A REVIEW ON MULTI-POTENTIAL MEDICINAL PLANT *MURRAYA KOENIGII* (CURRY LEAVES)

Dr. Anil Kumar*[1], Krishanu Samanta[2]
[1, 2]Pharmacy College, Itaura, Chandeshwar, Azamgarh U.P.- India

Corresponding Author
Dr. Anil Kumar
Email- howruakpatel@gmail.com

ABSTRACT

Plants have been used in traditional medicine for several thousand years because herbal drugs being relatively low cost with minimal side effects are used extensively in treating various diseases since ages. India is the largest producer of medicinal plant and is also called the "Herbanium of the medicinal plant of the World" The Indian traditional system of medicine claims to cure and control various diseases by means of herbal medicines. *Murraya koenigii* also known as Curry Leaves, Kadhi Patta, Mithi Neem, is the native to India and found throughout in India tropical and subtropical region. It is a small deciduous shrub with every part of plant having medicinal properties and nutrition values to makes it a potential future industrial crop. Curry Leaf (Murraya koenigii) is native to South Indian famous among various cuisines for its flavour and aroma. Literatures suggest the curry leaves used traditionally as anti-inflammatory, antianthelmiintic, antibacterial, antifungal, antiprotozoal, antiemetic, antidiarrheal, febrifuge and blood purifier. The whole plant is considered to be a tonic and stomachic. Curry leaves are found to be effective as antioxidant, antidiabetic, antihypertensive, cytotoxic, and in the treatment of bronchial respiratory difficulties. The leaves are used traditionally as a spice in curry and other eatables. The aim of the present review to study traditional uses, phytochemical, and pharmacological activities of Murraya koenigii leaf.

KEYWORDS -*Murraya koenigii, Phytochemical, traditional uses, pharmacological activity.*

INTRODUCTION

India is a country with a vast reserve of medicinal herbs, which contain numerous biologically active compounds that are helpful in improving the life and treatment of the diseases. Most of the population relies upon herbal medicines because they have been considered as safe, effective, and economical. *Murraya koenigii* known as curry leaves, belongs to the family Rutaceae. It is found to be native to South Asia particularly India, Sri Lanka, and Bangladesh. The use of *Murraya koenigii* dates to 1st and 4th century AD. Tamil and Kannada literature describes *Murraya koenigii* as Kari used as a flavouring agent (Mittal, 2017). It is considered as one of the important ingredients in South Asian cuisine for its fragrance and aroma (Ghimire and Magar, 2018). It maintains its flavour and other qualities even after drying, making it to be used as a popular spice and condiment in tropical countries. The whole plant is regarded as tonic and stomachic and has traditional uses (Ajay S et al., 2011; Plant et al., 2015). The leading component for flavour and aroma of curry leaf includes pinene, sabinene, caryophyllene, cardinol, and cardinene (Plant et al., 2015). *Murraya koenigii* has been found to have phytochemicals like alkaloids, essential oils, phenolics, minerals and proteins (Singh et al., 2011), terpenoids, tocopherol, β-carotene, and lutein (Patterson and Varghese, 2015). It can be used fresh, dried, powdered or in cooked form. *Murraya koenigii* is distributed in the moist forest of Asian regions particularly Nepal, Bhutan, Loas, Pakistan, Thailand and cultivated all over India. Curry leaves contain many important ingredients like carbohydrates, proteins, fibres, calcium, phosphorus, iron, magnesium, copper, carotene, and oxalic acid. The essential oil from leaves yielded di- α-phellandrene, D-sabinene, D-α-pinene, dipentene, D-α-terpinol and caryophyllene (Gopalan et al., 1984). *Murraya koenigii* is widely used in Indian cookery for centuries and have a versatile role to play in traditional medicine. Green leaves are eaten raw for cure of dysentery, diarrhoea and for checking vomiting. Leaves and roots are also used traditionally as bitter, anthelmintic, analgesic, curing piles, inflammation, itching and are useful in leucoderma and blood disorders (Nadkarni et al., 1976; Kirtikar et al., 1981). The oil is used externally for bruises, eruption, in soap and perfume industry (Prajapati et al.,2003). The phytoconstituents isolated from the leaves are alkaloids like girinimbiol, girinimibine (Adebajo et al., 2006), koenimbine, O-methyl murrayamine A, Omethyl mahanine (Tachibana et al., 2003), The stem of Murraya koenigii is an aromatic and deciduous shrub or small tree up to 7 meters in height and 14 to 42 cm in

diameter (Raghunathan, et al). The aim of present review to focus on its traditional uses, phytochemical, and pharmacological activities of *Murraya koenigii* (Curry plant).

FIGURE- LEAVES OF MURRAYA KOENIGII

PHYTOCONSTITUENTS

Mature leaves contain 63.2 % moisture, 1.15 % total nitrogen, 6.15 % fat, 18.92 % total sugars, 14.6 %-star 6.8 % crude fiber, ash 13.06 %, acid insoluble ash 1.35 %, alcohol-soluble extractive 1.82%, cold water (20°C) extractive 27.33% and a maximum of hot water soluble extractive 33.45%. 30 Constituents that have been stimulated the most interest include a wide range of carbazole alkaloids, essential oil, and carotenoids.

Carotenoids: Leaves contain 9744 ng of lutein, 212 ng of α-tocopherol and 183 ng of carotene/g of fresh weight (Palaniswamy et al., 2003) 21.4 mg/100 g of total carotene, 7.1 mg/100 g of β-carotene is reportedby (Bhaskarachary et al., 1995).

