Plant Archives Vol. 20, Supplement 2, 2020 pp. 3400-3406 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

NUTRITIONAL AND MEDICAL IMPORTANCE OF *CITRULLUS COLOCYNTHIS* - A REVIEW

Aparajita Bhasin[1*], Dr. Sanjay Singh[1] and Rajesh Garg[2]
[1]Assistant Professor, Lovely Professional University, Jalandhar-144411
[2]M.D. (Dermatology), PGIMER, Chandigarh-160012
[*]Corresponding Author – jita.84@gmail.com, Mob: +919460793860, +916239266925

Abstract

For ages, plants are used for medication purpose to treat various disorders to improve health and wellness. Now a day, consumption of synthetic drugs has increased which further cause side effects and adversely affect health of the population. However, health consciousness and increase in knowledge about side effects of synthetic drugs tends to further enhancing the interest towards traditional medicines. Medicinal plants help to cure diseased condition for further improved living, so that importance of 'ethno-medicine' study was realized by population and more use of herb based medicines was come in demand for further use. India is a country with diversification in culture as well as in botanical geography. The use of botanical knowledge for medication of different ailments and diseases is the cohesive part of Indian rural population. *Citrullus colocynthis* is herbaceous plant packed with abundance of nutrients which plays key role in improvement of wellbeing. This is an underutilized and less known fruit crop of arid region. Almost all parts of such fruit crop used for health benefits. Seeds are rich source of oil and protein with superior fatty acid and amino acid profile. Other than nutrients, there are number of bioactive compounds such as cucurbitacin, flavonoids and polyphenols are present in *Citrullus colocynthis* which are further responsible for medicinal properties. Although, consumption of such plant is common in rural population but further investigations are required to improve the utilization of this super food.

Keywords: Citrullus colocynthis, medicinal plants, nutritional composition, bioactive compounds, flavonoids, health significance.

Introduction

For ages, plants are used for medication purpose to treat various disorders to improve health and wellness. Now a day, consumption of synthetic drugs has increased which further cause side effects and adversely affect health of the population. However, health consciousness and increase in knowledge about side effects of synthetic drugs tends to further enhancing the interest towards traditional medicines. Ethnobotany plays key role in gathering of the information related to different plant species with economic nature, nontoxic effect and beneficial for health improvement. As recent data shows that approximately 70% of the total population of India still have faith in herbs and herbs based traditional medicines. From ancient period, almost 2,500 species from about 1000 genera are getting used for medicinal purpose by traditional therapists (Chandal *et al.,* 1996; Kumar and Dwivedi, 2018a; Kumar *et al*., 2018b; Kumar *et al*., 2018c; Kumar and Dwivedi, 2018d; Kumar and Purnima *et al*., 2018e; Kumar and Pathak, 2019f; Kumar and. Siddique *et al*., 2019g; Siddique and Kumar, 2018h; Siddique *et al*., 2018i).

Medicinal plants help to cure diseased condition for further improved living, so that importance of 'ethno-medicine' study was realized by population and more use of herb based medicines was come in demand for further use (Singh, 1998) and improved the interest related to less-known and underutilized medicinal plants (Tripathi, 2000; Pathak *et al*., 2017j; Prakash *et al*., 2017k; Kumar and Mandal, 2014L; Kumar *et al*., 2014m; Kumar *et al*., 2014n; Kumar, 2013o; Kumar and Dwivedi, 2015p; Gogia *et al*., 2014q; Kumar, 2014r; Kumar *et al*., 2012s).

India is a country with diversification in culture as well as in botanical geography. Almost 7.5% tribal population is the part of Indian population out of which contains approximately 400 tribes and other cultural groups. The Indian locale, in this manner, is rich in ethnobotanical legacy. The Indian clans are exceptional, very proficient about the accessibility of a wide decent variety of plants and livestock present in their surroundings. These tribes are totally dependent on plant sources for variety of food, fibre, fodder, shelter and medicines. The use of botanical knowledge for medication of different ailments and diseases is the cohesive part of Indian rural population. Medicinal plants are natural resources with high potential which acquires an important position in spiritual as well socio-cultural criteria of tribal and rural population. On the basis of available data it is expected that in India, there are approximately 50% of the flowering species of the total used for medicinal production. Out of which around 25, 000 species are used for the traditional medicines in rural region of India whereas formulations prepared with the incorporation of medicinal plants using about 10,000 plant species are available in written form (Fulekar and Jadia, 2006).

Citrullus colocynthis is a fruit belongs to the 'Cucurbitaceae' family. It is considered extraordinary compared to other hereditarily various collections of remedial plants in the plant realm. Most of the plants from this family are dry season tolerant, bigoted to wet, ice touchy and inadequately depleted soils. The distribution of Cucurbitaceae family is mostly found in countries with tropical and subtropical regions (Dhakad *et al.,* 2017). *Citrullus colocynthis* commonly named colocynth, bitter-apple, wild-gourd etc., originated in tropical region of Asia and Africa is now extensively produce in Mediteranean region and Saharo-Arabian phyto-geographic region of Africa (Amamou *et al.,* 2011). *Citrullus colocynthis* is a perennial herb and in India most usually found in sandy lands of Northern West region such as Sind, Punjab, Central

region, Southern region and Coromandal costal area (Borhade *et al.,* 2013).

