International Journal of Phytomedicine 2 (2010) 210-216

http://www.arjournals.org/ijop.html

Review

ISSN: 0975-0185

Medicinal uses and pharmacological properties of *Moringa oleifera*

P. Sudhir Kumar[1*], Debasis Mishra[1], Goutam Ghosh[1], Chandra S. Panda[2]

***Corresponding author:**

P. Sudhir Kumar

1. School of Pharmaceutical Sciences, Siksha O Anusandhan University, Bhubaneswar, Orissa, India
2. NISER, Institute of Physics, Bhubaneswar, Orissa, India.

Abstract

Moringa oleifera Lam [Moringaceae] is a highly valued plant, distributed in many countries of the tropics and subtropics. It has an impressive range of medicinal uses with high nutritional value. Different parts of this plant contain a profile of important minerals, and are a good source of protein, vitamins, β -carotene, aminoacids and various phenolics. In addition to its compelling water purifying powers and high nutritional value, *M. oleifera* is very important for its medicinal value. Various parts of this plant such as the leaves, roots, seed, bark, fruit, flowers and immature pods act as cardiac and circulatory stimulants, possess anitumor, antipyretic, antiepileptic, antiinflammatory, antiulcer, antispasmodic, diuretic, antihypertensive, cholesterol lowering, antioxidant, antidiabetic, hepatoprotective, antibacterial and antifungal activities, and are being employed for the treatment of different ailments in the indigenous system of medicine. This review focuses on the detailed phytochemical composition, medicinal uses, along with pharmacological properties of different parts of this multipurpose tree.

Keywords: Moringa oleifera; β –carotene; anitumor

Introduction

Moringa oleifera Lam [syn. *M. ptreygosperma* Gaertn.] is one of the best known and most widely distributed and naturalized species of a monogeneric family *Moringaceae]* It is found wild and cultivated throughout the plains, especially in hedges and in house yards, thrives best under the tropical insular climate, and is plentiful near the sandy beds of rivers and streams. It can grow well in the humid tropics or hot dry lands, can survive destitute soils, and is little affected by drought. *Moringa oleifera*, native of the western and sub-Himalayan tracts, India, Pakistan, Asia Minor & Africa. *Moringa oleifera* is an important food commodity which has had enormous attention as the 'natural nutrition of the tropics'. *Moringa* leaves have been reported to be a rich source of β-carotene, protein, vitamin C,calcium and potassium and act as a good source of natural antioxidants; and thus enhance the shelf-life of fat containing foods due to the presence of various types of antioxidant compounds such as ascorbic acid, flavonoids, phenolics and carotenoids. In the Philippines,it is known as 'mother's best friend' because of its utilization to increase woman's milk production.

doi:10.5138/ijpm.2010.0975.0185

Almost all the parts of this plant: root, bark, gum, leaf, fruit [pods], flowers, seed and seed oil have been used for various ailments in the indigenous medicine of South Asia, including the treatment of inflammation and infectious diseases along with cardiovascular, gastrointestinal ,hematological and hepatorenal disorders. The seeds of *Moringa* are considered to be antipyretic, acrid, bitter [1] and reported to show antimicrobial activity [The Wealth of India, 1962].The seed can be consumed fresh as peas; or pounded, roasted, or pressed into sweet, non-desiccating oil, commercially known as 'Ben oil' of high quality. The unique property is the ability of its dry, crushed seed and seed press cake, which contain polypeptides, to serve as natural coagulants for water treatment [2]. Its versatile utility as a medicine, functional food, nutraceutical and water purifying potential motivated us to bridge the information gap in this area, and to write a comprehensive review on the medicinal, phytochemical and pharmacological attributes of this plant of high economic value.

Medicinal Uses and Pharmacological Properties

Moringa oleifera also has numerous medicinal uses, which have long been recognized in the Ayurvedic and Unani systems of medicine [3]. The medicinal attributes and pharmacological activities ascribed to various parts of *Moringa* are detailed below.

