REVIEW

Medicinal plants combating against hypertension: A green antihypertensive approach

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Abstract: Hypertension (HTN) or high blood pressure is a medical condition that accounts 9.4 million deaths all over the world every year. It is leading cause of morbidity and mortality worldwide. It increases the risk of cardiovascular diseases, including heart failure, diffuse atherosclerosis, cognitive impairment and dementia. Clinically, synthetic antihypertensive drugs have been used to treat hypertension. However, the efficacy of these drugs is low and also produces side effects which include dry mouth, dizziness, emotional distress, gastrointestinal disturbance, visual disorders etc. These distressing side effects adversely affect health-related quality of life. Therefore, there is a need to search natural, cheaper and non-toxic compound. Plant are widely use in traditional systems of medicine for the treatment of several diseases. About 80% of the world population relies on traditional medicine for primary healthcare. In the last three decades, a lot of research has been done on local medicinal plants for hypotensive and antihypertensive potentials. Plants are the rich source of secondary metabolites which have been found in vivo to have antihypertensive properties. The current study is focused on reviewing the antihypertensive property of medicinal plants and their metabolites. In the current review, we conducted a literature search using Elsevier, Science direct, Springer Link (Springer), Pub Med and Google Scholar. The search included the keywords “plants”, “medicinal plants”, “plant extracts”, cross-referenced with the keywords “hypertension” “antihypertensive activity”. The use of plant origin natural compounds as cardio protective and antihypertensive agents is an interesting strategy for discovering bioactive products. Plants are rich in a variety of secondary metabolites, such as flavonoids, alkaloids, tannins and terpenoids. These have been found *in vivo* to have antihypertensive effects. The present review therefore; stand for a good basis to choose exact molecules belonging to the indicated categories that in the forthcoming future will become useful therapeutic tools.

Keywords: Hypertension, antihypertensive activity, medicinal plants, metabolites.

INTRODUCTION

Hypertension (HTN) or high blood pressure is a medical condition in which the blood vessels have persistently raised pressure (Carretero *et al.*, 2000). The elevated pressure in blood vessels makes heart harder to pump blood in the body (Sundström *et al.*, 2015). If it is not controlled in time, this can cause serious heart problem such as heart attack, an enlargement of the heart and ultimately heart failure (WHO, 2013).

Hypertension is the preventable risk factor for premature death worldwide (Burt *et al*., 1995). It increases the risk of ischemic heart disease (Ostchega, 2007) strokes, (O'Brien, 2007) peripheral vascular disease, (Lloyd-Jones, 2010)and other cardiovascular diseases, including heart failure, aneurysms and pulmonary embolism (O'Brien, 2007), Other complications include hypertensive retinopathy and hypertensive nephropathy(Franklin *et al.,* 2012).

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Worldwide cardiovascular disease causes for about 17 million deaths a year, almost one third of the total (WHO, 2008). In addition, 9.4 million deaths all over the in a year occurs due to the complications of hypertension (Lim *et al.,* 2012). Hypertension causes at least 45% of deaths as a result of heart disease, and 51% of deaths as a result of stroke (WHO, 2008). In 2008, worldwide survey report, nearly 40% of adults having age 25 year and above had been suffered in hyper tension; the number of people rose from 600 million in 1980 to 1 billion in 2008 (Global status report on non communicable diseases 2010 Geneva). Prevalence rate of hypertension is low (35%) in high income countries where as in low income countries it is high (40%) (WHO, 2008). According to the report "A Global Brief on Hypertension--silent killer, global public health crisis" issued by WHO, It is observed that Africa has the highest prevalence of hypertension (46%) of adults aged 25 and over, while the lowest prevalence is seen in the Americas (35%). GENEVA, April 3 (Xinhua) - On the event of celebrating the World Health Day on April 7 with a theme on hypertension, the World Health

Organization (WHO) called on Wednesday for greater efforts to prevent and control this disease, which is also known as high blood pressure. Every year, 17 May is dedicated to World Hypertension Day (WHD). World Hypertension Day is a day designated and initiated by The World Hypertension League (WHL), which was started to increase the awareness of hypertension. It is estimated that upto2030 more than 23 million people will die annually from CVDs (WHO, 2008).

