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NUTRICOGNOSY OF FRUITS AND VEGETABLES AGAINST HYPERTENSION

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ABSTRACT

Hypertension is a term used to describe high blood pressure which affects one billion or one in three adults worldwide, and attributes to about 40% of cardiovascular related deaths. Hypertension is reported to be the fourth contributor to premature death in developed countries and the seventh in developing countries. Although there are various preventive measures, that dietary factors play an important role in the modulation of BP in hypertensive or normotensive individuals. Fruit and vegetable consumption has an especially powerful association with lower levels of BP and a lower risk of hypertension. Intakes of potassium, calcium, magnesium, fiber, and nitrites derived from plants have also been shown to lower levels of BP. The current review addresses the potentiality of various fruits and vegetables to maintain a normal blood pressure and the bioactive compounds that are present in them how they mitigate vascular mechanism and thereby bring down blood pressure.

**Keywords: Hypertension, Fruits and Vegetables, Nitrates, Nitrites, Nitric Oxide,
Minerals, Polyphenols, Bioactive Compounds**

INTRODUCTION

Hypertension that defined as a systolic blood pressure greater than 140 mmHg and or a diastolic blood pressure greater than 90 mmHg is one of the major risk factors for cardiovascular morbidities including coronary artery disease, myocardial infarction and kidney disease, as well as for

mortality [1]. Hypertension affects one billion or one in three adults worldwide, and attributes to about 40% of cardiovascular related deaths; unfortunately more than 50% of hypertensive individuals are unaware of their condition [2]. High BP is also known as the silent killer'' as there are no warning

signs or symptoms [3]. People often do not realize they have it until they suffer from a related condition. Seventy-seven percent of first-time stroke victims, 69% of first-time heart attack victims, and 74% of first time congestive heart failure victims have blood pressure above 140/90 mmHg [4].

Recent reports indicate that nearly 1 billion adults (more than a quarter of the world's population) had hypertension in 2000, and this is predicted to increase to 1.56 billion by 2025 [5]. Hypertension is reported to be the fourth contributor to premature death in developed countries and the seventh in developing countries [6]. A number of factors that increase BP, includes 1) obesity, 2) insulin resistance, 3) high alcohol intake, 4) high salt intake (in salt-sensitive patients), 5) aging and perhaps 6) sedentary lifestyle, 7) stress, 8) low potassium intake, and 9) low calcium intake [7, 8]. Numerous studies have reported that certain lifestyle choices, such as maintaining a normal body weight, engaging in routine physical activity, and reducing sodium and alcohol intake, can lead to undeniable reductions in BP levels and the prevalence of hypertension [9]. Among these preventive factors, it is well known that dietary factors play an important role in the modulation of BP in hypertensive or normotensive individuals [9-19]. Fruit and vegetable consumption has an especially powerful

association with lower levels of BP and a lower risk of hypertension [11, 18, 19]. Intakes of potassium, calcium, magnesium, fiber, and protein derived from plants have also been shown to be associated with lower levels of BP [11, 12, 19-21].

When a question arises how fruits and vegetables attenuate blood pressure it leads to the paradigm of nitric oxide (NO) pathway. The discovery of the nitric oxide in the 1980s represented a critically evolutionary advancement in knowing the determinants that cause cardiovascular diseases and presently a number of human diseases have been characterized by NO insufficiency. Provisionally, reason bio medical researchers have documented that nitric oxide can be modulated by the diet irrespective of its enzymatic synthesis L-arginine eg; the ingestion of nitrite- and nitrate- rich food such as fruits, leafy vegetables along with anti- oxidant. Acceptable intake of nitrate- containing foods such as green leafy vegetables may ensure and make certain that blood and tissue levels of nitrite, nitric oxide pools are maintained at a level sufficient to compensate for any abnormalities in endogenous nitric oxide synthesis [22].

Growing Burden of Hypertension In India

In India, hypertension is the leading non communicable disease risk and estimated to

be attributable for nearly 10 per cent of all deaths [23]. From the studies of Gupta, 2004 and Reddy, 2005 it is evident that adult hypertension prevalence has risen dramatically over the past three decades from 5 per cent to 20-40 per cent in urban areas and 12-17 per cent in rural areas [24, 25]. Also, Reddy (2005) reported that the number of hypertensive individuals is anticipated to nearly double from 118 million in 2000 to 213 million by 2025 [25]. From the study of Mohan et al, 2011, it is understood that 16 per cent of ischemic heart disease, 21 per cent of peripheral vascular disease, 24 per cent of acute myocardial infarctions and 29 per cent of strokes are attributable to hypertension, emphasizing the huge impact of effective hypertension prevention and control in order to reduce the accelerating encumbrance of cardiovascular disease (CVD) [26].