The chemical composition plays vital role to determine the nutraceutical as well therapeutic properties of plant for further know the remedial effect. All of the medicinal plants contain number of bioactive compounds such as triterpenoids, steroids, alkaloids, tannins, flavonoids, essential oils, glycosides etc. which can produced by primary or secondary metabolism of living-being and further have direct effect on the physiological functions of human-being (Edogo *et al.,* 2005). These compounds are extensively used in different areas related to medicines like in different therapies related to human and veterinary, for agriculture purpose, for revenue generation, for scientific researches etc. Other than bioactive compounds some nutritional composition is also present in medicinal plants which further help to improve nutritional status of the population (Vasu *et al.,* 2009; Mishra *et al*., 2012t; Kumar *et al*., 2011u; Kumar *et al*., 2011v; Kumar and Pathak, 2016w; Pathak *et al*., 2016x; Kumar *et al*., 2018y; Kumar *et al*., 2018z; Kumar *et al*., 2018aa; Kumar *et al*., 2018bb; Kumar et al., 2018cc; Singh *et al.,* 2020a; Singh *et al*., 2020b; Sood *et al*., 2020; Bhadrecha *et al.,* 2020; Singh *et al*., 2020c; Sharma *et al*., 2020; Singh *et al*., 2020d; Bhati *et al*., 2020; Singh *et al*., 2019; Sharma *et al*., 2019).

"According to National Research Council, (2006)' the "moisture content of mature fruit" is recorded as 90% in *Citrullus colocynthis* as well it also contains high amount of protein at 30%, 10% of carbohydrates, 4% of ash content and 3% of fibre content. Other than these nutritional compounds different bioactive compounds are also present in this medicinal plant such as alkaloids, essential oils, flavonoids, glycosides etc. (Aviara *et al.,* 2007). *Citrullus colocynthis* contains a specific bioactive compound named as curcurbitacins (A, B, C, D, E, I, J, K and L)'as well colocynthosides (A & B)'respectively (Hussain *et al.,* 2014). For centuries, desert gourd is an important part of traditional Arabic medicines. On the basis of different studies, it has been reported that extract of root and callus part of *Citrullus colocynthis* contains anti-diabetic, anti-inflammatory, anti-oxidant as well as anti-cacinogenic properties (Gurudeeban, S. and Ramanathan, T., 2010; Rajamanickam *et al.,* 2010; Gurudeeban *et al.,* 2010). Although, *Citrullus colocynthis* is the widely grown fruit in arid regions with multiple medicinal and nutraceutical properties but still the fruit is less known and categorized as underutilized fruit crops. The present review enlightens the nutritional and medicinal properties of *Citrullus colocynthis* which can further help to increase the utilization of certain fruit crop in field of pharmacology."

Origin

Citrullus colocynthis is a vine plant of arid region which grows in sandy soil. Basically the origin place of *Citrullus colocynthis* is Asia and Mediterranean Basin specially Turkey and Nubia which further distributed in western coastal region of Africa, Sahara, Egypt in eastern region, through India it also reaches to northern coastal region of Caspian seas and Mediterranean seas. The growth of *Citrullus colocynthis* has been also found in European countries located in south such as islands of the Grecian archipelago and Spain. Cultivation of *Citrullus colocynthis* at small scale is taking place from 14th century which today continues with export. This plant is perennial in nature with high survival rate under extreme adverse conditions. Further it has tolerance capacity for yearly 'precipitation of 250 mm to 1500 mm' whereas the optimal temperature for growth is considered at 14.8°C-27.8°C respectively. The growth of *Citrullus colocynthis* can takes place at 1500 meters above sea level at 5.0-7.8 pH in soil types such as sandy-loam soil, sandy soils of sea coast or soils of sub-desert area (Anonymous, 2012).

Plant Description

"*Citrullus colocynthis* is 'herbaceous vine plant' of arid region with perennial nature. The tendrils of plant are angular and rough in texture with prominent rough hairs and can be spread upto 3 meters of length. The plant has fleshy roots and can climb on other shrubs and herbs due to auxiliary tendency of branching tendrils. The structure of leaves includes 5-10cm of length, 1.5cm to 2cm of width with deeply lobed arranged alternatively on petioles are rough in texture (Savithramma *et al.,* 2007; Amamou *et al.,* 2011). The flowers are monecious, single, pale yellow in color with pedunculated shape and attached with the 'axils of leaves.'Each *Citrullus colocynthis* plant produces 15 to 30 fruits.' The fruits of *Citrullus colocynthis* are round in shape with 7-10cm diameter, green in color with yellow bands which turns over all yellow after drying. It is smooth textured with globules and bitter in taste." It contains rind part and seeds about 200-300 in numbers which are small in length i.e. approximately 6mm, smooth textured, compressed and turns brown in color after ripening (Schafferman *et al.,* 1998). Further description is mentioned in Table1.

