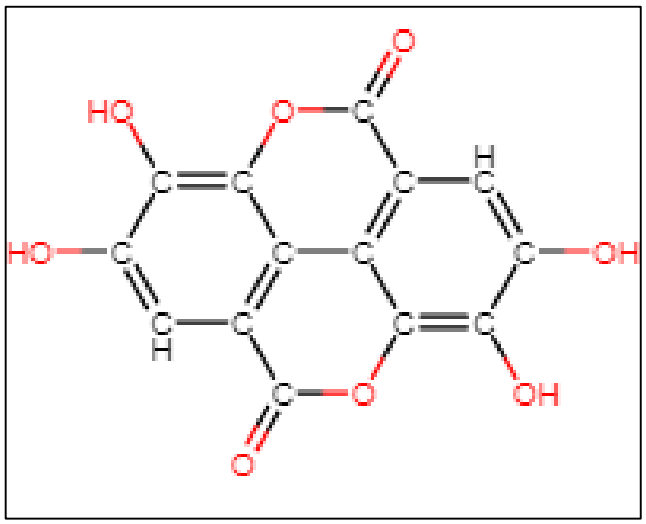
Hydroquinone



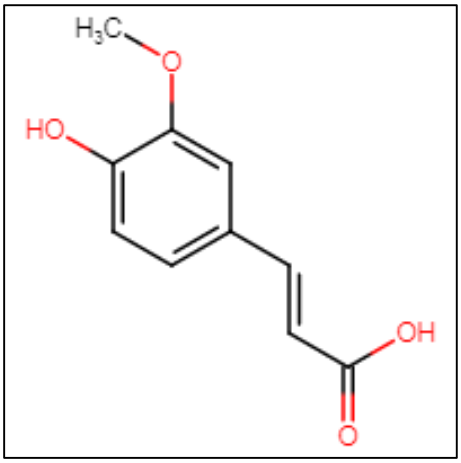
Gallic acid



3-4, Di hydroxycinnamic acid



C14H6O8 (ellagic acid)



C10H10O4 (Ferulic acid)

Dextrose engagement with phosphogluconate pathway is the initial step in production of phenolic chemicals. Phenols are involved during maximum metabolic activities in plants in plants. About mention phenolic compounds often known as polyphenols, encompass a wide range of components, including phytochemicals, phenol, carboxylic acid, and colorful nutraceuticals (Sandhu S.K., *et al*. 2014)

Studies have found that phenolics have properties of agelessness, which can cure swelling and have antioxidants, anticancer properties. Besides these adjustments, there are antioxidant enzymes that may be used to counteract oxidants (Moo-Huchin V.M *et al*. 2014).

Polyphenols have the significant virtue of blocking the enzymes -glucosidase and -amylase, that helps to make glucose from carbohydrates by breaking them. Polyphenols and substances that also help to avoid long lived effects like blood-vascular disease and help to increase the function of cells and promote the release of immune insulin.

Tetraterpenoids

Almost all biological things contain carotenoids animal, microbes and plants, from which over 700 carotenoids have been discovered and classified (Britton S, *et al*., 2004). Structure of most carotenoids is uniform tetraterpene. Rectilinear organic compound composed from 40 carbon. These systematic properties are linked with the reduction reaction, the existence like loops at at end of rectilinear framework is followed by addition of glycosyl. The intricate modification linked to lengthening of free radical results, structure, which results in carotenoids with 50 carbon chains. Carotenoids containing tetraterpene skeletons of 30 carbons. (Landrum JT *et al*.,2010). Carotenoids work as antioxidants by three mechanisms: the first is SET, and another is the creation of one adduct, and after that is HAT. (Willson RL *et al*., 1995)

Ascorbic acid (Vitamin C)

Vitamin C is class of ascorbic acid analogues that can be natural or synthetic compounds. Ascorbic acid is soluble in keto lactone having two groups of hydroxyls that can be ionized. At physiological pH, anion ascorbate is the predominant form. Ascorbate is a strong substance that loses an electron twice in a row to generate an ascorbate radical and

dehydroascorbic acid. Unpaired electrons are typically centered by resonance; the radical of resonance is stable. The content of ascorbate in healthy human plasma is 10 g/ml. At these quantities, ascorbate works with vitamin E as a co-antioxidant to protect radicals of LDL from peroxyl (Ames BN *et al.*,1989). Vitamin C is biologically capable of interconnecting with most of biological significant ROS.(Abraham SE. *et al*., 2014)