Global Consumption of Fruits and Vegetables

Globally, majority of people consistently are consuming less than the daily recommended fruits and vegetables requirement. Even in developed nations e.g., Australia, Canada, Europe, UK and USA, researchers have concluded that there is a large gap between actual and recommended consumption of both fruits and vegetables despite decades of concern and publicity while resultant outcomes were short-lived. In a study from

52 low and middle-income countries 77.6% of men and 78.4% of women consumed less than the minimum recommended servings of fruits and vegetables. In the same study, it has been reported that Indian adults consume 74% less fruits and vegetables than the recommended [27].

Consumption of Fruits And Vegetables In India

Traditionally, Indian life style has a preference for fresh fruits and vegetables or those processed at home. On the contrary, surveys indicate a consistently low consumption of fruits and vegetables. Annual consumption (kg/person/annum) of fruits was 9.6 (rural), 15.6 (urban) and 11.8 (India) while it was 74.3 (rural), 79.1 (urban), 76.1 (India) for vegetables [28]. According to latest National Sample Survey Office (NSSO) survey revealed that out of 1000 household in India, vegetable consumption was reported by 983 (rural) and 932 (urban) whereas fruits by 608 (rural) and 777 (urban) residents [29]. Other recent studies on avg. consumption of fruits and vegetables amongst urban residents of Chennai and Jaipur reported as 265 gm/day and less than 3 servings by 72.6% respondent's respectively [30, 31].

Recommended Intake of Fruits And Vegetables

The general recommendation for intake of fruits and vegetables is atleast 400 grams

per person per day (five serving of 80 g each day) or about 146 kg per person per year [32, 33]. Similarly, national nutrition guidelines recommends avg. daily consumption of 300 g for vegetables (portion size = 100 gm × no. of portions = 3) and 100 g of fruits (portion size = 100 gm × no. of portions = 1). The vegetables include (green leafy vegetables = 50 gm, other vegetables = 200 gm, roots and tubers = 50 gm) [34]. A glass of fruit juice (excluding sweetened beverages) counts towards a portion of fruit each day although whole fruit is encouraged for its fiber content in-conjunction with active life-style [35].

Experiences with “Dash Diet”

The DASH diet is a diet rich in fruits and vegetables (4-5 servings/day) and low-fat dairy products (2- 3 servings/day) and includes whole grains, poultry, fish, and nuts. This diet is rich in potassium, magnesium, calcium, dietary fiber, and protein and has reduced fat (total and saturated) and cholesterol (<25%), red meat, sweets, and sugar-containing beverages. The initial DASH trial [36] enrolled 459 untreated participants with prehypertension and stage I hypertension and randomly assigned them to one of 3 groups (1) a control group which consumed a typical US diet which was low in fruits, vegetables, and dairy products and had a high fat content,

(2) a diet rich in fruits and vegetables, or (3) the DASH diet sodium intake and body weight were held constant during the study period of eight weeks. Compared with the control group, systolic and diastolic blood pressure decreased by 5.5/3.0mmHg and 2.8/1.1mmHg in the DASH diet and fruits-and-vegetables diet, respectively. This reduction was higher among the subset of hypertensives at 11.4/5.5mmHg compared with 0.5/2.1mmHg for those without hypertension consuming the DASH diet. In addition, the reduction in blood pressure began within two weeks and was sustained for the next six weeks. Recent studies also demonstrated that vegans do have lower SBP and DBP and less likely to use antihypertensive medications. In a study, for vegans, the odds ratio of hypertension compared with omnivores was 0.37 (95% CI, 0.19 to 0.74) [37]. Vegetarian diet with increased intake of fruit and vegetables, polyunsaturated vegetable margarines, and oils, fiber, calcium, and magnesium and decreased intake of protein in mild untreated hypertensive patients resulted in a fall of 5mmHg in SBP. This diet improved blood pressure without a change in urinary sodium or potassium excretion or body weight [38]. Similarly, Rouse and colleagues (1983) included 59 healthy normotensive patients in a randomized controlled study in which they were randomized to a control group

(omnivorous diet) and one of 2 experimental groups (omnivorous and/or lacto-ovo-vegetarian diet). Mean SBP dropped by 5 to 6mmHg and DBP dropped by 2 to 3mmHg in the group on vegetarian diet after adjustment for age, obesity, heart rate, weight change, and blood pressure before dietary change. Blood pressure rose substantially in subjects who reverted to the omnivorous diet [39].