Antihypertensive, diuretic and cholesterol lowering activities

The widespread combination of diuretic along with lipid and blood pressure lowering constituents make this plant highly useful in cardiovascular disorders. *Moringa* leaf juice is known to have a stabilizing effect on blood pressure [The Wealth of India, 1962; [4]. Nitrile, mustard oil glycosides and thiocarbamate glycosides have been isolated from *Moringa* leaves, which were found to be responsible for the blood pressure lowering effect [5-7]. Most of these compounds, bearing thiocarbamate, carbamate or nitrile groups, are fully acetylated glycosides, which are very rare in nature [7]. Bioassay guided fractionation of the active ethanol extract of *Moringa* leaves led to the isolation of four pure compounds, niazinin A, niazinin B, niazimicin and niazininA. B which showed a blood pressure lowering effect in rats mediated possibly through a calcium antagonist effect [8]]. Activity-directed fractionation of the ethanol extract of pods of *M.oleifera* has led to the isolation of thiocarbamate and isothiocyanate glycosides which are known to be the hypotensive principles [7]. Methyl phydroxybenzoate and β-sitosterol investigated in the pods of *M. oleifera* have also shown promising hypotensive activity [9], *Moringa* roots, leaves, flowers, gum and the aqueous infusion of seeds have been found to possess diuretic activity [10,11] and such diuretic components are likely to play a complementary role in the overall blood pressure lowering effect of this plant. The crude extract of *Moringa* leaves has a significant cholesterol lowering action in the serum of high fat diet fed rats which might be attributed to the presence of a bioactive phytoconstituent, i.e. β-sitosterol [12]. *Moringa* fruit has been found to lower the serum cholesterol, phospholipids, triglycerides, low density lipoprotein [LDL], very low density lipoprotein[VLDL] cholesterol to phospholipid ratio, atherogenic index lipid and reduced the lipid profile of liver, heart and aorta in hypercholesteremic rabbits and increased the excretion of fecal cholesterol [13].

Antispasmodic, antiulcer and hepatoprotective activities

M. oleifera roots have been reported to possess antispasmodic activity [14]. *Moringa* leaves have been extensively studied pharmacologically and it has been found that the ethanol extract and its constituents exhibit antispasmodic effects possibly through calcium channel blockade [14,15]. The antispasmodic activity of the ethanol extract of *M. oleifera* leaves has been attributed to the presence of 4-[α-[L-rhamnosyloxy] benzyl]-o-methyl thiocarbamate [*trans*], which forms the basis for its traditional use in diarrhea [14]. Moreover, spasmolytic activity exhibited by

different constituents provides pharmacological basis for the traditional uses of this plant in gastrointestinal motility disorder [16].The methanol fraction of *M. oleifera* leaf extract showed antiulcerogenic and hepatoprotective effects in rats. Aqueous leaf extracts also showed antiulcer effect [17] indicating that the antiulcer component is widely distributed in this plant. *Moringa* roots have also been reported to possess hepatoprotective activity. The aqueous and alcohol extracts from *Moringa* flowers were also found to have a significant hepatoprotective effect which may be due to the presence of quercetin, a well known flavonoid with hepatoprotective activity[18].

Antibacterial and antifungal activities

Moringa roots have antibacterial activity [20] and are reported to be rich in antimicrobial agents. These are reported to contain an active antibiotic principle, pterygospermin, which has powerful antibacterial and fungicidal effects. A similar compound is found to be responsible for the antibacterial and fungicidal effects of its flowers [19]. The root extract also possesses antimicrobial activity attributed to the presence of 4- α-L-rhamnosyloxybenzyl isothiocyanate [21]. The aglycone of deoxy-niazimicine [N-benzyl, S-ethyl thioformate] isolated from the chloroform fraction of an ethanol extract of the root bark was found to be responsible for the antibacterial and antifungal activities [25]. The bark extract has been shown to possess antifungal activity [22], while the juice from the stem bark showed antibacterial effect against *Staphylococcus aureus* [24]. The fresh leaf juice was found to inhibit the growth of microorganisms [*Pseudomonas aeruginosa* and *Staphylococcus aureus*], pathogenic to man [23].