Carbazole alkaloids:

Leaves: Tachibana et.al has isolated 8, 10'- {3,3',11, 11'-tetrahydro-9,9' dihydroxy- 3,3',5, 8'-tetra methyl – 3,3'-bis (4-methyl-3-pentenyl)} bis pyrano (3,2 a) carbazole (a dimeric carbazole alkaloid) from methylene chloride extract of M. koenigii leaves together with six known alkaloids; koenimbine, Omethyl murrayamine, Omethyl mahanine, isomahanine and bismahanine and bispyrayafoline (Tachibana et al.,2003; Tachibana et al., 2001). Koenigine, koenine, koenidine and (-) mahanine were isolated from acetone extract of leaves. (Narasimhan et al., 1975). Form the hexane extract of leaves Joshi et.al has isolated mahanimbine, isomahanimbine, koenimbidine and murrayacine. Petroleum ether extract of leaves was used to isolate carbazole alkaloids, mahanimbine (3,5- dimethyl-3-(4- methylpent-3-enyl)-11H-pyrano[5,6-a] carbazole) (Kumar et al., 2010). Methanolic extract of M. koenigii was subjected to qualitative thin-layer chromatography and HPLC using the different solvent system by (Gupta, 2007) Spectral analysis (IR, 1H NMR, 13C NMR and MS) was carried out to establish the structure.

Coumarin: Indicolactone, anisoalctone and 2', 3' epoxy indicolactone (a furocoumarin lactone) were isolated from the seeds. This represents the first furocoumarin with a mono terpenoid lactone chain in the genus Murraya (Adeleke,1997) has reported xanthotoxin, isobyaknagelicol, byakangelicol and isogosferol as minor furocoumarins in seeds of M. koenigii (Adeleke, 2000). Isoheraclenin, isoimperatonin, oxypeucedanin, isopimpinellin, and bergaptan were isolated from seeds of Marassana village, Sri Lanka, suggesting it as a new chemical race (Johannes, 1994). A new coumarin galactoside marmesin- 1'-O-β-Dgalactopyranoside, osthol, and umbelliferone were isolated from ethanol stem bark extract (Ravindra,1992). 3-(1, 1- dimethyl allyl xanthyletin) was isolated from petroleum ether extract of stem bark of M. koenigii (Bhattacharya et al., 19984).

Lipids: Lipid composition of seeds revealed 4.4% of total lipids of which 85.4 % neutral lipids, 5.1 % glycolipids and 9.5 % phospho-lipids. Neutral lipids consisted of 73.9% triacylglycerol, 10.2% free fatty acids and small amounts of diacylglycerols, monoacylglycerols, and sterols. Steryl glucoside and acylated sterylglucoside are major glycolipids. Phospholipids mainly consisted of phosphatidyl ethanolamine and lysophosphatidic choline (Hemavathy et al., 1991).

Essential oil: leaves contain volatile oil Such as sesquiterpenes (89.1%). The major constituents were b-caryophyllene (20.5%), bicyclogermacrene (9.9%), a-cadinol (7.3%), caryophyllene epoxide (6.4%), b-selinene (6.2%) and humulene (5.0%). The fresh leaves of Murraya koenigii from Dehradun (Olubunmi et al., 2001) contains a pinene (51.7%), sabinene (10.5%), pinene (9.8%), ß- caryophyllene (5.5%), limonene (5.4%), bornyl acetate (1.8%), terpinen-4-ol (1.3%), g-terpinene (1.2%) and a-humulene (1.2%) as the major constituents. The

essential oil of leaves consists mainly of monoterpenoids and its oxygenated derivatives. The major oil constituents are β-caryophyllene (35.8%), β- phellandrene (2.57%), α- pinene (0.26%), β-elemene (0.18%) and β thujene (4.12%) as determined by GC- MS of steam distillate. Other components are α- caryopyllene (9.17%), cardinene (8.43%), selinene (8.88), linalool (0.27 %), trans Ocimene (3.12%), gujunene (1.46%). Volatile oil obtained from flowers consists of 34.4% monoterpenoids and 43.9 % of sesquiterpenoids. The major components are β-caryophyllene (24.2%), (E) - β-Ocimene (18.0%) and linalool (8.0%) (Wong et al.,1996). Volatile oil composition of the fruit of M. koenigii has been first time reported by Awasthi et.al. As per their studies, hydro distillation of fruits of Murraya koenigii resulted in the isolation of 0.13% of oils (w/v) on fresh weight basis respectively. GC and GC-MS analysis resulted in the identification of 73 constituents comprising 98.8% of the oil, of which the major ones were caryophyllene oxide (10.3%), bcaryophyllene (8.5%), tridecanoic acid (8.2 %), dehydroaromadendrene (8.0%), terpinen-4-ol (8.0%), acadinol (7.3%), and (Z,E)-farnesol (5.7%) (Awasthi et al., 2011).