In-vitro* Studies in *Cordia dichotoma

C. dichotoma extract antioxidant activity was determined using 5 steps: reducing power, free radical scavenging, superoxide anion scavenging activity, total antioxidant capacity, and ferrous ion chelating activity. The antioxidant extract activities were correlated to BHT and ascorbic acid controls. There were 4 quantities of each material and extract used: 100,250,500, and 1000 gram per millilitre.

Antioxidant assay

Evaluation of Antioxidants was done by a DPPH assay. For reference Ascorbic acid was used to make a standard curve. 0.1gran of plant extract was mixed with ten millilitre ethanol in a centrifuge tube. Then the sample was centrifuged for five min in 2000 rpm. For cooling it was placed in the refrigerator. Then one millilitre of plant extract was drawn out from the centrifuge tube and added in the test tube then three millilitre of ethanol and six millilitres of DPPH solution and incubate it for 30 minutes in gloom. After incubation absorption is observed in a UV-spectrophotometer. Evaluation of the antioxidant nature of the sample was determined by the% inhibition formula. (Kumar *et al*., 2020)

Total Phenolic Content

The total amount of phenolic content of plants was extracted and calculated by using freshly prepared Folin-Ciocalteu. Reference used for standard is gallic acid. In short extracts solution was produced from herb sample (0.1g) by mixing ethanol i.e 10ml. Then this extract was centrifuged for five minutes at 2000rpm. After that extract was placed in the refrigerator for cooling. One ml extract was taken as a working solution in a test tube then three ml of ethanol was added. After that forty microliter of freshly prepared Folin-Ciocalteu reagent was added then incubated for ten minutes in the dark(Kumar *et al*,.2020) [20].

DPPH radical scavenging activity

Through scavenging activity, the dichotoma extract was weakly dosed. Then correlated to BHT and ascorbic acid, large concentrations of herbal extract i.e., one thousand gram per millilitre demonstrated low radical scavenging activity. The value of IC 50 of ascorbic acid was 2 235 g/mL, which correlated BHT 41.25 and 48.66 g/ml.

Total antioxidant capacity

The total antioxidant activity of the extract was determined using the ABTS/H2O2 discoloration method, which corresponded to data from standard materials (ascorbic acid and BHT). C. dichotoma showed significant antioxidant potential at various concentrations. When the antioxidant activity of fruit pulp extract was observed it was 58.09mg/ml,54.23mg/ml,50.06 and the standard ascorbic acid was 72.34 (R.M. *et al*., 2010).

Superoxide anion radical scavenging activity

In a concentration-dependent manner, C. dichotoma extract gives the conclusion of scavenging properties against superoxide radicals (O2-). Extract (IC5o: 178.41 g/mL) was required to inhibit 50% of O2- produced in a phenazine Methosulphate-nicotinamide adenine dinucleotide system, especially in comparison to ascorbic acid (55.50 g/mL) and BHT (52.00 g/mL).

In-vivo studies and Pharmacological Properties

Rat dietary specifications

The management of an elevated diet of fat increased the total body weight gain of hyperlipidemic model rats [95.603.40 gram per weeks] correlated with negative control [(59.601.30) gram per four weeks]. *Cordia dichotoma* was administered in 2 doses: 0.5 and 1.0 gram per kilogram; these doses decrease total growth performance in the injected model of rats by the (79.803.40) along with (60.146.37) gram per four weeks, respectively, when correlated to hyperlipidemic control of rats. *C. dichotoma* extract had no effect on body weight obtained by control rats when correlated to the zone of inhibition.

Wound healing property

Wistar rats were used to test the wound healing activities of C. dichotoma fruits using 3 dissimilar wound replicas: Incision injury, excision injury, and injury after closure. *Cordia dichotoma* extract were made from fruit with ethyl alcohol by soxhlet, then alcoholic extract was then separated into Petroleum ether, ethyl acetate, solvent ether, butanone, and butanol ratio. Flavonoids tested positively in ethanol extract, butanol, and ethyl acetate ratio.

