

Evaluation of Antidiabetic and Antioxidant Activity of *Moringa Oleifera* in Experimental Diabetes

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Abstract: *It's interesting to note the potential health benefits of Moringa oleifera in addressing issues like diabetes, obesity, and malnutrition. The diverse pharmacological properties of Moringa, including its anti-cancer, anti-diabetic, anti-inflammatory, and antioxidant effects, make it a valuable plant with various potential applications in traditional medicine. Its nutritional richness adds to its appeal in addressing health concerns, particularly in regions like India where diabetes mellitus and obesity are significant challenges. The study Investigated the antidiabetic and antioxidant effects of methanol extracts from M. oleifera pods in STZ-induced diabetic rats. Additionally, it aimed to determine the antihyperglycemic effect of dried M. oleifera leaves powder or its ethanolic extract in both diabetic and normal rats. The findings suggest potential benefits in reducing oxidative damage and hypoglycemic activity, particularly in diabetic rats, while highlighting the need for further research on the hypoglycemic properties in normal rats.*

Keywords: Moringa oleifera

REFERENCES

- [1]. Hosni AA, Abdel-Moneim AA, Abdel-Reheim ES, Mohamed SM, Helmy H. Cinnamaldehyde potentially Attenuates gestational hyperglycemia in rats through Modulation of PPAR, proinflammatory cytokines and Oxidative stress. *Biomed Pharmacother* 2017; 88: 52-60.
- [2]. Chukwuma CI, Matsabisa MG, Ibrahim MA, Erukainure OL, Chabalala MH, Islam MS. Medicinal plants with Concomitant anti-diabetic and anti-hypertensive effects As potential sources of dual acting therapies against Diabetes and hypertension: A review. *J Ethnopharmacol* 2019; 235: 329-360.
- [3]. Anwer T, Sharma M, Khan G, Iqbal M, Ali MS, Alam MS, Safhi MM, Gupta N. Rhus coriaria ameliorates insulin Resistance in noninsulin-dependent diabetes mellitus (NIDDM) rats. *Acta Pol Pharm* 2013; 70(5): 861-867.
- [4]. Leone A, Spada A, Battezzati A, Schiraldi A, Aristil J, Bertoli S. Cultivation, genetic, ethnopharmacology, Phytochemistry and pharmacology of Moringa oleifera Leaves: An overview. *Int J Mol Sci* 2015; 16(6): 12791-12835.
- [5]. Gopalakrishnan L, Doriya K, Kumar DS. Moringa oleifera: A review on nutritive importance and its medicinal Application. *Food Sci Hum Wellness* 2016; 5: 49-56.
- [6]. Adepoju-Bello AA, Jolayemi OM, Ehianet TS, Ayoola GA. Preliminary phytochemical screening, antioxidant and Antihyperglycaemic activity of Moringa oleifera leaf Extracts. *Pak J Pharm Sci* 2017; 30(6): 2217-2222.
- [7]. Kou X, Li B, Olayanju JB, Drake JM, Chen N. Nutraceutical or pharmacological potential of Moringa Oleifera Lam. *Nutrients* 2018; 10(3): 343.
- [8]. Yassa HD, Tohamy AF. Extract of Moringa oleifera Leaves ameliorates streptozotocin-induced diabetes Mellitus in adult rats. *Acta Histochem* 2014; 116(5): 844-854.
- [9]. Bamagous GA, Al Ghamdi SS, Aziz Ibrahim IA, Mahfoz AM, Afify MA, Alsugoor MHM, Shammah AA, Arulselvan P, Rengarajan T. Antidiabetic and antioxidant activity of Ethyl acetate extract fraction of Moringa oleifera leaves In STZ-induced diabetes rats via inhibition of Inflammatory mediators. *Asian Pac J Trop Biomed* 2018; 8(6): 320-327.