Stem: From alcohol extract of stem bark Saha et al. (1998) has isolated koenigine- quinone A and koenigine quinone B, structures were established as 7- methoxy- 3 methyl carbazole- 1,4- quinone and 6, 7-dimethoxy- 3-methyl carbazole-1, 4- quinone respectively (Saha et al.,1998) 9- carbethoxy-3-methyl carbazole and 9- formyl –3- methyl carbazole were identified form M. Koenigii by (Chakraborty et al .,1997) me- 2- methoxy carbazole –3- carboxylate and 1- hydroxy –3- methyl carbazole were isolated form stem bark (Bhattacharya et al., 1994). Mukonal, a probable biogenetic intermediate of pyrano carbazole alkaloid was detected in stem bark (Bhattacharya,1984). From stem bark Murrayazolinol (a minor carbazole alkaloid) (Bhattacharya, 1989), mahanimbinol (Rama Rao et al., 1980), murrayazolidine (Chakraborty et al., 1974; Chakraborty et al., 1970) murrayacinine (Chakrabortyet al., 1974), mukonidine (Chakraborty, 1978), murrayazolinine (Chakraborty et al., 1973), murrayanine, girinimibine and mahanimbine (Das, 1965), girinimbinol and mahanimbilol (Reisch et al., 1994) possible biogenetic precursors of girinimbine and mahanimbine) has also been identified and isolated.
Roots: Murrayanol, murrayagetin, marmesin- 1”- Orutinoside were isolated from root extract (Srivastava et al., 1993). Three monomeric and five binary carbazole alkaloids named mukoenine- A, -B and C andmurrastifoline–F.bis–2-hydroxy-3-methyl carbazole, bismahanine, bi koeniquinone- A and bismurrayaquinone A were isolated from root and stem
bark (Chihiro et al., 1993). Koenoline (1- methoxy-3- hydroxy methyl carbazole) was isolated from the root.
Seeds: Mahanimbine, girinimbine, koenimbine, isomahanine and mahanine were isolated from seeds of M. koenigii from Marassana, Sri Lanka (Johannes, 1994) 2- methoxy-3- methyl carbazole was isolated from petroleum ether extract of seeds (Bhattacharya et al., 1984). Mandal et al.2010 isolated three bioactive carbazole alkaloids, kurryam (I), Koenimbine (II) and koenine (III) with structural confirmation with 2D-NMR spectra (Mandal et al., 2010).
Fruits: Mahanimbine and koenimbine were isolated from petroleum ether extract of fruits (Narsimha et al., 1968). Isomahanine and murrayanol were isolated from fruits by (Reisch et al.,1992) along with five previously reported carbazole alkaloids mahanimbine, murrayazolidine, girinimbine, koenimbine and mahanine.

TRADITIONAL USES

Curry leaf plant is popular among South Asian Dishes for its peculiar taste and aroma. It has been used as a home remedy since ages (Chauhan et al., 2017). The scented leaves are widely used in flavoring curries to promote appetite and digestion (Kataria et al., 2013). Leaves are locally used to treat external injuries, burns and remove poison from the bite of poisonous animals (Mustafa and Oktavia, n.d.) and for treating rheumatism (Tan et al., 2014). Baked (cooked, crisped) leaves are used to check vomiting (Kumar et al., 1999). Finely grinded leaves mixed in butter milk have positive effects for stomach upsets and act as laxative when taken in an empty stomach (Plant et al., 2015). Fresh leaves juice mixed with lime and sugar is used to treat morning sickness and root juice consumption gives renal pain relief (Nishan and Subramanian, 2015). Stem is used to cleanse teeth that lead to reinforcing the gums (Yankuzo et al., 2011). Fruit has anti-astringency properties. Root juice is used in kidney pain (Joseph and Peter, 1985). Curry leaf can be used in treating calcium, vitamin deficiencies and anemia. Moreover antitumor, hypoglycaemia, anti-hyper-cholesterol emic effects of the plant have been found (Kumari and Papiya, 2014). Piles, body heat, inflammation and itching are controlled with curry leaves (Bhandari, 2012). Traditional Ayurveda includes the use of curry leaf parts as a cure of cough, hypertension, hepatitis, rheumatism and hysteria (Ghasemzadeh, 2014). Traditionally curry leaves are boiled together with coconut oil until reduction to blanked residue to be used as hair tonic for keeping natural hair tone and invigorating growth of hair (Saini et al., n.d.).

PHARMACOLOGICAL ACTIVITIES

Antidiabetic property

Mahanimbine a chemical constituent of M. koenigii was isolated from column chromatography of the petroleum ether extract of the dried plant. The anti-diabetic activity was performed on the streptrozotocin induced Wistar rats by using pure compound at a dose of 50 mg/kg and 100 mg/kg. The possible mechanism by which the mahanimbine decreases blood sugar level may be by potentiating of insulin effect either by increasing the

pancreatic secretion of insulin from beta cells of islets of langerhans or by increasing the peripheral glucose uptake. Mahanimbine showed the appreciable alpha-amylase inhibitory effect as compared with acarbose (Dineshkumar et al., 2010).

Antioxidative property

Isolated carbazole alkaloids from dichloromethane extract of leaves of M. koenigii were evaluated on the basis of oil stability index together with their radical scavenging ability against DPPH radical on the basis of lag time to reach a steady state. The 12 carbazole were classified into 3 groups. It suggested that an aryl hydroxyl substituent on the carbazole ring plays a role in stabilizing the thermal oxidation and rate of reaction against DPPH radicals. The antioxidative properties of the leaf extracts of Murraya koenigii using different solvents were evaluated based on the oil stability index OSI together with their radical scavenging ability against 1, 1-diphenyl-2-picrylhydrazyl (Kureel et al., 1969). Mahanimbine and koenigine, two carbazole alkaloids, isolated from the leaves of M. koenigii showed antioxidant activity. Koenigine also showed a high degree of radical scavenging properties (Rao et al., 2006).