Certain factors that involve in the pathogenesis of hypertension are generally the increase activity of renin angiotensin aldosterone system, kalikereninkinin system, sympathetic nervous system and genetic influence etc. Angiotensin converting enzyme (ACE) plays a significant role in converting enzyme angiotensin I into angiotensin II which is responsible in increasing the blood pressure. Therefore, ACE inhibition should be control to overcome the increase expression of renin angiotensin aldosterone system (Balasuriya *et al.,* 2011).

Now days, number of antihypertensive agents have been used clinically, to treat hypertension and to overcome its symptoms. Although these agents are widely used clinically but their efficacy is only 40 to 60% and generally two or more antihypertensive drugs from different categories are needed to be combined together to get the desirable results and hence, in due course increase the cost of treatment and side effects. The side effects usually produced by synthetic antihypertensive agents include dry mouth, dizziness, emotional distress, gastrointestinal disturbance, visual disorders, headache etc. These distressing side effects disturb the quality of usual life. Therefore, there is a need to search natural, cheaper and non-toxic and cost effective antihypertensive compound (Otari *et al.,* 2012).

Medicinal Plant widely used in traditional systems of medicine, and in quite a lot of communities of the developing world. Worldwide 80% of the population relies on plant based medicine for their primary healthcare (Tagboto *et al.,* 2001). Thus, modern scientific methods for the search of botanical therapeutics are important to the development of medicine and both the standardization of extracts and the identification of the chemical or biological compounds; therefore, stress must be put on the conservation of plant populations to assurance pharmacologically active sources of material for herbal medicine (Dianella *et al.,* 2012).

Methodology

In the current review, we conducted a literature search using Elsevier, Science direct, Springer Link (Springer), Pub Med and Google Scholar. The search included the keywords “plants”, “medicinal plants”, “plant extracts”, cross-referenced with the keywords “hypertension” “antihypertensive activity”. We included in vitro, in vivo experimental studies, randomized controlled trials and meta analytical studies in this review carried out during the duration of 1980 to 2012. Observational studies were excluded during the literature search. The references found in the search were later conferring with details on the models or bio-assays used for examining the plant extracts against hypertension. Interest has been focused on experimental studies performed on antihypertensive plants in this review.

Plant derived antihypertensive phytochemicals

Drugs derived from plants have been used to treat hypertension and its associated complications. Such as from *Digitalis purpurea* (foxglove) digitoxin has been derived. Similarly derived, reserpine from *Rauwolfia serpentine,* aspirin from *Salix alba* (willow bark), tetramethylpyrazine, from *Jatropha podagrica*, and tetrandrine from *Stephenia tetradra* (Ojewole, 1980).These plant derived antihypertensive agents have been scientifically been proved via different mechanisms (Nie, 1985).

In the last 2 decades, medicinal plants have remained historically important as sources of discovery of novel compounds. They can be used in the development of safe, efficacious and cost-effective antihypertensive drugs (Amira, 2007).

Plant-derived compounds secondary plant metabolites possess therapeutic value andtradi- tionally used for medicinal purposes. They have a wide activity range, according to the species, the topography and climate of the country of origin, and may contain different categories of active principles (Assob *et al.,* 2011).

Alkaloids

Alkaloids are heterocyclic nitrogen containing compounds and most of them possess antihypertensive activities. *Rauwolfiaserpentina* is an origin of reserpine. Reserpine is an indole *Rauwolfia serpentina* used from prolonged period of time in India for the treatment of insanity, as well as fever and snakebites (Gawade *et al.,* 2012). Reserpine is an antihypertensive drug that has been used for the control of high blood pressure (Baumeister *et al.,* 2003).

Von Bezold and Hirt (1867) reported another alkaloids veratrine, isolated from Sabadilla seeds, exhibited antihypertensive activity. Von Bezold was supposed that this activity might be due to reflexing activity originating in the heart (Krayer *et al.,* 1977).