Table 1: Plant description of *Citrullus colocynthis*

Botanical Classification	
Kingdom	Plantae
Division	Magnoliophyta
Class	Magnoliopsida
Order	Cucurbitales
Family	Cucurbitiaceae
Genus	Citrullus Schard
Species	Citrullus colocynthis (L.) Schrad.

Vernacular Names	
Hindi	Badi Indrayan, Ghorumba, Indarayan
Sanskrit	Atmaraksha, Brihadvani, Brihatphala
Bengali	Indrayan, Panjot, Indrabaruni
Malayalam	Kattuvellari
Tamil	Kumatti, Peykomatti
Telagu	Chittipapara
Morphological Description	
Roots and	Large long and tap root.
Stems	The vine-like stems spread in all directions for a few meters looking for something over which to climb.
Leaves	Palmate and angular with three to seven divided lobes
Flowers	Monoecious, so the male (stamens) and the female reproductive parts (pistils and ovary) are borne in different flowers on the same plant.
Fruits	The fruit is smooth, spheric and extremely bitter taste
Seeds	They are edible but similarly bitter, nutty-flavored, and rich in fat and protein. They are eaten whole or used as an oilseed.

Source: Chopra, 1958; Upadhyay *et al.,* 2007

Nutritional composition of Citrullus colocynthis

Although *Citrullus colocynthis* is the widely grown but less known underutilized fruit crop of arid region, it contains certain important nutrients which can be further utilized and can play key role to enhance nutritional status of the population. All of the parts of *Citrullus colocynthis* having utility and can further improve the health of individuals. The moisture content of the fresh mature fruit was estimated at 90% of the total weight of fruit. Variation in agro-ecological conditions as well agricultural practices can affect the nutritional composition of such plant and its parts '(Aviara *et al.,* 2007).'

"As per data provided by 'National Research Council, (2006)' seed kernel of *Citrullus colocynthis* are rich source of oil and contains about 50% of oil content whereas other nutrients such as 'protein, 'carbohydrate, 'ash, 'fibre' etc. are present in amount of 30%, 10%, 4% and 3% respectively. The yield of oil content present in seeds of this respective fruit crop is equivalent to oil yield from oilseeds (sunflower and safflower) which was comparatively higher than the oil production from soyabean and cotton seeds (Sadou *et al.,* 2007). As per mentioned in literature, the oil extracted from *Citrullus colocynthis* seeds is It has been reported in the literature that the oil extracted from *Citrullus colocynthis* seeds is possibly appropriate for livestock as well as for human consumption (Sawaya *et al.,* 1983). Other than high oil content *Citrullus colocynthis* seeds were rich source of protein and contain all essential amino acids in appropriate amount which makes the protein quality of *Citrullus colocynthis* seeds superior and equally important as legumes (National Research Council, 2006)."

Fatty acids

As per the available data, the oil content of Citrullus colocynthis seeds reported as higher than some of the oilseeds. The Citrullus colocynthis seed oil contains two major Saturated Fatty Acids (SFAs) as palmitic acid and stearic acid within the range of 8.1%-17.3% and 6.1%-10.5% respectively (Sawaya *et al*., 1983; Sadou *et al*., 2007; Sebbagh *et al*., 2009). Whereas oleic acid and linoleic acid were majorly present Mono Unsaturated Fatty Acids (MUFAs) in respective oil. The content of linoleic acid was present in range of 50.6%-60.1% which was quit higher than other oils and makes the oil medicinally superior than other oils. Due to the presence of linoleic acid and oleic acid in *Citrullus colocynthis* seed oil it categorized under linoleic-oleic acidoils and considered as equivalent to various other vegetable oils (Sadou *et al*., 2007; Sebbagh *et al*., 2009). On the basis of fatty acid composition and chemical composition of this seed oil its estimated as the considerable source of β-carotene, α-tocopherol and γ-tocopherol at 0.18mg/kg, 45.1mg/kg and 43.5 mg/kg respectively (Kalhoro *et al*., 2002).

Amino Acids

As similar as fatty acid composition *Citrullus colocynthis* seeds are considerable sources of protein with the higher content of essential amino acids such as methionine, arginine and tryptophan etc. (National Research Council, 2006). The protein quality was estimated as lower than soya protein but considerably higher than other oilseed proteins. Lysine and threonine were reported as limiting amino acids in such oil. In a study the amino acid composition of *Citrullus colocynthis* seed protein was compared with other oilseeds protein and found that glutamic acid and arginine were majorly present in seed oil with certain concentration at 19.8 g/100g of protein and 15.9g/ 100g of protein respectively. Some other amino acids were also found in kernel seed protein such as glycine, alanine, leucine, aspartic acid, serine, glycine, and phenylalanine etc. (Sawaya *et al.,* 1986).