Anticancer activity

Koenoline isolated from root bark exhibited cytotoxic activity against the KB cell culture test system. 9- formyl-3 methyl carbazole displayed weak cytotoxic activity against both mouse melanoma B 16 and Adriamycin resistant P 388 mouse leukemia cell lines (Chakraborty et al., 1997). The effects of extracts of M. koenigii in in-vitro (short-term incubation method and in-vivo (Dalton's ascitic lymphoma (DAL) anticancer models have been evaluated in male Swiss albino mice. DAL cells were injected intraperitoneally (106 cells) to the mice (Nutan et al., 1998). The anticarcinogenic potential of curry leaf using benzo (a) pyrene-induced for stomach and 7, 12 dimethyl Benz (a) anthracene (DMBA) induced skin papillomas was studied. Chemoprotective responses were measured as a decrease in tumor burden (papillomas/mouse) and % of tumor-bearing animals in both the models. Increase in level of acid soluble sulphydral compounds, glutathione S- transferase and DTdiaphorases were also measured. Antioxidant parameters (reduced glutathione, Super Oxide dismutase, catalases, and glutathione peroxidase
and glutathione reductase) were also elevated (Khan et al., 1997). The in-vitro anti-tumor promoting activity and antioxidant properties of Girinimbine isolated from the stem bark of Murraya koenigii was studied by Yih et.al. The in vitro anti-tumor promoting activity of girinimbine was determined by measuring the percentage inhibition of induced early antigen (EA) of EBV on the surface of Raji cells.

Radiation protection activity

The effect of 4 Gy gamma radiation 30 min after the last injection of 100 mg/kg of methanolic extract of M. koenigii for 5 consecutive days was observed on adult Swiss albino mice. The extract itself increased the
glutathione and enzymes levels, whereas radiation significantly reduced all values. Pre-treatment with the extract reduced lipid peroxidation rate induced by radiation. The result demonstrated that M. koenigii leaves possess good antioxidant activity in vitro and are able to protect against radiation-induced depletion in cellular antioxidants (Deepa et al., 2009). The methanolic extract showed protection against gamma radiation and cyclophosphamide-induced chromosomal damage in Swiss albino mice at a single dose of 100 mg/kg body weight (Goswami et al., 2010).

Immunomodulatory activity

The methanolic extract of M. koenigii showed a significant increase in phagocytic index by rapid removal of carbon particles from bloodstream. The extract also increased the antibody titre against ovalbumin and protection towards cyclophosphamide induced myelosuppression in albino mice. Oral administration of the aqueous extract of leaves at doses of 250 and 500 mg/kg significantly enhanced the delayed-type hypersensitivity reaction induced by ovalbumin. The extract also potentiated the production of circulating antibody titre significantly in response to ovalbumin (Shah et al., 2010).

Antiobesity and Antihyperlipidemic activities

The dichloromethane (MKD) and ethyl acetate (MKE) extracts of Murraya koenigii leaves significantly reduced the body weight gain, plasma total cholesterol (TC) and triglyceride (TG) levels significantly. The observed antiobesity and antihyperlipidemic activities of these extract are correlated with the carbazole alkaloids, Mahanimbine. When it was given orally (30 mg/kg/day) significantly lowered the body weight gain as well as plasma TC and TG levels. These findings demonstrate the excellent pharmacological potential of mahanimbine to prevent obesity (Birari et al., 2010).

Hepatoprotective activity

The protective nature of M. koenigii leaves extract was studied by Gupta et al., 2007. The effect attributed to the combined effect of carbazole alkaloids– Mahanimbine, Girinimbine, Isomahanimbine, Murrayazoline, Murrayazolidine, Mahanine and ascorbic acid, α-tocopherol and mineral (Zn, Cu, Fe) contents of M. koenigii leaves extract. This study proved M. koenigii a promising and a rich source of free radical quenchers, which have been mediated through hepatocyte membrane stabilizing activity along with the reduction of fat metabolism (Gupta et al., 2007). The normal morphology of cell was maintained after ethanolic challenge when

aqueous extract containing tannins and carbazole alkaloids of M. koenigii was given. Hepatoprotective activity was measured with respect to the different parameters studied and
maintained normal morphology even after ethanolic challenge to the cells which was comparable to the protection offered by the standard drug L-ornithine-L aspartate (Gupta et al., 2007; Sathaye et al., 2010). The acetone extract of dried bark powder showed prominent protection of liver cells as compared with the control group and other solvents in CCl4-induced liver damage (Pande et al., 2009).

Cardioprotective activity

The studies indicated that the aqueous extract of Curry leaf protects the rat cardiac tissue against cadmium induced oxidative stress possibly through its antioxidant activity. Treatment of rats with cadmium also caused alterations in the activities of mitochondrial Krebs's cycle as well as respiratory chain enzymes. All these changes were ameliorated when the rats were
pre-treated with an aqueous extract of Curry leaf (Elina et al., 2012).

Antiulcer activity

Antiulcer activity was observed using aqueous extract at doses of 200 and 400 mg/kg. It produced significant inhibition of gastric lesion induced by non-steroidal anti-inflammatory drugs and pylorus ligation-induced ulcer. The extract reduced ulcerative lesion, gastric volume and free and total acidity but raised the pH value of gastric juice in pylorus ligation model. The results obtained suggested that the extract possesses significant antiulcer activity (Patidar et al., 2011).

Antimicrobial and anti-fungal activity

Murrayanine, girinimbine and mahanimbine isolated from stem bark showed antifungal activity against pathogenic fungi (Chowdhury et al., 2001). 1- formyl-3 methoxy-6- methyl carbazole and 6,7- dimethoxy-1-hydroxy-3- methyl carbazole were reported to possess antibacterial and antifungal property by Chowdhury et al. (2001). Mahanimbine, murrayanol, and mahanine from fresh leaves showed antimicrobial and topoisomerase I and II inhibitory activity (Ramsewak et al., 1999). Marmesin- 1'-O-β-Dgalactopyranoside from stem bark showed anti-bacterial, anti-viral and antifungal activity (Kumar et al., 2010). The essential oil was found to be effective against Rhizoctonia Batticaloa (ED 50 0.112 %) and Helminthosporium Oryza (0.1214%), and the effect is possibly due to the presence of β- caryophyllene and gurjunene. Essential oil and aqueous extract of leaf were found active against Staphylococcus epidermidis, S. aureus, and streptococcus species. Crude extract and
chloroform soluble fraction and petroleum ether soluble fraction showed a promising antibacterial activity against all the tested bacteria (Iyer et al., 2010; Srivastava et al., 2001; Akerel et al., 1998). The crude extract of M. koenigii roots showed strong antibacterial
activity. Extract containing murrayanol and or isomahanine is used as microbicide in a variety of industries due to high safety, strong activity, little odour and without colouring effect.