Corydalis racemosa (Thunb.) Pers. (Papaveraceae) tubers are the origin of dl-tetrahydropalmatine hydrochloride. Its antihypertensive effect was evaluated in experimental hypertensive rats. It was suggested that the antihypertensive effect of dl-tetrahydropalmatine hydrochloride was mainly by an effect on central nervous

system to lower sympathetic tone in spontaneously hypertensive rats (Hwa Chu *et al.,* 1996).

In vivo potential activity of (+)-nantenine, a natural aporphinoid alkaloid on the rat cardiovascular system was evaluated. This was the first in vivo study. Acute intravenous (i.v.) administration of (+)-nantenine in anaesthetized normotensive rats produced a dose-dependent fall in mean arterial pressure, accompanied by a significant decrease in heart rate (Orallo *et al.,* 2004)

*Uncaria rhynchophylla*ia another traditionally used medicinal plant. This plant is the source of Hirsutin which is an indole alkaloid. Its effects on cytosolic Ca^{2+} level ($[Ca^{2+}]$cyt) were studied by using fura-2-Ca^{2+} fluorescence in smooth muscle of the isolated rat aorta. Administration of hirsutine after the increases in [Ca2+]cyt induced by nor adrenaline and high K^+ remarkably decreased $[Ca^{2+}]$cyt, indicating that hirsutine block Ca^{2+} influx generally through a voltage-dependent Ca^{2+} channel. Furthermore, the effect of hirsutine on intracellular Ca^{2+} store was studied by using caffeine induced contraction in the rat aorta. Hirsutine slightly but significantly reduced the caffeine-induced contraction. It is concluded from the study that hirsutine decreases intracellular Ca^{2+} level by its effect on the Ca^{2+} store as well as through its effect on the voltage-dependent Ca^{2+} channel (Horie *et al.,* 1992).

Stephaniatetrandrae has been used since ancient times in China as an antirheumatic, antihypertension, analgesic and antipyretic agent. Tetrandrine is the major constituent isolated from *Step haniatetrandrae*. The antihypertensive and hypnotic effect of tetrandrine on spontaneously hypertensive rats and the possible mechanisms was evaluated. In the study Tetrandrine at a dose of 100 mg/kg, e.g. significantly suppressed blood pressure of spontaneously hypertensive rats. Meanwhile, tetrandrine improved the sleep efficiency by increasing total sleep time (Juan Zhang *et al.,* 2014)

Flavonoids

Flavonoids are secondary metabolites. They are potent ACE inhibitor and used for the treatment of hypertension since decades. Some examples are Captopril®, Enalpiril®, and Rampiril®. However, their use for a prolong period of time causing adverse side effects. Therefore, there is a need to search new alternatives having no side effects. Most of the researchers conducted studies to search bioactive compounds from natural resources. Peptides, anthocyanins, flavonols, triterpenes are some bioactive compound that have shown to possess ACE inhibitor activity (Balasuriya *et al.,* 2011).

Flavonoids have phenolic structures commonly found in fruit, vegetables, nuts, seeds, stems, flowers, tea, wine, propolis and honey. The basic structural feature of flavonoid compounds is the 2-phenyl- benzopyrane or flavane nucleus, consisting of two benzene rings linked through a heterocyclic pyrane ring (Cowan,1999; Fowler *et al*., 2011). Flavonoidsin the diet reduces the risk of several diseases such as cardiovascular disease, neurodegenerative disorders, various cancers, etc. (Tlili *et al.,* 2011).For instance, a flavonoid compound quercetin-3-O-glucosidecommonly present in fruits, has protective effect on human neuroblastoma cells (SH-SY5Y) (Reichling,1999).

Anthocyanins are water soluble vacuolar plant pigments responsible for red, blue and purple colors of fruits and vegetables (Archivio *et al.,* 2007). Anthocyanins possess ACE inhibitor activity. Delphinidin-3-O-sambubiosides and cyanidin-3-O-sambubiosides isolated from *Hibiscus sabdariffa* extracts exhibited ACE inhibition in a dose dependant manner (Ojeda *et al*., 2010). Similarly, cyanidin-3-O-β-glucoside isolated from *Rosa damascene* showed AC Einhibtion *in vitro* (Kwon *et al.,* 2010).