Minerals

The mineral content was also present in abundance in *Citrullus colocynthis* fruit and seeds. *Citrullus colocynthis* seed was considered as potential source of calcium as well as potassium and present in concentration at 569mg/100g and

465mg/100g respectively. The seeds also contain iron, zinc and phosphorus in abundant amount. The considerable amount of calcium and niacin present in seeds encourages the consumption *Citrullus colocynthis* in lesser milk-consuming regions of lower West Africa (Sadou *et al.,* 2007; Zaini *et al.,* 2011).

Bioactive Compounds

Cucurbitacins

Citrullus colocynthis is an herbaceous arid fruit which contains various nutrients in considerable quantity. Other than these nutrients this fruit is also having number of bioactive compounds in abundance which are further responsible for medicinal properties. The main bioactive compound present in *Citrullus colocynthis* is cucurbitacins, a group of plant substances tetracyclic in nature with oxygenation capacity and responsible for bitter taste. "These substances are mainly derived from 19-(10-9β)-abeo-10α-lanost-5-en, the skeleton of cucurbitane and not considered as steroids because of methyl group present in structure. Basically cucurbitacin is present in 12 forms but cucurbitacin E(2-O-β-D-glucopyranoside) found in abundance in *Citrullus colocynthis*." Cucurbitacin have cytotoxic behavior due to which it plays vital role in formulation of drug with anti-carcinogenic effect. Other than cucurbitacin E, it also commonly found in forms of cucurbitacin A, cucurbitacin B, cucurbitacin C and cucurbitacin D respectively (Ali *et al.,* 2013).

Glycosides, phenolic acids and flavonoids

Flavonoids are considered as the secondary metabolites which further unveil anti-oxidant activity and acts as free radical terminator. One of the study reported the presence of flavonoid glycosides in *Citrullus colocynthis* as present in forms of isovitexin, isosaponarin and isoorientin along with cucurbitacin glycosides such as 2-O-β-D-glucopyranosyl (cucurbitacin L) and 2-O-β-D-glucopyranosyl (cucurbitacin I) whereas commonly present flavonoids in *Citrullus colocynthis* fruit were reported as catechin, quercetin, kaempferol and myricetin respectively (Delazar *et al.,* 2006).

Other than flavonoids *Citrullus colocynthis* also contains phenolic compounds which further acts as anti-oxidants. Almost eight kind of phenols were observed in *Citrullus colocynthis* i.e. caffeic acid, chlorogenic acid, sinapic acid, ferulic acid, gallic acid, p-hydroxy- benzoic acid, p-coumeric acid and vanillic acid (Hussain *et al.,* 2013).

Alkaloids

Some of the studies reported that *Citrullus colocynthis* fruit contains alkaloids in form of choline and some unidentified alkaloids which further need to investigate (Ali *et al.,* 2013).

Medicinal Importance of *Citrullus colocynthis*

On the basis of various investigations it has observed that *Citrullus colocynthis* is a fruit with abundance of essential nutrients which can further use in formulation of drugs to improve health status as well as can combat the nutritional deficiencies. Due to the presence of plenty of bioactive compounds *Citrullus colocynthis* contains pharmacological properties which can further helps in improvement of diseased conditions. These bioactive compounds have various health effects such as anti-inflammatory, anti-diabetic, anti-microbial, anti-bacterial, anti-carcinogenic, anti-ulcerogenic along with hypolipidemic and hypoglycemic and also perform anti-oxidant activity. Various health effects associated with different bioactive compounds are presented in Table 2.

Table 2: Bioactive compounds and their health significance.

Plant part	Extract	Bioactive Compound	Health significance	References
Fruit pulp	Methanolic Extract	Colocynthin, δ–Tocopherol. Phenolic compounds	Promote wound contraction	Gupta et al., 2018
Stem	Callus Extract	Silver nanoparticles, Polyphenols	Anti-bacterial effect, Anti-Inflammatory effect	Satyavani et al., 2011
Fruit pulp	Methanolic Extract	Antioxidants, Phenols	Anti-oxidant activity, Free radical scavenging activity	Kumar et al., 2008
Fruit	Petroleum ether Extract	Flavanoids	Anti-alopecia effect	Dhamotha et al , 2011
Seed	Hydro-Methanolic Extract	Saponins	Anti-Hyperlipidemic effect	Zamani et al . 2007
Root	Aqueous Extract	Glycosides. Flavonoids. Alkaloids	Hypoglycemic Activity	Agrawal et al., 2012
Leaves	Cucubitacin glucoside Extract	Cucurbitacin. Glucosides	Inhibit growth of breast cancer cells	Tannin-Spitz et al , 2007
Leaves	Methanolic Extract	Flavonoids (Apigenin. Quercetin, Naringein and Luteolin)	Anti-Inflammatory effect	Rajamanickam et al . 2010
Fruit pulp	Petroleum ether Extract	Saponins. Flavonoids, and Glycosides	Anti-Diabetic effect	Jayaraman R. et al , 2009
Seed	Methanolic	Anti-oxidants	Anti-Ulcerogenic	Gill et al., 2011