Cytotoxic Activity

The isolated carbazole alkaloid as Koenoline from the root bark of M. koenigii exhibited the cytotoxic activity against KB cell culture system. Carbazole alkaloids isolated from the stems of M. koenigii have effects on the growth of the human leukemia cell line HL-60. Also, the carbazole alkaloids, mahanine, Pyrafoline-D and murrafoline-I showed significant cytotoxicity against HL-60 cells and induced the loss of mitochondrial membrane potential (Manfred et al., 1958).

C O N C L U S I O N

Murraya koenigii was one of the medically beneficial plants which have been used many centuries ago by our ancestors. Keeping in view the tremendous traditional and pharmacological activities of curry leaves availability of literature, Murraya koenigii may be utilized treatment of various diseases.

REFERENCES

1. Adebajo AC, Reisch J. Minor furocoumarins of Murraya koenigii. Fitoterpia. 2000; 71(3): 334-7.
2. Atta-Ur- Rahman, Zaidi R., Firdous S. NMR Studies on Mahanine. Fitoterapia. 1988;59 (6):494- 495.
3. Adesina SK, Olatunji OA, Brgenthal D, Reisch J. New Biogenetically Significant Constituents of Clausena anisate and Murraya koenigii. Pharmazie. 1988;43(3): 221-222.
4. Adebajo Adeleke C, Reisch Johannes. Minor Furocoumarins of Murraya koenigii. Fitoterapia. 2000; 71(3):334-337.
5. Adebajo Adeleke C, Olugbade Tiwalade A, Elujoba Anthony A, Aladesanmi Adetunji J, J Reisch Johannes. 2', 3' Epoxyindicolactone from Murraya koenigii. Nigerian Journal of Natural Products and Medicine. 1997; 1(1): 21- 24).
6. Awasthi PK. Chemical Constituents of Volatile oil of Murraya koenigii Fruits from the Plains of Northern India. Journal of Pharmacy Research. 2011, 4(7):2201-2202.
7. Akerel O, Ayinde BA. Antibacterial Activity of The Volatile Oil and Aqueous Extract of Murraya koenigii Leaves. Nigerian Journal of Natural Products and Medicine. 1998; 2:44-45).
8. Bhattacharya P, Maiti A. K., Basu K, Chowdhury BK. Carbazole Alkaloids From Murraya koenigii. Phytochemistry. 1994; 35(4):1085-1086.