Vacciniummyrtillus extracts rich source of major anthocyanins i.e. cyanidin, delphinidin and malvidin. Their ACE inhibitor effects were evaluated in a human umbilical vein endothelial cell culture model. The ACE activity had been significantly reduced after incubation of cells with bilberry extracts (Persson *et al.,* 2009). The reduction of blood pressure by anthocyanins was reported because of their antioxidant activity, preservation of endothelial nitric oxide, and prevention of serum lipid oxidation (Shindo *et al.,* 2007).

Flavanols (Flavan-3-ols) are compounds found both in monomer form (catechins) and as well as polymer form (procyanidins) (Archivio *et al.,* 2007).Research reveals thatthese exhibited ACE inhibition activity (Actis-Goretta *et al.,* 2006).

The major phytoconstituents of the tea arecatechins, (–)-epicatechin, (–)-epigallocatechin, (–)-epicatechingallate and (–) -epigallocatechingallate. These compound had also possess dose dependant ACE inhibition (Persson *et al.,* 2006)

Pinus maritime French maritime pine is the source of Pycnogenol. It is procyanidin oligomer. It is an effective mediator for blood pressure regulation possibly by ACE inhibition (Zibadi *et al.,* 2008).

Flavonols are widely distributed flavonoid sub-group in foods. Most common flavonols are Quercetin, kaempferol and myricetin. They are commonly present in our diet (Archivio *et al.,* 2007). Many flavonols possess ACE inhibitory property. *Sedum sarmentosum*is traditional medicinal plant and is the source of five flavonols which were found to possess ACE inhibitory activity (Oh H *et al.,* 2004). *Ficusracemosa* commonly known as cluster fig is Kaempferol-rich plant. The stem bark has shown a dose dependant ACE inhibition property *in vitro* in one of the

study (Ahmed *et al*., 2010). Kaempferol was found to be an effective ACE inhibitor conducted study on an ex vivo experiment using aortic tissues of male Wistar-Kyoto rats (Olszanecki *et al.,* 2008). In a randomized, double-blind, placebo-controlled, crossover study dietary quercetin supplementation at 730 mg/d for 28 days was found effective in reducing blood pressure in hypertensive patients (Edwards *et al.,*2007). In another study, Captopril® and quercetin treatments significantly reduced hypertension in male Wistar rats which was induced by angiotensin I and bradikinin® injections (Hackl *et al.,*2002).

Isoflavones are flavonoids are structurally similarity to mammalian estrogen hormone. They can bind to the estrogen receptors and often called as phytoestrogens (Jackson, 2002). The common isoflavones present in plants are genistein, daidzein and glycetin. Genistein is widely possess therapeutic effects (Wu J *et al.,* 2008). Genistein has been reported for reducing elevated blood pressure in experimental animal. Genistein has decreased NaCl-sensitive hypertension in stroke-prone spontaneously hypertensive rats (Cho *et al.,* 2007), decreased ACE gene expression and enzyme activity in rat aortic endothelial cells, serum and aorta tissue in dose dependant manner (Xu YY *et al.,* 2006). Pretreatment of single intravenous injection of genistein at a dose of 25 mg/kg had shown antihypertensive effects in hypertensive Wistar rats. The anti hypertensive effect was might be due to the significant reduction of ACE activity in rat plasma (Montenegro *et al.,* 2009).

Apigenin and luteolin are two major flavones isolated from *Ailanthus excelsa* Roxb, possesses dose dependent ACE enzyme inhibition (Loizzo *et al*., 2007). The ethanol extracts of the outer bark of Japanescedar exhibited ACE inhibitor activity *in vitro*. The extract was known to possess flavan-3-ols and flavones (Tsutsumi *et al.,* 1997).