Although various significant studies have conducted and analyzed the significant effect of *Citrullus colocynthis* on health improvement but still more investigations are required related to this super fruit. Use of different parts of such plant is common in rural population and they use it in traditional remedies for treatment of different diseased conditions and for further health benefits. However, the substances responsible for these medicinal properties are unknown but it helps to improve wellness. According to Meena *et al.* (2014) some of the traditional remedies used by rural population are:

- Pulverized form of fruit part stuffed with carom seeds and salt treats Dyspepsia.
- Consumption of decoction of fruit helps to relief in Constipation.
- Paste of root helps to heal open wound.
- Application of paste prepared by root part helps to treat Paronychia.
- Seed oil helps to treat alopecia and premature greying.
- Consumption of fruit with Aswagandha helps in treatment of Rheumatism.
- Decoction of fruit helps to promote Lactation.
- Consumption of fruit with combination of carom seeds helps to recover in Jaundice.
- Consumption of root paste helps in haemorrhoid condition.

Conclusion

In the present review the nutritional composition and medicinal properties of *Citrullus colocynthis* has discussed with incorporation of different relevant studies. On the basis of this overview it can be analyzed that *Citrullus colocynthis* is a fruit crop with number of health benefits and which can further help in formation of different drugs to treat various disorders. Although, it is a fruit crop with abundance of nutritional significance but it is still unfamiliar for the huge population. So further investigations are required to enhance the utility of such fruit crop and can use as functional food for further improvement in health of individuals.

References

Agarwal, G.R.; V. Sharma, A. Kumar, A. Upadhyay and G. Singh (2012). Hypoglycemic effects of *Citrullus colocynthis* (L.) Schrad Roots. Acta Polaniae Pharmaceutica- Drug Res.; 69(1): 75–79.

Ali, A.A.; M.A. Alian and H.A. Elmahi (2013). Phytochemical analysis of some chemical metabolites of Colocynth plant (Citrullus colocynthis L.) and its activities as antimicrobial and antiplasmidial. J. Basic Appl. Sci. Res.; 3: 228–236.

Amamou, F.; M. Bouafia, D. Chabane-Sari and R. Kaouthar Meziane (2011). *Citrullus colocynthis*: a desert plant native in Algeria, effects of fixed oil on blood homeostasis in Wistar rat. J. National Production Plant Resources, 1(3): 1-7.

Anonymous (2012) Citrullus Colocynthis-Potential Arid Land Biodiesel Feedstock from an Ancient Cucurbit.

Aviara, N.A.; S.K. Shittu and M.A. Haque (2007) Physical properties of guna fruits relevant in bulk handling and mechanical processing. Inter. Agrophys.; 21: 7–16.

Bhadrecha, P.; Bala, M.; Khasa, Y.P.; Arshi, A.; Singh, J. and Kumar, M. (2020). *Hippophae rhamnoides* L. rhizobacteria exhibit diversified cellulase and pectinase activities. Physiology and Molecular Biology of Plants.

Bhati, S.; Kumar, V.; Singh, S. and Singh, J. (2020). Synthesis, Characterization, Antimicrobial, Anti-tubercular, Antioxidant Activities and Docking Simulations of Derivatives of 2-(pyridine-3-yl)-1H-benzo[d]imidazole and 1,3,4-Oxadiazole Analogy. Letters in Drug Design & Discovery.

Borhade, P.; T. Deshmukh, V. Patil and K. Khandelwal (2013) Review on *Citrullus colocnythis*. Inter. J. Res. Pharm. Chem.; 3(1): 46-53.

Chandal, K.P.S.; G. Shukla and N. Sharma (1996) Biodiversity in medicinal and Aromatic plants in India. Conservation and utilization, 239-258.

Chopra R. (1958) Chopra's indigenous drugs of India, UN Dhur & Sons Pvt. Ltd, Calcutta, 12: 495-521.

Delazar, A.; S. Gibbons, A.R. Kosari, H. Nazemiyeh, M. Modarresi, L. Nahar and S.D. Sarker (2006) Flavone C-glycosides and cucurbitacin glycosides from Citrullus colocynthis. Daru- J. Faculty Pharm.; 14: 109–114.

Dhakad, P. K.; P.K. Sharma and S. Kumar (2017) A Review on Phytochemical Studies and Biological Potential of *Citrullus colocynthis* (L.) Schrad. (Cucurbitaceae). Bioengineering and Bioscience, 5(4): 55-64.

Dhanotia, R.; N.S. Chauhan, D.K. Saraf and V.K. Dixit (2011) Effect of Citrullus colocynthis Schrad fruits on testosterone-induced alopecia. Natural Product Res.; 25(15): 1432-1443.