- [10]. Clark JD, Gebhart GF, Gonder JC, Keeling ME, Kohn DF. The 1996 guide for the care and use of laboratory Animals. *Ilar Journal* 1997; 38(1): 41-48.
- [11]. Suman RK, Mohanty IR, Borde MK, Maheshwari U, Deshmukh YA. Development of an experimental model Of diabetes co-existing with metabolic syndrome in rats. *Adv Pharmacol Sci* 2016; 2016: 9463476.
- [12]. Braham D, Trinder P. An improved colour reaction for the Determination of blood glucose by oxidase system. *Analyst* 1972; 97(151): 142-145 <https://pubmed.ncbi.nlm.nih.gov/22103446/>
- [13]. W. Fan, "Epidemiology in diabetes mellitus and cardiovascular disease," *Cardiovascular Endocrinology*, vol. 6, no. 1, pp. 8–16, 2017. View at: Publisher Site | Google ScholarW. Fan, "Epidemiology in diabetes mellitus and cardiovascular disease," *Cardiovascular Endocrinology*, vol. 6, no. 1, Pp. 8–16, 2017.
- [14]. J. Khawandanah, "Double or hybrid diabetes: a systematic Review on disease prevalence, Characteristics and risk factors," *Nutrition & Diabetes*, vol. 9, no. 1, p. 33, 2019
- [15]. W. Khan, R. Parveen, K. Chester, S. Parveen, and S. Ahmad, "Hypoglycemic potential of Aqueous extract of Moringa oleifera leaf and in vivo GC-MS metabolomics," *Frontiers in Pharmacology*, vol. 8, p. 577, 2017.
- [16]. Y. Mukhtar, A. Galalain, and U. Yunusa, "A modern overview on diabetes mellitus: a chronic Endocrine disorder," *European Journal of Biology*, vol. 5, no. 2, pp. 1–14, 2020.
- [17]. P. Saeedi, P. Salpea, S. Karuranga et al., "Mortality attributable to diabetes in 20-79 years Old adults, 2019 estimates:
- [18]. Results from the International Diabetes Federation Diabetes Atlas, 9th edition," *Diabetes Research and Clinical Practice*, Vol. 162, p. 108086, 202
- [19]. L. Jung, "Soluble extract from Moringa oleifera leaves with A new anticancer activity," *PLoS One*, vol. 9, no. 4, article E95492, 2014
- [20]. R. Kumari, A. K. Singh, R. Kumar, and A. Kumar, "Phytoremedial effect of fruit extract of Moringa oleifera on alloxan induced Diabetic model in Swiss albino mice," *Journal of Applied And Natural Science*, vol. 13, no. 4, pp. 1420–1429, 2021.
- [21]. D. Patel, S. K. Prasad, R. Kumar, and S. Hemalatha, "An overview on antidiabetic medicinal Plants having insulin mimetic Property," *Asian Pacific Journal of Tropical Biomedicine*, Vol. 2, No. 4, pp. 320–330, 2012.
- [22]. T. Rosenzweig and S. R. Sampson, "Activation of insulin signaling by botanical Products," *International Journal of Molecular Sciences*, vol. 22, no. 8, p. 4193, 2021.
- [23]. R. K. Saini, I. Sivanesan, and Y.-S. Keum, "Phytochemicals of Moringa oleifera: a review of their Nutritional, therapeutic And industrial significance," *3 Biotech*, vol. 6, no. 2, pp. 1–14, 2016.
- [24]. M. Slaoui and L. Fiette, "Histopathology procedures: from Tissue sampling to histopathological Evaluation," *Drug Safety Evaluation: Methods and Protocols*, pp. 69–82, 2011.
- [25]. S. Odeyemi and G. Bradley, "Medicinal plants used for the
- [26]. Traditional management of diabetes in the Eastern Cape, South Africa: pharmacology and Toxicology," *Molecules*, Vol. 23, no. 11, p. 2759, 2018.
- [27]. P. Sakong, T. Khampitak, U. Cha'on et al., "Antioxidant Activity and bioactive phytochemical," *Journal of Medicinal Plant Research*, vol. 5, no. 31, pp. 6822–6831, 2011
- [28]. C. Sun, C. Zhao, E. C. Guven et al., "Dietary polyphenols as Antidiabetic agents: advances and Opportunities," *Food Frontiers*, vol. 1, no. 1, pp. 18–44, 2020.
- [29]. Thompson CJ, Ernst E. Herbs for serum cholesterol Reduction: a systematic view. *The Journal Of Family Practice*. 2003 Jun;52(6):468-78
- [30]. Adeneye AA, Benebo AS. Pharmacological evaluation Of a Nigerian polyherbal health tonic tea In rat. *African Journal of Biomedical Research*. 2007;10(3)249-255.
- [31]. Agrawal RP, Sharma P, Pal M, Kochar A, Kochar DK. Magnitude of dyslipedemia and its Association with micro And macro vascular complications in type 2 diabetes: a Hospital based Study from Bikaner (Northwest India). *Diabetes Research and Clinical Practice*. 2006 Aug 1;73(2):211-4.
- [32]. Scott AI, Clarke BE, Healy H, D'Emden M, Bell SC. Microvascular complications in cystic Fibrosis-related Diabetes mellitus: a case report. *JOP. Journal of the Pancreas*. 2000;1(4):208-10.