Another analysis of the Nurses' Health Study (NHS) I and II and the Health Professionals Follow-up Study (HPFS) after 14 years of follow-up with flavonoid intake calculated by an updated nutrient database from 2010 showed a risk reduction in hypertension with increasing intake of anthocyanins [40]. In line with this, anyone can understand that fruits and to some extent vegetables are the best sources of flavanols.

Especially there are some vegetable sources which exhibit such tremendous favourable effect on hypertension. The plant raddish has been found to have antihypertensive activity. Isolated tissue preparations were suspended in tissue baths containing Krebs solution, while acute toxicity study was performed in mice for 24 hours. The extract caused a dose-dependent (0.1-3 mg/kg) fall in BP and HR of rats that was mediated through an atropine-sensitive pathway. In isolated guinea-pig atria, it showed dose-

dependent (0.03-3.0 mg/ml) inhibition of force and rate of contractions. In the atropine-treated tissues, the inhibitory effect was abolished and a cardiac stimulant effect was unmasked, which was resistant to adrenergic and serotonergic receptor blockade. In the endothelium-intact rat aorta, it inhibited phenylephrine-induced contractions, which was blocked by atropine. The extract was safe in mice up to the dose of 10 g/kg. The study showed that the cardiovascular inhibitory effects of the plant are mediated through activation of muscarinic receptors, thus possibly justifying its use in HTN [41].

Consumption of Pomegranate juice which is rich in tannins, possess anti-atherosclerotic properties which could be related to its potent anti-oxidative characteristics. Aviram (2001) studied the effect of pomegranate juice consumption (50 ml, 1.5mmol of total polyphenols per day, for 2 weeks) by hypertensive patients on their blood pressure and on serum angiotensin converting enzyme (ACE) activity. And his study result revealed that a 36% decrement in serum ACE activity and a 5% reduction in systolic blood pressure [42].

Similarly, Tomato extract contains 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) modestly reduces BP in patients with mild, untreated HTN. Engelhard gave a tomato extract to 31 hypertensive subjects over 12 weeks demonstrating a significant correlation was between systolic BP and lycopene levels [43]. Paran et al. 2001 evaluated 30 subjects with grade 1 hypertension, age 40- 65 years, and taking no anti hypertensive or anti- lipid medications treated with a tomato lycopene extract for 8 weeks and his results revealed that systolic blood pressure was reduced from 144 to 135 mmHg [9-mmHg reduction; $p < 0.001$] and diastolic blood pressure fell from 91 to 84 mmHg [7- mmHg reduction; $p < 0.001$] [44]. The same author in 2009 reported that the tomato extract when added to patients treated with low doses of ACE inhibition, calcium channel blockers, or their combination with low-dose diuretics had a clinically significant effect-reduction of BP by more than 10 mmHg systolic and more than 5 mmHg diastolic pressures [45]. In anesthetized rats, the crude extract of the leaves of *M. oleifera* (Moringa), a green leafy vegetable caused a fall in systolic, diastolic, and mean BP in a dose-dependent manner. The antihypertensive effect was brief, returning to normal within two minutes. HR was not affected significantly, except at high doses (3 and 10 mg/kg), which produced a small degree of

bradycardia. It was also established that thiocarbamate and isothiocyanate fractions of the crude extract were responsible for the antihypertensive activity [46].

Among the root vegetables, carrot has been used as a traditional medicine to treat HTN, may be owing to their fiber content and antioxidants, particularly carotenes. Activity-directed fractionation of aerial parts of *D. carota* resulted in the isolation of two coumarin glycosides coded as DC-2 and DC-3. Intravenous administration of these compounds caused a dose-dependent (1–10 mg/kg) fall in arterial BP in neuromuscular transmission NMT anesthetized rats. In the *in vitro* studies, both compounds caused a dose-dependent (10–200 $\mu\text{g/ml}$) inhibitory effect on spontaneously beating guinea pig atria as well as on the K^+ -induced contractions of rabbit aorta at similar concentrations. These results 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 [47].