Hydroalcoholic extract of *H. Sabdariffa* rich in flavones had shown satisfactory enzyme inhibition on ACE (Jonadet *et al.,* 1990). Chalcones are precursor molecules of the biosynthetic pathways of flavonoids Rupasinghe HPV (Paliyath, 2008). It has number of beneficial properties Chalcones and their pyrazole derivatives inhibited ACE in a concentration dependent manner *in vitro* (Bonsei *et al.,* 2010). Butein, a chalcone, through intravenous injection has been found to decrease the arterial blood pressure in anesthetized normotensive rats (Kang *et al.,* 2003). In one of the study Duarte *et al* have evaluated the effects of quercetin (10 mg kg^{-1}) on blood pressure, vascular structure, endothelial function and oxidative status inspontaneously hypertensive rats and normotensive Wistar Kyoto rats. Quercetin induced a significant reduction in systolic, diastolic and mean arterial blood pressure and heart rate in spontaneously hypertensive but not in normotensive Wistar Kyotorats (Duarte *et al.,* 2001).

In another study ACE inhibitory property of a flavonoid-rich apple peel extract, its constituents, selected flavonoids and some quercetin metabolites were investigated using a biochemical assay of ACE inhibition and a human umbilical vein endothelial cell model. In the study flavonoid-rich apple peel extract, all the tested flavonoids except genistein, and two quercetin metabolites (quercetin-3-O-glucuronic acid and quercetin-3-O-sulfate) significantly inhibited ACE (Balasuriya, 2011).

Propolis, is a honeybee product, used as a food and alternative medicine. Its constituents possess anticancer, antimicrobial, and anti-inflammatory effects. Brazilian green propoliswas evaluated for antihypertensive effects in spontaneously hypertensive rats. It significantly decreases the blood pressure. The active constituents were flavonoids such as dihydrokaempferide, isosakuranetin betuletol and kaempferide purified and identified by column chromatography. On Upon oral administration of these flavonoids significantly decrease blood pressure in hypertensive rats. These constituents also relaxed isolated spontaneously hypertensive rats in a concentration-dependent manner (Maruyama *et al.,* 2009).

Tannins

The tannins are natural polyphenols, also possess inhibitory effects on the angiotensin converting enzyme (ACE). The authors Liu JC *et al.* isolated 18 polyphenolic compounds (tannins) from Chinese herbs. They examined the *in vitro* effects of these polyphenols on ACE inhibition activity. They also evaluated the *in vivo* inhibitory effect of the tannins on increased blood pressure elevated by the induction of angiotensin I in spontaneously hypertensive rats. Nine tannins were belongs to three tannin classes i.e. caffeoylquinates, flavan-3-ols and gallotannins. In vitro, they found caffeoylquinates chelate the ACE zinc cofactor. Two of the flavan-3-ols: epigallocatechin-3-O-gallate and epigallocatechin-3-O-methylgallate, and one of gallotannin: 1, 2, 3, 4, 6-penta-O-galloyl-beta-D-glucose were non-specific inhibitors. The ACE inhibition of 1, 2, 3, 4, 6-penta-O-galloyl-beta-D-glucose was also reduced after addition of bovine serum albumin, suggesting a non-specific mode of action. In vivo, 1,2,3,6-tetra-O-galloyl-beta-D-glucose and epigallocatechin-3-O-methylgallate produced strong dose-dependent hypotensive effect reducing the blood pressure significantly in the spontaneously hypertensive rats with infusion of the angiotensin I. These findings suggest that some of the tannins isolated from herbs inhibit ACE activity non-specifically (Liu *et al.,* 2003).

The antihypertensive activity of eleven hydrolyzable tannins isolated from the leaves of *Lumnitzera racemosa* (Combretaceae) was investigated in spontaneously hypertensive rats. Corilagin, castalagin, and chebulinic

acid were give significant response (Ta-Chen Lin *et al.,* 1993).

Diterpenoids

Andrographis paniculata, used traditionally for the treatment of common cold, diarrhea and hypertension. It contains three major active diterpenoids which are andrographolide (AP1), 14-deoxy-11,12-didehydro andrographolide (AP3) and neoandrographolide (AP4). Yoopan *et al* (2007) investigated the effects of these diterpenoids, AP1, AP3 and AP4, isolated from *A. paniculata*, and different aqueous plant extracts on blood pressure, vascular and chronotropic responses by using conscious rats and their isolated aortas and right atria as the test models. He found that among the three major diterpenoids, AP3 was the most potent compound for inducing vasorelaxation and decreasing heart rate. Therefore, the use of *A. paniculata* products containing increase levels of AP3 may be responsible for causing hypotension in some patients taking this herbal drug (Yoopan *et al.,* 2007).