Antitumor and anticancer activities

Makonnen *et al.* [1997] found *Moringa* leaves to be a potential source for antitumor activity. *O*-Ethyl- 4-[α-L-rhamnosyloxy]benzyl carbamate together with 4[α-L-rhamnosyloxy]-benzyl isothiocyanate, niazimicin and 3-*O*-[6′-*O*-oleoyl-α-D-glucopyranosyl]-β-sitosterol have been tested for their potential antitumor promoting activity using an *in vitro* assay which showed significant inhibitory effects on Epstein–Barr virus-early antigen. Niazimicin has been proposed to be a potent chemo preventive agent in chemical carcinogenesis [26]. The seed extracts have also been found to be effective on hepatic carcinogen metabolizing enzymes, antioxidant parameters and skin papillomagenesis in mice [27]. A seed ointment had a similar effect to neomycin against *Staphylococcus aureus pyodermia* in mice [28].It has been found that niaziminin ,a thiocarbamate from the leaves of *M. oleifera*, exhibits inhibition of tumor-promoter-induced Epstein–Barr virus activation. On the other hand, among the isothiocyanates, naturally occurring 4-[[4′-*O*-acetyl- α-i-rhamnosyloxy]benzyl], significantly inhibited tumor-promoter induced Epstein–Barr virus activation, suggesting that the isothiocyano group is a critical structural factor for activity [29].

Other diverse activities

Moringa oleifera has also been reported to exhibit other diverse activities. Aqueous leaf extracts regulate thyroid hormone and can be used to treat hyperthyroidism and exhibit an antioxidant effect [17,30,31]. A methanol extract of *M.oleifera* leaves conferred significant radiation protection to the bone marrow chromosomes in mice [20]. *Moringa* leaves are effective for the regulation of thyroid hormone status [31]. A recent report showed that *M. oleifera* leaf may be applicable as a prophylactic or therapeutic anti-HSV[Herpes simplex virus type 1] medicine and may be effective against the acyclovir-resistant variant [33]. The flowers and leaves also are considered to be of high medicinal value with anthelmintic activity [34].An infusion of leaf juice was shown to reduce glucose levels in rabbits [32].*Moringa oleifera* is coming to the forefront as a result of scientific evidence that *Moringa* is an important source of naturally occurring phytochemicals and this provides a basis for future viable developments. Different parts of *M. oleifera* are also incorporated in

various marketed health formulations. *Moringa* seeds have specific protein fractions for skin and hair care. Two new active components for the cosmetic industry have been extracted from oil cake.Purisoft® consists of peptides of the *Moringa* seed. It protects the human skin from environmental influences and combats premature skin aging. With dual activity, antipollution and conditioning/strengthening of hair, the *M. oleifera* seed extract is a globally acceptable innovative solution for hair care.

Water purifying attributes of *m. Oleifera* seed

Moringa seeds as coagulant

Moringa seeds are one of the best natural coagulants discovered so far [35]. Crushed seeds are a viable replacement of synthetic coagulants [36]. In Sudan, seed crude extract is used instead of alum by rural women to treat the highly turbid Nile water because of a traditional fear of alum causing gastrointestinal disturbances and Alzheimer's disease [38, 39,40, 37]. *Moringa* seeds are very effective for high turbidity water and show similar coagulation effects to alum [37]. The coagulation effectiveness of *M. oleifera* varies depending on the initial turbidity and it has been reported that *M. oleifera* could reduce turbidity by between 92% and 99% [37]. *Moringa* seeds also have softening properties in addition to being a pH correct ant [alkalinity reduction], as well as exhibiting a natural buffering capacity, which could handle moderately high to high alkaline surface and ground waters. The *Moringa* seeds can also be used as an antiseptic in the treatment of drinking water [41]. It is believed that the seed is an organic natural polymer [42]. The active ingredients are dimeric proteins with a molecular weight of about 1300 Da and n iso-electric point between 10 and 11 [35]. The protein powder is stable and totally soluble in water.

Moringa coagulant protein can be extracted by water or salt solution [commonly NaCl]. The amount and efectiveness of the coagulant protein from salt and water extraction methods vary significantly. In crude form, the salt extract shows a better coagulation performance than the corresponding water extract [43]. This may be explained by the presence of higher amount of soluble protein due to the salting-in phenomenon. However, purification of the *M. oleifera* coagulant protein from the crude salt extract may not be technically and economically feasible. The coagulation mechanism of the *M. oleifera* coagulant protein has been explained in different ways. It has been described as adsorption and charge neutralization [35,44] and interparticle bridging [45]. Flocculation by inter-particle bridging is mainly characteristic of high molecular weight polyelectrolytes. Due to the small size of the *M. oleifera* coagulant protein [6.5–13 kDa], a bridging effect may not be considered as the likely coagulation mechanism. The high positive charge [pI above 10] and small size may suggest that the main destabilization mechanism could be adsorption and charge neutralization.