Ladeji *et al.* investigated the effect of oral administration of the black plum extract on BP of rats. The extract was found to exert hypotensive effect. Both the systolic and diastolic BPs were significantly reduced within 45 min after oral administration of

the extract. The BP began to return to normal after 2 hours [48].

Bananas are one of the best sources of potassium, an essential mineral for maintaining normal blood pressure and heart function. A medium-sized banana provides 350 mg of potassium. The effectiveness of potassium-rich foods in lowering blood pressure has been demonstrated by a number of studies. The US Food and Drug Administration have allowed the banana industry to make official claims for the fruit's ability to reduce the risk of blood pressure and stroke. According to the FDA, "Diets containing foods that are good sources of potassium and low in sodium may reduce the risk of high blood pressure and stroke." Plus, potassium helps body to maintain normal fluid and electrolyte balances in the cells. Scientists report that natural compounds in bananas act in a manner similar to antihypertensive drugs. The team studied six popular banana varieties and found that all had ACE inhibiting properties, though the ripened bananas had a stronger action than unripe ones. Researchers have reported that blood pressure fell by 10% in people who ate two bananas daily for a week [49].

Ferulic acid (FA; 4-hydroxy-3-methoxycinnamic acid) is a ubiquitous phenolic compound found in plant tissues and thus is a bio- active ingredient in many

foods. Some of the rich sources of FA are rice bran, whole grain food, citrus fruits, banana, beetroot, cabbage, spinach and broccoli [50]. Seok *et al.*, 2012, conducted a study by inducing hypertension in 2K1C rats by clipping the left renal artery and age-matched rats that received a sham treatment served as a control. The effects of ferulic acid on vasodilatatory responses were evaluated based on contractile responses induced by phenylephrine in the aortic rings obtained from both 2K1C and sham rats. Basal nitric oxide (NO) bioavailability in the aorta was determined by the contractile response induced by NO synthase inhibitor NG-nitro-L-argininemethylester(L-NAME). The results of the study suggested that ferulic acid restores endothelial function by altering the bioavailability of NO in 2K1C hypertensive rats [51].

Moline *et al.*, 2000, reported that there are over 400 naturally occurring flavanoids (flavanols, flavones and isoflavones) which are found in diverse substances such as fruits, vegetables, red wine, tea, soy and licorice. He also stated that flavanoids are potent free radical scavengers that inhibit lipid peroxidation prevent atherosclerosis promote vascular relaxation and have anti-hypertensive properties [52].

Resveratrol is a potent antioxidant antihypertensive found in the skin of red grapes and red wine. Karatzi *et al.*, 2005, in

his study endorsed that “Red wine acutely induces favourable effects on wave reflection and central pressure in coronary artery patients” in addition, he found that the Resveratrol administration to human reduces augmentation index, improves arterial compliance and lower central arterial pressure [53].

Blood pressure reducing properties of garlic have been linked to its hydrogen sulphide production and allicin content – liberated from alliin and the enzyme allinase which has angiotensin II inhibiting and vasodilating effects, as shown in animal and human cell studies [54]. Rashid and Khan, 1985, suggested that the mechanism of antihypertensive activity of garlic is due to its prostaglandin-like effects, which decrease peripheral vascular resistance [55]. Similarly, Ried et al., 2013 found out from his study a dosage of 240- 960 mg of aged garlic extract containing 0.6- 2.4 of S-allylcysteine significantly lowered blood pressure by about 12 mmHg over 12 weeks [56].

In *in vivo* animal experiments, intravenous administration of garlic extracts produced slight reductions in both systolic and diastolic pressures [57] and oral ingestion of garlic extract in hypertensive animals brought the blood pressure back to the normal level [58].

There is a emerging paradigm that certain foods promote nitric oxide (NO) production from the stepwise reduction of nitrate and nitrite to nitric oxide, providing an endothelium independent source of bio-active nitrate rich beetroot along with Hawthorn berry shown to have a robust nitrite reductive activity would improve NO status in humans and modify cardiovascular risk factor [59].

Dietary nitrate, from beetroot has been reported to lower blood pressure (BP) by the sequential reduction of nitrate to nitrite and further to nitric oxide (NO) in the circulation. Hobbs *et al.*, 2013, showed that bread enriched with beetroot may be a suitable vehicle to obtain endothelium independent vasodilatation and reduced diastolic blood pressure as well as assured beetroot may be a cardio protective vegetable and may further provide novel therapeutic perspective in the management of hypertension [60].