In another study the effect of a diterpenoids; *cinnabarina*, 3,4-seicosopimar-4(18),7,15-triene-3-oic acid isolated from *Salvia* on arterial blood pressure was determined in anaesthetized rats. On different groups of rats treated with the ganglion-blocking agent chlorisondamine (2.5 mg/kg i.p.). The effect of 3, 4-seicosopimar-4(18), 7, 15-triene-3-oic acid (3mg/kg i.v.) was evaluated before and following an infusion of the nitric oxide synthase inhibitor (0.3mg/kg/min i.v.). Intravenous administration of 3,4-seicosopimar-4(18),7,15-triene-3-oic acid at doses of 3, 10 and 30mg/kg led to a fall in mean arterial blood pressure, which was not modified by treatment of the rat with chlorisondamine nor with nitric oxide synthase inhibitor. The results suggest a hypotensive effect of 3,4-seicosopimar-4(18),7,15-triene-3-oic acid due to a peripheral mechanism but independent of endothelial nitric oxide release (Alfieri *et al.,* 2007).

Glycoside

Steviosideis a natural glycoside isolated from the plant *Stevia rebaudiana* Bertoni. It has been used as a commercial sweetening agent in Japan and Brazil from many years. Studies on animal and human beings have showed that stevioside has an antihypertensive effect. In one of the study stevioside effect has been evaluated on one hundred seventy-four patients. 87 were male and, 87 were female were enrolled in the study, and 168 completed it. After 2 years, the stevioside group had significant decreases in mean arterial blood pressure compared with placebo. There were no significant changes in body mass index or blood biochemistry, and the results of laboratory tests were similar in the 2 groups throughout the study. No significant difference in the incidence of adverse effects was noted between groups (Hsieh *et al.,* 2003).

Scientific evidence of medicinal plants having antihypertensive activity Centellaasiatica

Intharachatorn *et al*., 2013determined the effects of *Centella asiatica* extract on blood pressure and heart rate of N-nitro-L-arginine methyl ester (L-NAME) induced hypertensive rats. *Centella asiatica* extract (16g/20ml/kg) and quercetin significantly lowered the elevated (Intharachatorn *et al.,* 2013).

Citrus aurantifolia

Citrus aurantifolia is used in African folk medicine for the treatment of hypertension. Souza *et al*., 2011 studied the effects of an aqueous extract of *Citrus aurantifolia* (Ecita) on arterial blood pressure and on isolated heart and aorta activities. Extract produced a dose-dependent significant decrease in rabbit blood pressure ($p<0.05$) (Souza *et al.,* 2011)

Allium sativum

*Allium sativum*belongs to Liliaceae family, commonly known as garlic, used in variety of cardiovascular conditions, especially hyperlipidemia. Its hypotensive action has also been reported. Meta-analysis of randomly chosen literary data has demonstrated that garlic is involved in decreasing BP in patients with increased systolic pressure, but not in patients without increased systolic pressure (KM *et al.,* 2008).

Apiumgraveolens

Apiumgraveolens (Family: Apiaceae) commonly known as celery used in several disorders. According to Chinese theory, Celery is effective for HTN that is associated with liverdhan *et al.,* 1999. In a study conducted on human beings, it has been reported that it is involved in decreasing systolic and diastolic BP (Gharooni *et al.,* 2000).

Artocarpusaltilis

Artocarpusaltilis belongs to family Moraceae commonly known as breadfruit, widely distributed in western Pacific islands. Its leaf extract of exhibited anti hypertension effect in phenylephrine-stimulated isolated guinea pig aorta rings (Hasrat *et al.,* 2004).

Cuscutareflexa

C. reflexa crude extract decreases systolic and diastolic BP as well as HR in anesthetized rats. Extract produces dose dependent antihypertensive activity and bradycardia, accompanied with decrease in HR. Study reported that pretreatment with atropine (1mg/kg) did not close down the cardiovascular responses to *C. reflexa* (Gilani *et al.,* 1992).