9. Bhaskarachary K, Sankar Rao DS, Deosthale YG, Reddy V. Carotene Content of Some Common and Less Familiar Foods of Plant Origin.Food chemistry, 1995;54:189-193.
10. Bhattacharya P, Chakraborty A, Mukonal A. Probable Biogenetic Intermediate of Pyrano Carbazole Alkaloid Form Murraya koenigii. Phytochemistry. 1984; 23(2):471- 472.
11. Bhattacharya L, Chatterjee SK, Roy S, Chakraborty DP. Murrayazolinol- A Minor Carbazole Alkaloid Form Murraya koenigii Spreng Journal of the Indian chemical society, 1989; 66(2):140-141.
12. Bandyopadhyaya S, Roy KC, Roy M, Pal BC, Bhandra R, Das K, Bhattacharya S. An Herbal Composition For The Treatment of Bronchial Respiratory Disorders, PCT Int. Appl. WO 03 13, 564 (Cl A61k35/78), 20 Feb 2003, US Appl. 985, 160, 1 Nov 2001, 38.
13. Bhattacharya P, Chakrabory A. 3- (1, 1- Dimethyl Allyl) Xanthyletin from Murraya koenigii Spreng. Journal of the Indian chemical society 1984; 61(7):650-651.
14. Bhattacharya P, Chowdhury BK. 2-Methoxy- 3- Methyl Carbazole From Murraya koenigii. Indian Journal of Chemistry, 1984; Sect. B, 24 B (4):452.
15. Birari R, Javia V, Bhutani KK. Antiobesity and lipid lowering effects of Murraya koenigii (L.) Spreng leaves extracts and mahanimbine on high fat diet induced obese rats. Fitoterapia. 2010; 81(8):1129-33
16. Chowdhury BK. Jha S., Bhattacharya P, Mukherjee J. Two New Carbazole Alkaloids Form Murraya koenigii. Indian Journal of Chemistry, 2001; Sect B, 40 B (6): 490-494.
17. Chakraborty M, Nath AC, Khasnobis S, Chakraborty M, Konda Y, Harigaya Y et al. Carbazole Alkaloids from Murraya koenigii. Phytochemistry. 1997; 46 (4): 751-755.
18. Chakraborty DP, Bhattacharya P, Mitra AR. Murrayazolidine. Chemistry and Industry London), 1974; 6: 260.
19. Chakraborty DP, Islam A, Basak SP, Das R. Structure of Murrayazolidine: The First Pentacyclic Carbazole Alkaloid. Chemistry and Industry London, 1970; 18:593- 594.
20. Chakraborty DP, Roy S, Guha R. Structure of Mukonidine. Journal of Indian Chemical Society. 1978; Vol LV: 1114- 1115.
21. Chakraborty DP, Bhattacharya P, Islam A, Roy S. Chemical Taxonomy: XXXV. Structure of Murrayacinine, A New Carbazole Alkaloid Form Murraya koenigii. Chemistry and Industry London, 1974; 4: 165-166.
22. Chakraborty DP, Ganguly SN., Maji PN, Mitra AR, Das KC, Weinstein B. Chemical Taxonomy: XXXII, Murrayazolinine, A Carbazole Alkaloid from Murraya koenigii. Chemistry and Industry London. 1973; 7: 322-333.
23. Chihiro I, Thoyama Y, Omura M, Kajiura I, Furukawa H. Alkaloid Constituents of Murraya koenigii. Isolation and Structure Elucidation of Novel Binary Carbazoloquinones and Carbazole Alkaloids. Chemical and Pharmaceutical Bulletin1993; 41(12):2096-2100.
24. Chowdhury BK, Chakraborty Debi B. Taxonomy XXVIII, Mukeic Acid; First Carbazole Carboxylic Acid Form A Plant Source. Phytochemistry. 1971; 10(8):1967-1970.
25. Chowdhury AR. Essential Oil Form the Leaves of Murraya koenigii Spreng. Journal of Medicinal and Aromatic Plant Science. 2000; 22(1B): 643-645.
26. Chowdhury BK, Chakraborty Debi B. Taxonomy XVIII, Mukoeic Acid; First Carbazole Carboxylic Acid Form Plant Sources. Chemistry and Industry London,1969; 17:549.
27. Chakrabarty M, Nath A, Khasnobis S, Chakrabarty M, Konda Y, Harigaya Y, Komiyama K. Carbazole alkaloids from Murraya koenigii. Phytochemistry. 1997; 46(4) : 751-755.
28. Chowdhury BK. Jha S., Bhattacharya P, Mukherjee J. Two New Carbazole Alkaloids Form Murraya koenigii. Indian Journal of Chemistry. 2001; Sect B, 40 B (6): 490-494.
29. Chakraborty M, Nath AC, Khasnobis S, Chakraborty M, Konda Y, Harigaya Y et.al, Carbazole Alkaloids From Murraya koenigii. Phytochemistry. 1997;46 (4): 751-755.
30. Das, KC, Chakraborty DP, Bose PK. Antifungal Activity of Some Constituents of Murraya koenigii. Experiment Journal. 1965; 21(6): 340.
31. Deepa I, Devi PU. Radio protective activity of Murraya koenigii (L.) on cellular antioxidants in Swiss albino mice. Journal of Pharmacy Research. 2009; 2(3):495-501.
32. Das, KC, Chakraborty DP, Bose PK. Antifungal Activity of Some Constituents of Murraya koenigii. Experiment Journal,1965; 21(6): 340.
33. Dineshkumar B, Mitra A, Mahadevappa M. Antidiabetic and hypolipidemic effects of mahanimbine carbazole alkaloid from Murraya koenigii Rutaceae leaves. International Journal of Phytomedicine. 2010; 2:22-30.
34. Gopalan C, Rama Shastri BV. Balasubramanian SC. Nutritive value of Indian Foods. New Delhi: ICMR, 1984: 66,117.
35. Gupta GL, Nigam SS. Chemical Examination of Leaves Of Murraya koenigii. Planta Medica, 1971; 19(1): 83-86.