In a systemic review and meta analysis of randomized control clinical trial using beetroot supplementation and examining the effects of inorganic nitrate on blood pressure by Siervo et al understood that meta regression was showing an association between daily dose of inorganic nitrate and changes in systolic blood pressure($p < 0.05$) [61]. In another study Coles and Clifton (2012) categorically demonstrated that

beetroot juice will lower blood pressure in men when consumed as part of a normal diet free living healthy adults [62]. Lamsley and colleagues demonstrated that dietary NO_3^- administered in the form of beetroot juice (500ml/ day for 6 days), decreases resting systolic pressure (SBP) and O_2 consumption during walking and running [63].

Flavanoids and nitrates can augment nitric oxide status via distinct pathway, which may improve endothelial function and lower blood pressure. Bondonno *et al.*, 2012, investigated the independent and additive effects of Flavonoid- rich apples and nitrate- rich spinach on nitric oxide status, endothelial function, and blood pressure. In his randomized, controlled study he demonstrated that Flavonoid- rich apples and nitrate- rich spinach can independently augment nitric oxide status, enhance endothelial function, and lower blood pressure acutely, outcomes that may benefit cardiovascular health [64].

CONCLUSION

The renewed interest in the search for new drugs from natural sources, especially from plant sources, has gained global attention during the last two decades. Considering the magnitude of the health and financial consequences of HTN, scientific search for more effective and at the same time more affordable means of tackling HTN has

become more than a necessity. Various dietary bioactive compounds have attracted an increasing research interest over the last decade due to their acclaimed health benefits. Among these compounds, nitrates as well as nitrites in particular and calcium, magnesium, potassium along with antioxidants have been positively associated with hypertension. Accumulating evidence has documented a positive link between consumption of fruits and vegetables containing these bioactive compounds, also described as functional foods, and their effect on reducing the blood pressure. However, it is the need of the hour to ponder upon how to reach the public and disseminate the efficacy of these functional fruits and vegetables in controlling hypertension. First of all the young generation have to be inculcated about the usage of fruits and vegetables and thereby many non communicable diseases including the devastating hypertension may be prevented. Perhaps, People in India also have poor compliance towards consumption of recommended levels of fruits and vegetables, mainly owing to their exorbitant price. At this juncture, one must always agree that when People indulge in regular consumption of large quantities of fruits and vegetables, obviously the demand would increase and the production of the same would also be directionally proportional to

it. Thus, the price of these veggie items would also simultaneously and drastically drop down as the demand will more. Hence, in this line educational institutions and societal organisations should come forward to implement this rather than blaming the policy makers. At least through publications of such articles let us make sure to spread the message and be determined in controlling the dreadful silent killer hypertension.

REFERENCES

1. American heart association web site. Understanding blood pressure readings, 2011, [http://www.heart.org/HEARTORG/conditions/High blood pressure/about blood pressure/UCM_301764_article.jsp](http://www.heart.org/HEARTORG/conditions/High%20blood%20pressure/about%20blood%20pressure/UCM_301764_article.jsp).
2. Ried K and Frank R, Aged garlic extract reduces blood pressure in hypertensives: a dose–response trial, *Eur. J. Clin. Nutr.*, 67 (1), 2013, 64-70.
3. Ostchega Y, Yoon SS, Hughes J and Louis T, Hypertension awareness, treatment and control – continued disparities in adults: United States, 2005-2006, *NCHS Data Brief*, (3), 2008, 1-8.
4. American Heart Association Web site [Internet], Why blood pressure matters, [cited 2011 November 20], Available from: [http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/WhyBloodPressureMatters/ Why-Blood-Pressure-Matters_UCM_002051_Article.jsp](http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/WhyBloodPressureMatters/Why-Blood-Pressure-Matters_UCM_002051_Article.jsp).
5. Kearney PM, Whelton M, Reynolds K, Muntner P, Whelton PK and He J, Global burden of hypertension: analysis of worldwide data, *Lancet*, 365, 2005, 217-23.
6. Deepa R, Shanthirani CS, Pradeepa R, Mohan V. Is the ‘rule of halves’ in hypertension still valid?--Evidence from the Chennai Urban Population Study, *J. Assoc. Physicians India*, 51, 2003, 153-7.
7. Intersalt Co-operative Research Group, Sodium, potassium, body mass, alcohol and blood pressure: the INTERSALT study, *J. Hypertens*, 6 (Suppl 4), 1988, S584-6.
8. Sever PS and Poulter NR, A hypothesis for the pathogenesis of essential hypertension: the initiating factors, *J. Hypertens*, 7 (Suppl 1), 1989, S9-12.