The dosages of fractions were determined using the Up and Down approach in an acute toxicity investigation and found to be 300 mg/kg. At a significance level of P0.001, the findings were analyzed using a student t-test. Rats injected with ethanol extract fractions showed early wound epithelialization and a considerable high tensile property when compared to controls. C. dichotoma fruit extracts have powerful wound healing properties, according to the findings.

Anti-Cerebrovascular insufficiency activity

Long-term cerebral hypo perfusion in rats resulted in the propensity towards listlessness and anxiety (elevated plus maze test and open field paradigm) accompanied by deficits in memory and learning (Mori's water maze test) and tendency towards depression (Porsolt's swim test). Gliosis, cellular edema, Astrocytosis, and inflammatory changes were observed in the forebrain. Treatment by *Cordia dichotoma* (250 mg/kg PO for 28 days) alleviated these cognitive, behavioral, and histopathological changes suggesting that *Cordia dichotoma* may be useful in cerebrovascular insufficiency conditions.

Angiotensin-converting enzyme inhibitory activity

The ethanolic extract of bark showed a high ability to inhibit the angiotensin-converting enzyme.

Diuretic activity

Petroleum ether, solvent ether, and butanol fractions of alcoholic extract of the fruits 300 mg/kg b wt. were evaluated for diuretic activity in rats for total urine volume, urine

concentration of Na+ and K+ and showed an increase in cation excretion and urine volume.

Activity against microbes and fungi

C. dichotoma tree's outer layer was observed for antibacterial and antifungal functions. The bark's antibacterial activity regarding 2 Gram(-) bacteria, E- coli and P.aeruginosa, and 2 Gram (+)bacteria, S. pyogenes and S. aureus, was tested. Infective fungi A. niger, A. clavatus, and C. albicans were tested for antifungal activity of the extract. The zone of inhibition of extracts was correlated to that of different standards such as ampicillin, chloramphenicol, ciprofloxacin, norfloxacin, for antibacterial activity and for antifungal activity-nystatin and griseofulvin was used.

Antibacterial, cytotoxic, and analgesic properties

Antibacterial activity of alcoholic and aqueous extracts of C. *dichotoma* were screened antibacterial activity against six bacterial strains belonging to Enterobacteriaceae, *viz*., *Escherichia coli, Enterobacter aerogenes, Klebsiella pneumoniae, Salmonella typhimurium, Proteus mirabilis,* and *Proteus vulgaris* by the agar well diffusion and disc diffusion methods.

The ethanol extracts were more active than aqueous extracts for all the plants studied. Aqueous extract of *Cordia dichotoma* inhibited only to *Proteus mirabilis*, while ethanolic extract inhibited to *Klebsiella pneumonia* and *Proteus mirabilis*

Leaves of C. dichotoma studied by two different methods i.e., well diffusion and disc diffusion methods against the strain of *E. coli* revealed that it possesses antibacterial activity against *E. coli*. The activity of the extract is due to the flavonoid active constituent.

Phytochemical analysis showed a positive result for tannin, protein, and flavonoid Antibacterial activity of petroleum ether, chloroform, methanol, and aqueous extracts of *Cordia dichotoma f*irst ripened fruits against urinary tract pathogens such as *Pseudomonas aeruginosa, Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Proteus vulgaris* and *Staphylococcus aureus* using disc diffusion method was evaluated. From the result of the study, it is observed that the methanolic extract exhibited better antibacterial activity against the bacterial strains as compared to other extracts.

The antiviral activity was evaluated using the method described previously (W. He *et al*., 2010). The antiviral effect of isolated compounds on influenza virus was evaluated using Madin-Darby canine kidney (MDCK) cell lines.

Gastroprotective and anti-ulcer effect

Aspirin-persuade stomach ulcer, pylorus ligation, the anti-hyperglycemic activity for various abstraction. The full-grown firm fruit was examined. Maceration was used to get methyl alcohol and water extract from firm fruit. OECD 423 standards were used to derive a safe oral dosage, which falls within the GSH 5 category.

When Wistar rats were given water extract instead of methanolic extract, the ulcer index was reduced significantly. And the outcomes were compared to regular ranitidine (50 mg/kg). In both, the aspirin-persuade stomach ulcer (P0.001) demonstrated a substantial antiulcer effect (P0.001).