Edogo, H.O.; D.E. Okwu and B.O. Mbaebie (2005) Phytochemicals constituents of some Nigerian medicinal plants. Afr. J. Biotechnol.; 4(7): 685-688.

Fulekar, M.H. and C. Jadia (2006) Ethnobotany, a science of medicinal plants-intellectual property rights. Nat. Env. Poll. Technol.; 5(1): 119-121.

Gill, N.S.; S. Kaur, R. Arora and M. Bali (2011) Screening of Antioxidant and Antiulcer Potential of *Citrullus colocynthis* Methanolic Seed Extract. Res. J. Phytochem.; 5(2): 98-106.

Gogia, N.; Kumar, P.; Singh, J.; Rani, A. Sirohi, Kumar, P. (2014q). "Cloning and molecular characterization of an active gene from garlic (*Allium sativum* L.)" International Journal of Agriculture, Environment and Biotechnology, 7(1): 1-10.

Gupta, S.C.; T. Tripathi, S.K. Paswan, A.G. Agrawal, C.V. Rao and O.P. Sidhu (2018) Phytochemical investigation, antioxidant and wound healing activities of *Citrullus colocynthis* (bitter apple). Asian Pac. J.Trop. Biomed.; 8(8): 418-424.

Gurudeeban, S. and T. Ramanathan (2010) Antidiabetic effect of *Citrullus colocynthis* in alloxon-induced diabetic rats. Inventi Rapid: Ethno pharmacol.; 1: 112-119.

Gurudeeban, S.; T. Ramanathan and K. Satyavani (2010) Antioxidant and radical scavenging activity of *Citrullus colocynthis*. Inventi Rapid: Nutraceuticals, 1: 38-49.

Hussain, A.I.; H.A. Rathore, M.Z.A. Sattar, S.A.S. Chatha, F. Ahmad, A. Ahmad and E.J. Johns (2013) Phenolic profile and antioxidant activity of various extracts from *Citrullus colocynthis* (L.) from the Pakistani flora. Industrial Crops and Products, 45: 416–422.

Hussain, A.I.; H.A. Rathore, M.Z.A. Sattar, S.A.S. Chatha, S.D. Sarker and A.H. Gilani (2014) *Citrullus*

colocynthis (L.) Schrad. (bitter apple fruit): A review of its phytochemistry, pharmacology, traditional uses and nutritional potential. J. Ethnopharmacol.; 155(1): 54-66.

Jayaraman R,P.N.N.; S.K. Arihara, T. Anitha and V.D. Joshi (2009) Antidiabetic effect of petroleum ether extract of *Citrullus colocynthis* (L.) Schrad. fruits against streptozotocin-induced hyperglycemic rats. Romanian J. Biol.; 54: 127–134.

Kalhoro, M.A.; N. Afza, M. Saleem and A. Malik (2002) Pharmacochemical studies of the oil, aerial parts, pulp and peel of Citrullus colocynthis. J. Chem. Soc. Pak, 24: 274–276.

Kumar, P. (2013o). "Cultivation of traditional crops: an overlooked answer". Agriculture Update, 8(3): 504-508.

Kumar, P. (2014r). Studies on cadmium, lead, chromium, and nickel scavenging capacity by in-vivo grown Musa paradisiacal. using atomic absorption spectroscopy" Journal of Functional and Environmental Botany, 4(1): 22-25.

Kumar, P. Pathak, S. (2019f). "Responsiveness index of sorghum (Sorghum bicolor (l.) Moench) grown under cadmium contaminated soil treated with putrescine and mycorrhiza" *Bangladesh J. Bot.* vol.48 (1).

Kumar, P. Purnima *et al*. (2018e). "Impact of Polyamines and Mycorrhiza on Chlorophyll Substance of Maize Grown under Cadmium Toxicity" *International Journal of Current Microbiology and Applied Sciences*, 7(10): 1635-1639.

Kumar, P. Siddique, A. *et al*.; (2019g). "Role of Polyamines and Endo-mycorrhiza on Leaf Morphology of Sorghum Grown under Cadmium Toxicity" Biological Forum – An International Journal. 11(1): 01-05.

Kumar, P.; Kumar, P.K.; Singh, S. (2014n). "Heavy metal analysis in the root, shoot and a leaf of psidium guajava l. by using atomic absorption spectrophotometer" Pollution Research, 33(4): 135-138.

Kumar, P.; Mandal, B.; Dwivedi P. (2014m). "Phytoremediation for defending heavy metal stress in weed flora" International Journal of Agriculture, Environment & Biotechnology, 6(4): 587-595.

Kumar, P.; Dwivedi, P. (2015p). "Role of polyamines for mitigation of cadmium toxicity in sorghum crop" Journal of Scientific Research, B.H.U.; 59: 121-148.