9. Whelton PK, He J, Appel LJ, *et al.*, Primary prevention of hypertension: clinical and public health advisory from The National High Blood Pressure Education Program, *JAMA*, 288, 2002, 1882-1888.
10. Appel LJ, Moore TJ, Obarzanek E, *et al.*, A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group, *N. Engl. J. Med.*, 336, 1997, 1117-1124.
11. Ascherio A, Hennekens C, Willett WC, *et al.*, Prospective study of nutritional factors, blood pressure, and hypertension among US women, *Hypertension*, 27, 1996, 1065-1072.
12. Lairon D, Arnault N, Bertrais S, *et al.*, Dietary fiber intake and risk factors for cardiovascular disease in French adults, *Am. J. Clin. Nutri.*, 82, 2005, 1185-1194.
13. Miura K, Greenland P, Stamler J, Liu K, Daviglus ML and Nakagawa H, Relation of vegetable, fruit, and meat intake to 7-year blood pressure change in middle-aged men: the Chicago Western Electric Study, *Am. J. Epidemiol.*, 159, 2004, 572-580.
14. Psaltopoulou T, Naska A, Orfanos P, Trichopoulos D, Mountokalakis T and Trichopoulou A: Olive oil, the Mediterranean diet, and arterial blood pressure: the Greek European Prospective Investigation into Cancer and Nutrition (EPIC) study, *Am. J. Clin. Nutri.*, 80, 2004, 1012-1018.
15. Sacks FM, Svetkey LP, Vollmer WM, *et al.*, Effects on blood pressure of reduced dietary sodium and the Dietary Approaches to Stop Hypertension (DASH) diet, DASH Sodium Collaborative Research Group, *N. Engl. J. Med.*, 344, 2001, 3-10.
16. Srinath Reddy K and Katan MB, Diet, nutrition and the prevention of hypertension and cardiovascular diseases, *Public Health Nutri.*, 7, 2004, 167-186.
17. Svetkey LP, Simons-Morton D, Vollmer WM, *et al.*, Effects of dietary patterns on blood pressure: subgroup analysis of the Dietary Approaches to Stop Hypertension (DASH)

- randomized clinical trial, Arch. Int. Med., 159, 1999, 285- 293.
18. Stamler J, Liu K, Ruth KJ, Pryer J and Greenland P: Eight-year blood pressure change in middle-aged men: relationship to multiple nutrients, Hypertension, 39, 2002, 1000-1006.
19. Ascherio A, Rimm EB, Giovannucci EL, *et al.*, A prospective study of nutritional factors and hypertension among US men, Circulation, 86, 1992, 1475-1484.
20. Intersalt Cooperative Research Group: Intersalt: an international study of electrolyte excretion and blood pressure, Results for 24 hour urinary sodium and potassium excretion, BMJ, 1988, 297, 319-328.
21. Elliott P, Stamler J, Dyer AR, *et al.*, Association between protein intake and blood pressure: the Intersalt Study, Arch. Int. Med., 166, 2006, 79-87.
22. Milkowski A, Garg HK, Coughlin JR and Bryan NS, Nutritional epidemiology in the context of nitric oxide biology: a risk-benefit evaluation for dietary nitrite and nitrate, Nitric Oxide, 22 (2): 2010, 110-119.
23. Patel V, Chatterji S, Chisholm D, Ebrahim S, Gopalakrishna G, Mathers C, *et al.*, Chronic diseases and injuries in India, Lancet, 2011, 377, 413-28.
24. Gupta R, Trends in hypertension epidemiology in India, J. Hum. Hypertens., 18, 2004, 73-8.
25. Reddy KS, Shah B, Varghese C and Ramadoss A. Responding 6, to the threat of chronic diseases in India, Lancet, 366, 2005, 1744-9.
26. Mohan S, Reddy KS and Prabhakaran D, Chronic non-7. communicable diseases in India, Reversing the tide, New Delhi: Public Health Foundation of India, 2011
27. Hall JN, Moore S, Harper SB and Lynch JW, Global variability in fruit and vegetable consumption, Am. J. Prev. Med., 36, 2009, 402-9.e5.
28. Surabhi Mittal, Can horticulture be a success story for India? New Delhi: Indian Council for Research on International Economic Relations, 2007.
29. Household consumption of various goods and services in India: 66th Round (2009-10), National Sample Survey Office