Microbial elimination with *Moringa* seeds

Moringa seeds also possess antimicrobial properties [48,47,46] reported that a recombinant protein in the seed is able to flocculate Gram-positive and Gram-negative bacterial cells. In this case, microorganisms can be removed by settling in the same manner as the removal of colloids in properly coagulated and flocculated water [49]. On the other hand, the seeds may also act directly upon microorganisms and result in growth inhibition. Antimicrobial peptides are thought to act by disrupting the cell membrane or by inhibiting essential enzymes [50, 51, 52] reported that *Moringa* seeds could inhibit the replication of bacteriophages. The antimicrobial effects of the seeds are attributed to the compound 4[α-L-rhamnosyloxy] benzyl isothiocynate [53].

Moringa seeds as biosorbent

Moringa seeds could be used as a less expensive biosorbent for the removal of cadmium [Cd] from aqueous media [54]. The aqueous solution of *Moringa* seed is a heterogeneous complex mixture having various functional groups, mainly low molecular weight organic acids [amino

acids]. These amino acids have been found to constitute a physiologically active group of binding agents, working even at a low concentration, which because of the ability to interact with metal ions is likely to increase the sorption of metal ions [55]. The proteineous amino acids have a variety of structurally related pH dependent properties, generating a negatively charged atmosphere and play an important role in the binding of metals [56].

References

1. Oliveira JTA, Silveira SB, Vasconcelos IM, Cavada BS, Moreira RA. 1999. Compositional and nutritional attributes of seeds from the multipurpose tree Moringa oleifera Lamarck. J Sci Food Agric 79: 815–820.
2. Nikkon F, Saud ZA, Rehman MH, Haque ME. 2003. In vitro antimicrobial activity of the compound isolated from chloroform extract of Moringa oleifera Lam. Pak J Biol Sci 22: 1888–1890.
3. Mughal MH, Ali G, Srivastava PS, Iqbal M. 1999. Improvement of drumstick [Moringa pterygosperma Gaertn.] – a unique source of food and medicine through tissue culture. Hamdard Med 42: 37–42.
4. Dahot MU. 1988. Vitamin contents of flowers and seeds of Moringa oleifera. Pak J Biochem 21: 1–24.
5. Faizi S, Siddiqui B, Saleem R, Saddiqui S, Aftab K. 1994a. Isolation and structure elucidation of new nitrile and mustard oil glycosides from Moringa oleifera and their effect on blood pressure. J Nat Prod 57: 1256–1261.
6. Faizi S, Siddiqui B, Saleem R, Siddiqui S, Aftab K, Gilani A. 1994b. Novel hypotensive agents, niazimin A, niazimin B, niazicin A and niazicin B from Moringa oleifera; Isolation of first naturally occurring carbamates. J Chem Soc Perkin Trans I: 3035–3640.
7. Faizi S, Siddiqui BS, Saleem R, Siddiqui S, Aftab K, Gilani AH. 1995. Fully acetylated carbamate and hypotensive thiocarbamate glycosides from Moringa oleifera. Phytochemistry 38:957–963.
8. Gilani AH, Janbaz KH, Lateef A, Zaman M. 1994b. Cạ channel blocking activity of Artemisia scoparia extract. Phytother Res 8: 161–165.
9. Faizi S, Siddiqui BS, Saleem R, Aftab K, Shaheen F, Gilani AH. 1998. Hypotensive constituents from the pods of Moringa oleifera. Planta Med 64: 225–228.
10. Caceres A, Saravia A, Rizzo S, Zabala L, Leon ED, Nave F. 1992.Pharmacologic properties of Moringa oleifera: 2: ScreeningCopyright © 2006 for antispasmodic, anti-inflammatory and diuretic activity.J Ethnopharmacol 36: 233–237
11. Morton JF. 1991. The horseradish tree, Moringa pterigosperma [Moringaceae]. A boon to arid lands. Econ Bot 45: 318–333.
12. Ghasi S, Nwobodo E, Ofili JO. 2000. Hypocholesterolemic effects of crude extract of leaf of Moringa oleifera Lam in high-fat diet fed Wistar rats. J Ethnopharmacol 69: 21–25.
13. Mehta LK, Balaraman R, Amin AH, Bafna PA, Gulati OD. 2003. Effect of fruits of Moringa oleifera on the lipid profile of normal and hypercholesterolaemic rabbits. J Ethnopharmacol 86: 191–195.
14. Gilani AH, Aftab K, Shaheen F et al. 1992. Antispasmodic activity of active principle from Moringa oleifera. In Natural Drugs and the Digestive Tract, Capasso F, Mascolo N [eds]. EMSI: Rome, 60–63.
15. Dangi SY, Jolly CI, Narayana S. 2002. Antihypertensive activity of the total alkaloids from the leaves of Moringa oleifera. Pharm Biol 40: 144–148.
16. Gilani AH, Aftab K, Suria A et al. 1994a. Pharmacological studies on hypotensive and spasmodic activities of pure compounds from Moringa oleifera. Phytother Res 8: 87–91.
17. Pal SK, Mukherjee PK, Saha BP. 1995a. Studies on the antiulcer activity of Moringa