Kumar, P.; Dwivedi, P.; Singh, P. (2012s). "Role of polyamine in combating heavy metal stress in stevia rebaudiana Bertoni plants under in vitro condition" International Journal of Agriculture, Environment and Biotechnology, 5(3): 185-187.

Kumar, P.; Harsavardhn, M. *et al*. (2018y). "Effect of Chlorophyll a/b ratio in Cadmium Contaminated Maize Leaves Treated with Putrescine and mycorrhiza" Annals of Biology, 34(3): 281-283.

Kumar, P.; Krishna, V. *et al*. (2018cc). "Assessment of Scavenging Competence for Cadmium, Lead, Chromium and Nickel Metals by in vivo Grown *Zea mays* L. using Atomic Absorption Spectrophotometer, Annals of Ari-Bio Research, 23(2): 166-168.

Kumar, P.; Kumar, S. *et al*. (2018bb). "Evaluation of Plant Height and Leaf Length of Sorghum Grown Under Different Sources of Nutrition" Annals of Biology, 34(3): 284-286.

Kumar, P.; Mandal, B.; (2014L). "Combating heavy metals toxicity from hazardous waste sites by harnessing scavenging activity of some vegetable plants" *vegetos*, 26(2): 416-425.

Kumar, P.; Mandal, B.; Dwivedi, P. (2011u). "Heavy metal scavenging capacity of Mentha spicata and *Allium cepa*" Medicinal Plant- International Journal of Phytomedicines and Related Industries, 3(4): 315-318.

Kumar, P.; Mandal, B.; Dwivedi, P. (2011v). "Screening plant species for their capacity of scavenging heavy metals from soils and sludges. Journal of Applied Horticulture, 13(2): 144-146.

Kumar, P.; Pandey, A.K. *et al*. (2018aa). "Phytoextraction of Lead, Chromium, Cadmium, and Nickel by Tagetes Plant Grown at Hazardous Waste site" Annals of Biology, 34(3): 287-289.

Kumar, P.; Pathak, S. (2016w). Heavy metal contagion in seed: its delivery, distribution, and uptake" Journal of the Kalash Sciences, An International Journal, 4(2): 65-66.

Kumar, P.; Yumnam, J. *et al*. (2018z). "Cadmium Induced Changes in Germination of Maize Seed Treated with Mycorrhiza" Annals of Agri-Bio Research, 23(2): 169-170.

Kumar, S.; D. Kumar, Manjusha, K. Saroha, N. Singh and B. Vashishta (2008) Antioxidant and free radical scavenging potential of *Citrullus colocynthis* (L.) Schrad. methanolic fruit extract. ACTA Pharmceutica, 58: 215–220.

Meena, M.C.; R.K. Meena and V. Patni (2014) Ethnobotanical studies of *Citrullus colocynthis* (Linn.) Schrad.- An important threatened medicinal herb. J. Med. Plants Stud.; 2(2): 15-22.

Mishra, P.K.; Maurya, B.R.; Kumar, P. (2012t). "Studies on the biochemical composition of *Parthenium hysterophorus* L. in different season" Journal of Functional and Environmental Botany, 2(2): 1-6.

National Research Council (2006) Lost Crops of Africa. National Academies Press, Washington, DC, (ISBN 978-0-309–10333-6).

Pathak, S.; Kumar, P.; Mishra, P.K.; Kumar, M. (2016x). "Plant-based remediation of arsenic-contaminated soil with special reference to sorghum- a sustainable approach for a cure". Journal of the Kalash Sciences, An International Journal, 4(2): 61-65.

Pathak, S.; Kumar, P.; P.K Mishra, M. Kumar, (2017j). "Mycorrhiza assisted approach for bioremediation with special reference to biosorption", *Pollution Research*, Vol. 36(2).

Prakash, A.; P. Kumar, (2017k). "Evaluation of heavy metal scavenging competence by in-vivo grown *Ricinus communis* L. using atomic absorption spectrophotometer" *Pollution Research*, 37(2): 148-151.

Rajamanickam, E.; S. Gurudeeban, T. Ramanathan and K. Satyavani (2010). Antimicrobial activity of Citrullus colocynthis in gulf of mannar. Inter. J. Current Res.; 2: 78-81.

Sadou, H.; H. Sabo, M.M. Alma, M. Saadou and C.L. Leger (2007). Chemical content of the seeds and physico-chemical characteristic of the seed oils from *Citrullus colocynthis*, Coccinia grandis, Cucumis metuliferus and Cucumis prophetarum of Niger. Bulletin of the Chemical Society of Ethiopia, 21: 323–330.

Satyavani, K.; T. Ramanathan and S. Gurudeeban (2011). Green synthesis of silver nanoparticles by using stem

derived callus extract of bitter apple (*Citrullus colocynthis*). Digest J. Nanomaterials and Biostructures, 6(3): 1019 -1024.

Sawaya, W.N.; N.J. Daghir and J.K. Khalil (1986) *Citrullus colocynthis* seeds as a potential source of protein for food and feed. J. Agric. Food Chem.; 34: 285–288.