- (NSSO), Ministry of Statistics and Programme Implementation, New Delhi: Government of India, 2012.
30. Radhika G, Sathya RM, Ganesan A, Saroja R, Vijayalakshmi P, Sudha V, *et al.*, Dietary profile of urban adult population in South India in the context of chronic disease epidemiology (CURES-68), *Public Health Nutri.*, 14, 2011, 591-98.
31. Rajeev G, Sharma KK, Arvind G, Aachu A, Indu M, Gupta VP, *et al.*, Persistent high prevalence of cardiovascular risk factors in the Urban middle class in India: Jaipur Heart Watch-5, *JAPI*, 60, 2012, 11-60.
32. Diet, nutrition and the prevention of chronic diseases, Report of a Joint FAO/WHO Expert Consultation, 2003.
33. Food and Agriculture Organization of the United Nations, What is serving? Available from: <http://www.fao.org/english/newsroom/focus/2003/fruitveg2.htm>. [Last accessed on 2010 Dec].
34. Dietary guidelines for Indians: A manual. Hyderabad: National Institute of Nutrition, 2011
35. Landon S, Fruit juice nutrition and health, *Food Australia*, 59, 2007, 533-538
36. Appel LJ, Moore TJ, Obarzanek E, Vollmer WM, Svetkey LP, Sacks FM *et al.*, "A clinical trial of the effects of dietary patterns on blood pressure. DASH Collaborative Research Group," *The New England J. Medicine*, 336 (16), 1997, 1117-1124.
37. Pettersen BJ, Anousheh R, Fan J, Jaceldo-Siegl K, and Fraser GE, Vegetarian diets and blood pressure among white subjects: results from the Adventist Health Study-2 (AHS-2), *Public Health Nutri.*, 15 (10), 2012, 1909-1916.
38. Margetts BM, Beilin LJ, Vandongen R, and Armstrong BK, Vegetarian diet in mild hypertension: a randomised controlled trial, *British Medical J.*, 293 (6560), 1986, 1468-1471,
39. Rouse IL, Armstrong BK, Beilin LJ and Vandongen R, Blood-pressure-lowering effect of a vegetarian diet: controlled trial in normotensive subjects, *The Lancet*, 1 (8314), 1983, 5-10.

40. Cassidy A, O'Reilly EJ, Kay C, *et al.*, Habitual intake of flavonoid subclasses and incident hypertension in adults, *Am. J. Clin. Nutr.*, 2011, 93, 338-347, doi: 10.3945/ajcn.110.006783.
41. Ghayur MN and Gilani AH, Radish seed extract mediates its cardiovascular inhibitory effects via muscarinic receptor activation, *Fundamental Clin. Pharmacol.*, 20, 2006, 57-63.
42. Aviram M and Dornfeld L, Pomegranate juice consumption inhibits serum angiotensin converting enzyme activity and reduces systolic blood pressure, *Atherosclerosis*, 158, 2001, 195-8.
43. Engelhard YN, Gazer B and Paran E, Natural antioxidants from tomato extract reduce blood pressure in patients with grade-1 hypertension: A double-blind, placebo-controlled pilot study, *Am. Heart J.*, 151, 2006, 100. [PubMed]
44. Paran E, Novac C, Engelhard YN and Hazan-Halevy, I, The effects of natural antioxidants from tomato extract in treated but uncontrolled hypertensive patients, *Cardiovasc. Drugs Ther.*, 23, 2009, 145-151.
45. Paran E, Novack V, Engelhard YN and Hazan-Halevy I, The effects of natural antioxidants from tomato extract in treated but uncontrolled hypertension patients, *Cardiovasc. Drugs Ther.*, 23, 2009, 145-51.
46. Faizi S, Siddiqui BS, Saleem R, Aftab K, Shaheen F and Gilani AH, Hypotensive constituents from the pods of *Moringa oleifera.*, *Planta Med.*, 1998, 64, 225-8.
47. Gilani AH, Shaheen E, Saeed SA, Bibi S, Irfanullah, Sadiq M and Faizi S, Hypotensive action of coumarin glycosides from *Daucus carota*, *Phytomed.*, 7, 2000, 423-6.
48. Ladeji O, Udoh FV and Okoye ZS, Activity of aqueous extract of the bark of *Vitex doniana* on uterine muscle response to drugs, *Phytother. Res.*, 19, 2005, 804-6.
49. Kumar KPS, Bhowmik D, Duraivel S and Umadevi M, Traditional and Medicinal Uses of Banana, 1 (3), 2012, 51-63.
50. Baskaran N, Manoharan S, Balakrishnan S, Pugalendhi P,