oleifera leaf extract on gastric ulcer models in rats. Phytother Res 9: 463–465.
18. Gilani AH, Janbaz KH, Shah BH. 1997. Quercetin exhibits hepatoprotective activity in rats. Biochem Soc Trans 25: 85.
19. Das BR, Kurup PA, Rao PL, Narasimha Rao PL. 1957. Antibiotic principle from Moringa pterygosperma. VII. Antibacterial activity and chemical structure of compounds related to pterygospermin. Indian J Med Res 45: 191–196.
20. Rao VA, Devi PU, Kamath R. 2001. In vivo radioprotective effect of Moringa
21. Eilert U, Wolters B, Nadrtedt A. 1981. The antibiotic principle of seeds of Moringa oleifera and Moringa stenopetala. PlantaMed 42: 55–61.
22. Bhatnagar SS, Santapau H, Desai JDH, Yellore S, Rao TNS 1961. Biological activity of Indian medicinal plants. Part 1. Antibacterial, antitubercular and antifungal action. Indian J Med Res 49: 799–805.
23. Caceres A, Cabrera O, Morales O, Mollinedo P, Mendia P. 1991.Pharmacological properties of Moringa oleifera. 1: Preliminaryscreening for antimicrobial activity. J Ethnopharmacol 33: 213–216.
24. Mehta LK, Balaraman R, Amin AH, Bafna PA, Gulati OD. 2003. Effect of fruits of Moringa oleifera on the lipid profile of normal and hypercholesterolaemic rabbits. J Ethnopharmacol 86: 191–195
25. Nikkon F, Saud ZA, Rehman MH, Haque ME. 2003. In vitro antimicrobial activity of the compound isolated from chloroform extract of Moringa oleifera Lam. Pak J Biol Sci 22: 1888–1890.
26. Guevara AP, Vargas C, Sakurai H et al. 1999. An antitumor promoter from Moringa oleifera Lam. Mutat Res 440: 181–188.
27. Bharali R, Tabassum J, Azad MRH. 2003. Chemomodulatory effect of Moringa oleifera, Lam, on hepatic carcinogen metabolizing enzymes, anti-oxidant parameters and skin papillomagenesis in mice. Asia Pacific J Cancer Prev4: 131–139.
28. Caceres A, Lopez S. 1991. Pharmacologic properties of Moringa oleifera: 3: Effect of seed extracts in the treatment of experimental Pyodermia. Fitoterapia 62: 449–450.
29. Murakami A, Kitazono Y, Jiwajinda S, Koshimizu K, Ohigashi H. 1998. Niaziminin, a thiocarbamate from the leaves of Moringa oleifera, holds a strict structural requirement for inhibition of tumor-promoter-induced Epstein-Barr virus activation. Planta Med 64: 319–323.
30. Pal SK, Mukherjee PK, Saha K, Pal M, Saha BP. 1995b. Antimicrobial action of the leaf extract of Moringa oleifera Lam. Ancient Science of Life 14: 197–199
31. Tahiliani P, Kar A. 2000. Role of Moringa oleifera leaf extract in the regulation of thyroid hormone status in adult male and female rats. Pharmacol Res 41: 319–323.
32. Makonnen E, Hunde A, Damecha G. 1997. Hypoglycaemic effect of Moringa stenopetala aqueous extract in rabbits. Phytother Res 11: 147–148.
33. Lipipun V, Kurokawa M, Suttisri R et al. 2003. Efficacy of Thai medicinal plant extracts against herpes simplex virus type1 infection in vitro and in vivo. Antiviral Res 60: 175–180.
34. Bhattacharya SB, Das AK, Banerji N. 1982. Chemical investigations on the gum exudates from Sonja [Moringa oleifera]. Carbohydr Res 102: 253–262.
35. Ndabigengesere A, Narasiah KS, Talbot BG. 1995. Active agents and mechanism of coagulation of turbid waters using Moringa oleifera. Water Res 29: 703–710.
36. Kalogo Y, Rosillon F, Hammes F, Verstraete W. 2000. Effect of a water extract of Moringa oleifera seeds on the hydrolytic microbial species diversity of a UASB reactor treating domestic wastewater. Lett Appl Microbiol 31: 259–264.