Sawaya, W.N.; N.J. Daghir and P. Khan (1983) Chemical characterization and edibility of the oil extracted from *Citrullus colocynthis* seeds. J. Food Sci.; 48: 104–106.

Sebbagh, N.; C. Cruciani-Guglielmacci, F. Ouali, M.F. Berthault, C. Rouch, D.C. Sari and C. Magnan (2009) Comparative effects of *Citrullus colocynthis*, sunflower and olive oil-enriched diet in streptozotocin-induced diabetes in rats. Diabetes and Metabolism, 35: 178–184.

Sharma, M.; Singh, J.; Chinnappan, P.; and Kumar, A. (2019). A comprehensive review of renewable energy production from biomass-derived bio-oil. Biotechnologia 100(2):179-194.

Sharma, R.; Jasrotia, K.; Singh, N.; Ghosh, P.; Sharma, N.R.; Singh, J.; Kanwar, R. and Kumar, A. (2020). A Comprehensive Review on Hydrothermal Carbonization of Biomass and its Applications. Chemistry Africa, 3(1):1-19

Siddique, A. Kumar, P. (2018h). "Physiological and Biochemical basis of Pre-sowing soaking seed treatments-An overview" *Plant Archive*, 18(2): 1933-1937.

Siddique, A.; Kandpal, G.; Kumar P. (2018i). "Proline accumulation and its defensive role under Diverse Stress condition in Plants: An Overview" Journal of Pure and Applied Microbiology, 12(3): 1655-1659.

Singh, S.; Kumar, V. and Singh, J. (2019). The effects of Fe(II), Cu(II) and Humic Acid on biodegradation of atrazine. Journal of Environmental Chemical Engineering, 8: 103539.

Singh, S.; Kumar, V.; Datta, S.; Dhanjal, D.S.; Sharma, K.; Samuel, J. and Singh, J. (2020). Current advancement and future prospect of biosorbents for bioremediation. Science of the Total Environment, 709: 135895.

Singh, S.; Kumar, V.; Datta, S.; Wani, A.B.; Dhanjal, D.S.; Romero, R. and Singh, J. (2020). Glyphosate uptake, translocation, resistance emergence in crops, analytical monitoring, toxicity, and degradation: a review. Environmental Chemistry

Singh, S.; Kumar, V.; Kapoor, D.; Kumar, S.; Singh, S.; Dhanjal, D.S.; Datta, S.; Samuel, J.; Dey, P.; Wang, S.; Prasad, R. and Singh, J. (2020). Revealing on hydrogen sulfide and nitric oxide signals co-ordination for plant growth under stress conditions. Physiologia Plantarum, 168(2): 301-317.

Singh, S.; Kumar, V.; Singla, S.; Sharma, M.; Singh, D.P.; Prasad, R.; Thakur, V.K. and Singh, J. (2020). Kinetic Study of the Biodegradation of Acephate by Indigenous Soil Bacterial Isolates in the Presence of Humic Acid and Metal Ions. Biomolecules, 10: 433

Singh, V.K. (1998) Relevance of folk medicines in the context of primary health care programmes in North India. Procured Herbal Medicines in primary health Care, Lome (West Africa), MC, Geneva, 14-19.

Sood, M.; Sharma, S.S.; Singh, J, Prasad, R.; and Kapoor, D. (2020). Stress Ameliorative Effects of Indole Acetic Acid on *Hordeum vulgare* L. Seedlings Subjected to Zinc Toxicity. Phyton – International Journal of Experimental Botany, 89(1): 71-86

Tannin-Spitz, T.; S. Grossman, S. Dovart, E. Gottlieb and M. Bergman (2007). Growth inhibitory activity of cucurbitacin glucosides isolated from *Citrullus colocynthis* on human breast cancer cells. Biochem. Pharmacol., 73(1): 56-67.

Tripathi, Y.C. (2000) Ethnomedicinal- treasure of tribal rajasthan. J. Non-Timber for Products, 7(2): 77-84.

Upadhyay, B.; S. Roy and A. Kumar (2007). Traditional uses of medicinal plants among the rural communities of Churu district in the Thar Desert, India. J. Ethnopharmacol.; 113(3): 387-399.

Vasu, K.; J.V. Goud, A. Suryam and C.M.A. Singara (2009) Biomolecular and phytochemical analysis of three aquatic angiosperons. Afr. J. Microbiol.; 3(8): 418-421.

Zaini, N.A.M.; F. Anwar, A.A. Hamid and N. Saari (2011). Kundur [*Benincasa hispida* (Thunb.) Cogn.]: a potential source for valuable nutrients and functional foods. Food Res. Inter.; 44: 2368–2376.

Zamani, M.; A.O. Rahimi, R. Mahdavi, M. Nikbakhsh and V. Morteza (2007) "Artigo." Brazilian J. Pharmacogn.; 17(4): 492–496.