- Chemopreventive potential of ferulic acid in 7, 12-dimethylbenz [a] anthracene-induced mammary carcinogenesis in Sprague-Dawley rats, *Eur. J. Pharmacol.*, 637, 2010, 22-9.
51. Choi S, Kim H, Park S, Lee M, Jun J, Kim HL, Chung JH and Yeum CH, Endothelium-dependent vasodilation by ferulic acid in aorta from chronic renal hypertensive rats, *Kidney Res. Clin. Pract.*, 31, 2012, 227-233.
52. Moline J, Bukharovich IF, Wolff MS and Phillips R, Dietary flavonoids and hypertension: is there a link? *Med. Hypotheses*, 55 (4), 2000, 306-9.
53. Karatzi KN, Papamichael CM, Karatzis EN, Papaioannou TG, Aznaouridis KA, Katsichti PP, Stamatelopoulos KS, Zampelas A, Lekakis JP and Mavrikakis ME, Red wine acutely induces favorable effects on wave reflections and central pressures in coronary artery disease patients, *Am. J. Hypertens*, 18 (9 Pt 1), 2005, 1161-7.
54. Londhe VP, Gavasane AT, Nipate SS, Bandawane DD and Chaudhari PD, Role Of Garlic (*Allium Sativum*) In Various Diseases: An Overview, *J. Pharmaceu. Res. and Opinion*, 1 (4), 2011, 129-34 .
55. Rashid A, Khan HH: The mechanism of hypotensive effect of garlic extract, *J. Pak. Med. Assoc.*, 35, 1985, 357-362.
56. Ried K, Frank OR and Stocks NP, Aged garlic extract reduces blood pressure in hypertensives: a dose-response trial, *Eur. J. Clin. Nutri.*, 67, 2013a, 64-70.
57. Sial AY and Ahmed SJ, Study of the hypotensive action gerlic extract in experimental animals, *J. Pak. Med. Assoc.*, 32, 1982, 237-239.
58. Chanderkar AG and Jain PK, Analysis of hypotensive action of *Allium sativum* (garlic), *Ind. J. Physiol. Pharmacol.*, 17, 1973, 132-133.
59. Zand J, Lanza F, Garg HK and Bryan NS, All-natural nitrite and nitrate containing dietary supplement promotes nitric oxide production and reduces triglycerides in humans, *Nutri. Res.*, 31 (4), 2011, 262-9.

60. Hobbs DA, Goulding MG, Nguyen A, Malaver T, Walker CF, George TW, Methven L and Lovegrove JA, Acute ingestion of beetroot bread increases endothelium-independent vasodilation and lowers diastolic blood pressure in healthy men: a randomized controlled trial, *J. Nutri.*, 143 (9), 2013, 1399-405.
61. Siervo M, Lara J, Ogbonmwan I and Mathers JC, Inorganic nitrate and beetroot juice supplementation reduces blood pressure in adults: a systematic review and meta-analysis, *J. Nutri.*, 143 (6), 2013, 818-26.
62. Coles LT and Clifton PM, Effect of beetroot juice on lowering blood pressure in free-living, disease-free adults: a randomized, placebo-controlled trial, *Nutri. J.*, 11 (106), 2012. doi: 10.1186/1475-2891-11-106.
63. Lansley KE, Winyard PG, Fulford J, Vanhatalo A, Bailey SJ, Blackwell JR, DiMenna FJ, Gilchrist M, Benjamin N and Jones AM, Dietary nitrate supplementation reduces the O₂ cost of walking and running: a placebo-controlled study, *J. Appl. Physiol.*
64. Bondonno CP, Yang X, Croft KD, Considine MJ, Ward NC, Rich L, Puddey IB, Swinney E, Mubarak A and Hodgson JM, Flavonoid-rich apples and nitrate-rich spinach augment nitric oxide status and improve endothelial function in healthy men and women: a randomized controlled trial, *Free Radic. Biol. Med.*, 52 (1), 2012, 95-102.