37. Muyibi SA, Evison LM. 1995b. Optimizing physical parameters affecting coagulation of turbid water with Moringa oleifera seeds. Water Res 29: 2689–2695.
38. Crapper DR, Krishnan SS, Dalton AJ. 1973. Brain aluminum distribution in Alzheimer's disease and experimental neurofibrillary degeneration. Science 180: 511–513
39. Martyn CN, Barker DJP, Osmond C, Harris EC, Edwardson JA, Lacey RF. 1989. Geographical relation between Alzheimer's disease and aluminum in drinking water. Lancet 1: 59–62.
40. Miller RG, Kopfler FC, Kelty KC, Stober JA, Ulmer NS. 1984 . The occurrence of aluminum in drinking water. J Am Water Works Assoc 76: 84–91.
41. Obioma UN, Adikwu MU. 1997. Investigation on some physiochemical antioxidant and toxicological properties of Moringa oleifera seed oil. Acta Pharm 47: 287–290.
42. Jahn SAA. 1984. Effectiveness of traditional flocculants asprimary coagulants and coagulant aids for the treatment of tropical waters with more than a thousand fold flocculation in turbidity. Water Supply 2: 8–10.
43. Okuda T, Baes AU, Nishijima W, Okada M. 1999. Improvement of extraction method of coagulation active components from Moringa oleifera seed. Water Res 33: 3373–3378.
44. Gassenschmidt U, Jany KD, Tauscher B, Niebergall H. 1995. Isolation and characterization of a flocculating protein from Moringa oleifera Lam. Biochim Biophys Acta 1243: 477– 481.
45. Muyibi SA, Evison LM. 1995a. Moringa oleifera seeds for softening hard water. Water Res 29: 1099–1104.
46. Broin M, Santaella C, Cuine S, Kokou K, Peltier G, Joet T. 2002. Flocculent activity of a recombinant protein from Moringa oleifera Lam. seeds. Appl Microbiol Biotechnol 60: 114–119.
47. Madsen M, Schlundt J, Omer El-FE. 1987. Effect of water coagulation by seeds of Moringa oleifera on bacterial concentration. J Trop Med Hyg 90: 101–109
48. Olsen A. 1987. Low technology water purification by bentonite clay and Moringa oleifera seed flocculation as performed in Sudanese villages: effects on Schistosoma mansoni cercariae. Water Res 21: 517–522.
49. Casey TJ. 1997. Unit Treatment Processes in Water and Wastewater Engineering. John Wiley & Sons: London.
50. Silvestro L, Weiser JN, Axelsen PH. 2000. Antibacterial and antimembrane activities of cecropin A in Escherichia coli. Antimicrob Agents Chemother 44: 602–607.
51. Suarez M, Entenza JM, Doerries C et al. 2003. Expression of a plant-derived peptide harbouring water-cleaning and antimicrobial activities. Biotechnol Bioeng 81: 13–20.
52. Sutherland JP, Folkard G, Grant WD. 1990. Natural coagulants for appropriate water treatment: a novel approach. Waterlines 8: 30–32.
53. Eilert U, Wolters B, Nadrtedt A. 1981. The antibiotic principle of seeds of Moringa oleifera and Moringa stenopetala. PlantaMed 42: 55–61.
54. Sharma P, Kumari P, Srivastava MM, Srivastava S. 2006. Removal of cadmium from aqueous system by shelled Moringa oleifera Lam. seed powder. Bioresour Technol 97: 299–305.
55. Brostlap AC, Schuurmans J. 1988. Kinetics of valine uptake in tobacco leaf disc. Comparison of wild types the digenic mutant and its monogenic derivatives.Planta 176: 42–50.
56. Sharma P, Kumari P, Srivastava MM, Srivastava S. 2006. Removal of cadmium from aqueous system by shelled Moringa oleifera Lam. seed powder. Bioresour Technol 97: 299–305.