Anthelmintic activity

The vermifuge ability herb extraction of fruits was tested on Indian Earthworm after the death of earthworm which are morphologically and biologically similar to the parasite which humans having in intestine. The variation of extraction potency is 10, 25, 25, 50, 75mg/ml were liquefied by 100mg, 250, 500, 750 mg per ml crude extract in 1ml of adjusting volume to optimum salty solution and the different concentrations (10, 25, 50, 75, and 100 mg/ml) of ethanolic and aqueous extracts are prepared from pulp obtained after separation of seeds from fruits of *Cordia dichotoma* Forts by Soxhlet extraction were studied for anthelmintic activity by using *Eudrilus euginiae* earthworms. Both ethanolic and aqueous extracts showed paralysis and death of worms in a concentration-dependent manner. Aqueous extract showed significant activity than ethanolic extract. The extracts also showed the presence of alkaloid, glycoside, saponins, flavonoid, triterpenoids, protein, amino acid, and carbohydrate in the preliminary phytochemical investigation.

Values Shown by various parts of Cordia dichotoma

The whole plant is edible and can be used as food. Immature fruits of C. dichotoma are pickled and are also used in vegetable. The C. dichotoma is used as the protector from sun heat by making a mixture of flowers with curd. The seed kernels of C. dichotoma are rich in fatty oils, proteins. The polysaccharide gum (97%)

Leaves

The leaves of *Cordia dichotoma are good* anti-inflammatory and anti-cancer agents. *Cordia dichotoma* leaves contain 42-54% nitrogen free extract and 2-4% ether extract with 13-17% total ash content. Its total calcium content is 2%-4% and 0.3% phosphorus

Seed

Seed kernels of *Cordia dichotoma* are extraordinarily rich in fatty oils and proteins & exceptionally good for cattle fodder. Four types of flavonoids such as glycosides (datiscoside, hesperidin, robinin, rutin, rutoside), aglycone flavonoids of 2phenolic acid which are obtained from seeds. Seed contains several types of phytochemicals. Seed of *Cordia dichotoma* shows 32g of water per 100g and it contains 46% fatty oils and 31% of proteins.

Fruits

Cordia dichotoma fruits are beneficial to us and it contains several types of phytochemicals as well as many health benefits with. Fruits of *Cordia dichotoma* contains 70% of fruit pulp according per 100 g in which it contains 6 g of water, 35 g of proteins and 18 g of carbohydrates and contains few micronutrients such as calcium as 55 mg, Phosphorus 275mg, Zinc 2 mg, Iron as 6 mg, Manganese is 2 mg, copper 1.6 mg.

Clinical trials on *Cordia dichotoma*

There is ample number of tests performed on the *Cordia dichotoma.* In vitro and In vivo both studies are carried out on *Cordia dichotoma* and it is clear that it has various types of major pharmacological and therapeutic benefits.

Market products

There are very few products of Cordia dichotoma in the market. There is availability of dried *Cordia dichotoma* in packets. By some local people the Cordia dichotoma is being

used in the form of pickles or as vegetables.

Conclusion

Cordia dichotoma is a medicinal fruit and its whole tree is also full of benefits and can be used for different types of medicinal purposes. It is beneficial in many ways such as it Antifungal, antidiuretic, antibacterial, antimicrobial and have good antiulcer and wound healing property. *Cordia dichotoma* trees are commonly found in many areas but there is less awareness of tree benefits, so no cultivation of this fruiting tree is done on a large scale. It is especially important to grow increasingly of these types of trees, in this time where human life is facing so many types of diseases. So, researchers should also make easier generative vegetative techniques so that there is progress in growing this tree.

Future Prospects

Research is going on the whole tree of *Cordia dichotoma*, many of the benefits are known to us and many will be found. The Government should focus on these types of trees and should make large production and cultivation of these of trees, because in the present scenario as well as in future we need these types of flora more.

From various researches we found that the *Cordia dichotoma* can be used as packaging product (biodegradable) which is eco-friendly as well as exceptionally light weighted also. In future it will be going to be particularly useful for us such as it is in present day.

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