Daucuscarota

Traditionally, *Daucuscarota* has been used to treat HTN. Arial part of *Daucuscarota* contains two coumarin glycosides coded as DC-2 and DC-3. Intravenous

administration of both compounds caused a concentration-dependent (1-10mg/kg) fall in arterial BP in anesthetized rats. Furthermore, both compounds caused a dose-dependent (10-200µg/ml) inhibitory effect on spontaneously beating guinea pig atria as well as on the K^+-induced contractions of rabbit aorta at similar concentrations. The findings indicate that DC-2 and DC-3 may be acting through blockade of calcium channels, and this effect may be responsible for the BP-lowering effect of the compounds observed in the *in vivo* studies (H, *et al.,* 2000).

Lavandulastoechas

L. stoechas crude extract produce a fall in BP and HR in anesthetized NMT rats. Pretreatment of atropine eliminate the cardiovascular responses, demonstrating that the antihypertensive and bradycardia effects of the crude extract of *L. stoechas* may be arbitrated through mechanism (s) similar to that of acetylcholine (*H et al*., 2000).

Moringaoleifera

The crude extract of the leaves of *M. oleifera* caused a decrease in systolic, diastolic and mean BP in a dose-dependent manner in anesthetized rats. The antihypertensive effect was recurring to normal within two minutes. HR was affected significantly, at high doses (3 and 10 mg/kg). It was also reported that thiocarbamate and isothiocyanate fractions of the crude extract were responsible for the antihypertensive activity (Siddiqui *et al.,* 1998).

Peganumharmala

Crude extract fraction of *P. harmala* and all pure compounds such as harmine, harmaline, tetrahydroharmine, harmol, and harmaloi exhibited antihypertensive effects in anesthetized rats in a dose-dependent manner (Gilani *et al.,* 1992).

Punicagranatum

Research has been reported that pomegranate reduces the activity of angiotensin converting enzymes (ACE) by about 36% (Dornfeld 2001).

Zingiberofficinale

Ginger root is commonly used in cooking. It is known to improve blood circulation and relaxes muscles surrounding blood vessels. The crude extract of ginger induced a dose-dependent (0.3-3mg/kg) fall in the arterial BP in anesthetized rats (Fugh-Berman 2000).

Carumcopticum

The crude extracts of *C. copticum* at a dose of 1-30mg/kg decreases BP and heart rate of anesthetized normotensive rats. Conversely, at the low dose (up to 1mg/kg), the extract exhibited insignificant change in the heart rate. However, the extract causes Bradycardia at the higher doses (10-30 mg/kg) (H *et al.,* 2005).

Aristolochiamanshuriensis

*Aristolochiamanshuriensis,*traditionally used as a diuretic and antiphlogistic for the treatment of edema and rheumatic pain. The extract of *Aristolochia manshuriensis* plant containsmagnoflorine which is known to possess hypotensive effects (Hansawasdi *et al.,* 2000).

Lycopersiconesculentum

Lycopersiconesculentum commonly known as tomato contains constituent carotenoids, such as lycopene, beta carotene, and vitamin E, which are known as effective antioxidants, to inactivate free radicals and to slow the progress of atherosclerosis. A study showed that extract of tomato (Lyc-O-Mato) reduces BP in patients with mild, untreated HTN (Yechiel *et al.,* 2006).

CONCLUSION

Hypertension is considered a most important risk factor for number of cardiovascular diseases such as atherosclerosis, heart failure, coronary artery disease and stroke. Several synthetic drugs are used for the treatment of hypertension. Most of these drugs possess better efficacy but causes number of side effects. Recent attention has been focused on the herbal preparations as alternative treatment for cardiovascular problems because of their easy availability, less side effects and cost effective. The use of plant origin natural compounds as cardioprotective and antihypertensive agents is an interesting strategy for discovering bioactive products. Plants are rich in a variety of secondary metabolites, such as flavonoids, alkaloids, tannins and terpenoids. These have been found *in vivo* to have antihypertensive effects. The present review therefore, stands for a good source to choose particular molecules belonging to the specified categories that in the coming future will become useful therapeutic tools.

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