36. Gupta P, Nahata A, Dixit VK. An update on Murraya koenigii spreng: A multifunctional Ayurvedic herb. Zhong Xi Yi Jie He Xue Bao Journal of Chineese Integrative Medicine. 2011; 9:824-33.
37. Gupta RS, Singh D. Protective nature of Murraya koenigii leaves against hepatosupression through antioxidant status in experimental rats. Pharmacology online. 2007; 1: 232-242
38. Goswami RB, Khare P, Singh S, Goswami N, Thomas P, Devi PU, Pathak AK. Studies on antigentoxic effect of Murraya koenigii leaves. International Journal of Pharmaceutical Sciences and Research. 2010; 2(21):65-68.
39. Gupta RS, Singh D, Protective nature of Murraya koenigii leaves against hepatosupression through antioxidant status in experimental rats. Pharmacology online. 2007; 1: 232-242.
40. Hemavathy J, Lipid Composition of Murraya koenigii Seed. Journal of American Oil Chemist Society,1991; 68(9):651- 652.
41. Ito C, Itoigawa M, Nakao K, Murata T, Tsuboi M, and Kaneda N et al. Induction of apoptosis by carbazole alkaloids isolated from Murraya koenigii. Phytomedicine. 2006; 13:359-365.
42. Iyer UM, Mani UV. Studies on the Effect of Curry Leave Supplementation on Lipid Profile, Glycated Proteins and Amino Acids in NIDDM Patients. Plant Foods Human Nutrition. 1990; 40(4): 275-282.
43. Inahata Keishiro, Nakasugi Toru Matsumura Shinichi, Nakahara Satoe, (Inahata Koryo Co. Ltd. Japan), Foods Containing Murraya Extract For Prevention And Control Of Bad Breath Jpn. Kokai Tokkyo Koho JP 09, 238, 648 (97, 238, 648) (Cl A 23 L1/30), 16 Sep 1997, Appl. 96/80, 599, 7 Mar 1996, 8 Pp (Japan).
44. Joshi BS, Kamat VN, Gawd DH. Structures of Girinimbine, Mahanimbine, Isomahanimbine, Koenimbidine and Murrayacine. Tetrahedron journal1970;26(6): 1475- 1482.
45. Jain Ravindra K, Srivstava Savitri D. Anti-Inflammatory, Anti-Microbial And Phytochemical Studies On The Stem Bark Of Murraya koenigii. Proceedings of National Academic Sciences India, 1992; Sect A., 62(1):5-9.
46. Kirtikar KR, Basu BD. Indian Medicinal Plants, Edition 2, Vol. I, Oriental Enterprises, Uttarchal Pradesh, 1981, 473.
47. Kureel SP, Kapil RS, Popli SP. Two Novel Alkaloids Form Murraya koenigii: Mahnimbicine and Bicyclomahanimbicine. Chemistry and Industry London, 1970; 29: 958.
48. Kureel SP, Kapil RS, Popli SP. Terpenoid Alkaloids Form Murraya koenigii Spreng- II: Constitution Of Cyclomahanimbine, Bicyclomahanimbine and Mahanimbidine. Tetrahedron Letter, 1969; 44:3857-3862.
49. Khan PA, Abraham A, Lellamma. Antioxidant effects of curry leaf (Murraya koenigii) and mustard seeds (Brassica juncea) in rats fed with high fat diet. Indian Journal of Experimental Biology, 1997; 35(2):148-50.
50. Kumar VS, Sharma A, Tiwari R, Kumar S. Murraya koenigii (curry leaf): a review. Journal of Medical and Aromatic Plant Sciences, 1999; 21(4): 1139-1141.
51. Kureel SP, Kapil RS, Popli SP. Terpenoid alkaloids from Murraya koenigii Spreng. -II. The constitution of cyclomahanimbine, bicyclomahanimbine & mahanimbidine. Tetrahedrone Letters. 1969; 44:3857- 3862.
52. Khan BA, Abraham Annie, Lellamma S, Antioxidant Effects of Curry Leaf Murraya koenigii And Mustard Seeds, Brassica juncea in Rats Fed with High Fat Diet. Indian Journal of Experimental Biology, 1997; 35: 148-150.
53. Kumar NS, Mukherjee PK, Bhadra S, Saha BP, Pal BC. Acetylcholinesterase inhibitory potential of a carbazole alkaloid, mahanimbine, from Murraya koenigii. Journal of Phytotherapy Research, 2010; 24(4):629-31.
54. Kumar NS, Mukharjee PK, Bhadra S, Saha BP, Pal BC. Journal of Phytotherapy Research, 2010; 24:629-631.
55. Lal RK, Sharma JR, Naqui AA, Singh N. Phenotypic and Genetic Variability for Morphometric Traits and Essential Oil Composition in Diverse Origin Germ Plasma Lines Of Curry Neem. Journal of Medical and Aromatic Plant Sciences, 2001; 23(3):392-398.
56. Lal RK, Sharma JR, Singh N, Misra HO Naqui A. Genetic Associations And Diversity in the Genetic Resources of Curry Neem. Journal of Medical and Aromatic Plant Sciences,2001; 22/4A-23/1 A: 216-220.
57. Mukherjee M, Mukherjee S, Shaw AK, Ganguly SN. Mukonicine, A Carbazole Alkaloid Form Leaves of Murraya koenigii. Phytochemistry, 1983; 22(10):2328-2329
58. Mandal S, Nayak A, Kar M, Banergee SK, Upadyay SN, Singh RK, et.al. Global current trends in Natural products for Diabetis Management:A Review, Fitotherapia. 2010; 81(1):72-74.
59. Mallavarapu Gopal R, Ramesh S, Syamasunder KV, Chandrashekhara RS. Composition of Indian Curry Leaf Oil. Journal of Essential Oil Research. 999; 11(2):176-178.

60. Manfred F, John MP, Dajaja DS, Douglas AK. Koeniline, a further cytotoxic carbazole alkaloid from Murraya koenigii. Phytochemistry. 1985; 24 12: 3041-3043.
61. Mac Leod, Alexander J, Pieris Nirmala M. Analysis of Essential oil of Murraya koenigii and Pandanus latifolius. Phytochemsitry, 1982; 21(7):1653-1657.
62. NS, Paradkar MV, Kelkar SL. Alkaloids of Murraya koenigi, Structures of mahanine, koenine, koenigine and koenidine. Indian Journal of Chemistry,1970
63. Narasimhan NS, Paradkar MV, Chitguppi VP, Kelkar SL. Alkaloids of Murraya koenigi, Structures of mahanimbine, koenimbine, mahanine, koenine, koenigine and koenidine. Indian Journal of Chemistry, 1975; 13: 993-995.
64. Nadkarni KM. Indian Materia Medica, Edition 3, Vol. I, Popular Prakashan, Mumbai, 1976, 196.
65. Narasimhan NS, Paradkar MV, Chitguppi VP, Kelkar SL, Alkaloids of Murraya koenigii: Structures of Mahanimbine, Koenimbine, (-) Mahanine, Koenine, Koenigine, Koenidine and (+) – Isomahanimbine. Indian Journal of Chemistry, 1975; 13(10): 993-999.
66. Nutan MTH, Hasan CM, Rashid MA, Bismurrayafoline E: A New Dimeric Carbazole Alkaloid Form Murraya koenigii. Fitoterapia. 1999; 70(2): 130-133.
67. Narsimha NS, Paradkar MV, Chitguppi VP. Structure of Mahanimbine and Koenimbine, Tetrahedron Letter. 1968; 53:5501-5504.
68. Nutan MTH, Hasnat A, Rashid MA. Antibacterial and cytotoxic activities of Murraya koenigii. Fitoterapia. 1998; 69(2):173-175.
69. Nutan MTH, Hasnat A, Rashid MA. Antibacteria l and Cytotoxic Activities of Murraya koenigii. Fitoterapia. 1998; 69(2):173-175.
70. Olubunmi A. Onayade, Adeleke C. Adebajo. Composition of the Leaf Volatile Oil of Murraya koenigii growing in Nigeria. Journal of Herbs, Spices & Medicinal Plants; 2001, 7(4): 59 – 66.
71. Palaniswamy UR., Caporuscio C, Stuart J. A Chemical Analysis Of Antioxidant Vitamins In Fresh Curry Leaves By Reverse Phase High Performance Liquid Chromatography with UV Detection. Acta Horticulturae, 2003; 620: 475- 478.
72. Purohit SS, Sharma AK, Prajapati ND, Kumar T. A handbook of medicinal plants: a complete source book. Edition 2. Jodhpur: Agrobios (India). 2009, 352-353.
73. Ponnusamy S, Ravindran R, Zinjarde S, Bhargava S, Ravi Kumar A. Evaluation of traditional Indian Antidiabetic medicinal plants for human pancreatic amylase inhibitory effect in vitro. Evid Based Complement Alternative Medicine, 2010.
74. Pande MS, Gupta SPBN, Pathak A. Hepatoprotective activity of Murraya koenigii Linn bark. Journal of Herbal Medicine and Toxicology, 2009; 3(1):69-71.
75. Patidar DK. Anti-ulcer activity of aqueous extract of Murraya koenigii in albino rats. International Journal of Pharma and Bio Sciences, 2011; 2(1):524-529.
76. Raghunathan K, Mitra R, Pharmacognosy of Indigenous Drugs, Central Council for Research in Ayurveda and Siddha, New Delhi, Vol. I: 433.
77. Rama Rao AV, Bhide KS, Mujumdar RB. Mahanimbinol, Chemistry and Industry wiley online library, 1980; 17: 697-698.
78. Reisch J, Adebazo AC, Kumar V, Aladesanmi AJ. Two Carbazole Alkaloids from Murraya koenigii, Phytochemistry, 1994; 36(4):1073-1076.
79. Reisch Johannes, Adebajo Adel eke C, Aladesanmi Adetunji J, Adesina Kolawole S et al. Chemo types Of Murraya koenigii Growing In Sri Lanka. Planta Medica.1994;60(3):295-296.
80. Reisch Johannes, Goj Olav, Wickramasinghe Anura, Herath HMT, Henkel Gerald. Natural Products Chemistry, Part 148, Carbazole Alkaloid from Seeds of Murraya koenigii. Phytochemistry. 1992; 31(8):2877-2879
81. Reisch Johannes, Bergenthal Dieter, Adebajo Adeleke C, Aladesanmi Adetunji J, Furocoumarins of Murraya koenigii Seeds. Fitoterapia. 1994; 65(4):380-381.
82. Rao BRR, Rajput DK, Mallavarapu GR. Chemical diversity in curry leaf (Murraya koenigii) essential oil. Journal of Agricultural and Food Chemistry2011; 126(3): 989-994.17.
83. Rana VS, Juyal JP, Rashmi, Blazquez MA. Chemical constituents of the volatile oil of Murraya koenigii leaves. International Journal of Aromatherapy, 2004; 14(1): 23- 25.
84. Rao LJM, Ramalakshmi K, Borse BB, Raghavan B. Chemical composition of volatiles from coconut sap neera and effect of processing. Food Chemistry, 2006; 100: 742-747. Saha C, Chowdhury BK, Carbazoloquinones Form Murraya koenigii. Phytochemistry. 1998; 48 (2): 363-366.
85. Srivastava SK, Srivastava SD, New Constituents and Biological Activity of the Roots of Murraya koenigii. Journal of Indian Chemical Society 1993; 70(7):655-659.
86. Shah AS, Juvekar AR. Immunostimulatory activity of aqueous extract of Murraya koenigii (Linn.) Spreng. Leaves. Indian Journal of Natural Products and Resources, 2010; 1(2) 450-455.

87. Sathaye S, Bagul Y, Gupta S, Kaur H, Redkar R. Hepatoprotective effects of aqueous leaf extract and crude isolates of Murraya koenigii against in vitro ethanolinduced hepatotoxicity model. Experimental and Toxicologic Pathology, 2010; 5:18.
88. Tachibana Y, Kikuzaki H, Lajis NH, Nakatani N. Comparison of antioxidative properties of carbazole. Asian Journal of Pharmacy and Life Science. 2011; 1(4):423.
89. Tachibana Y, Kikuzaki H, Lajis NH, Nakatani N. Comparison of Anti Oxidative Properties of Carbazole Alkaloids FromMurraya koenigii Leaves. Journal of Agricultural and Food Chemistry, 2003; 51: 6461-6467.
90. Tachibana Y, Kikuzaki H, Lajis NH, Nakatani N. Anti Oxidative Activity of Carbazole Form Murraya koenigii Leaves. Journal of Agricultural and Food Chemistry, 2001; 49: 5589-5594.
91. Vaskudevan Padma, Tandem Mamta, Pathak Namrata. Fluid Carbon Dioxide Extraction And Hydro Distillation Of Certain Bio Cidal Essential Oils And Their Constituents. Journal of Scientific and Indian Research. 1997; 56(11):662-672.
92. Wang YS, He HP, Hong X, Zhao Q, Hao XJ. A New Binary Carbazole Alkaloid From Murraya koenigii. Chinese Chemical Letters. 2002; 13(9): 849-850
93. Wong KC, Tie DY. The Essential Oil of the Leaves of Murraya koenigii Spreng. Journal of Essential Oil Research. 1993; 5(4): 371-374.
94. Wong KC, Chee SG, Volatile Constituents Of Murraya koenigii Spreng Flowers. Journal of Essential Oil Research. 1996, 8(5):545-547.
95. Yun SW, Hong PH, Yue MS, Xin Hong, Xiao JH. Two New Carbazole Alkaloids From Murraya koenigii. Journal of Natural Products. 2003;66: 416-418.