- [33]. Marles RJ, Farnsworth NR. Antidiabetic plants And their active constituents. *Phytomedicine*. 1995 Oct 1;2(2):137-89.
- [34]. Nimenibo-Uadia R. Effect of aqueous extract of *Canavalia ensiformis* seeds on hyperlipidaemia And Hyperketonaemia in alloxan-induced diabetic rats. *Biokemistri*. 2003;15(1):7-15.
- [35]. Okoli CO, Ibiam AF, Ezike AC, Akah PA, Okoye TC. Evaluation of antidiabetic potentials of *Phyllanthus niruri* In alloxan diabetic rats. *African Journal of Biotechnology*. 2010;9(2):248-259.
- [36]. Owulade MO, Eghianruwa KI, Daramola FO. Effects Of aqueous extracts of *Hibiscus sabdariffa* Calyces and *Ocimum gratissimum*leaves on interstinal transit in rats. *African Journal of Biomedical Research*. 2004;7(1):31-34.
- [37]. Rotimi SO, Omotosho OE, Rotimi OA. Persistence Of acidosis in alloxan-induced diabetic Rats treated with The juice of *Asystasia gangetica* leaves. *Pharmacognosy Magazine*. 2011 Jan;7(25):25-30.
- [38]. Szkudelski T. The mechanism of alloxan and Streptozotocin action in B cells of the rat Pancreas. *Physiological Research*. 2001 Jan 1;50(6):536-
- [39]. Tasaduq SA, Singh K, Sethi S, Sharma SC, Bedi KL, Singh J, et al. Hepatocurative and antioxidant Profile of HP-1, a polyherbal phytomedicine. *Human & Experimental Toxicology*. 2003 Dec;22(12):639-45.
- [40]. Thompson CJ, Ernst E. Herbs for serum cholesterol Reduction: a systematic view. *The Journal Of Family Practice*. 2003 Jun;52(6):468-78. *Biometrics*. 1955 Mar 1;11(1):1-42.
- [41]. Duncan DB. Multiple range and multiple F tests.
- [42]. Fröde TS, Medeiros YS. Animal models to test Drugs with potential antidiabetic activity. *Journal of Ethnopharmacology*. 2008 Jan 17;115(2):173-83.
- [43]. Lee JH, Park JW, Kim JS, Park BH, Rho HW. Protective effect of Amomi semen extract on Alloxaninduced pancreatic β cell damage. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*. 2008 Jan;22(1):86-90.
- [44]. Rakesh B, Sanjay J, Deep Q, Amit J, Girraj ST and Ravi G. Antidiabetic activity of aqueous root Extract of *Ichnocarpus frutescens* in STZnicotinamide induced type II diabetes in rats. *Indian J. Pharmacology*, 2008; 40 (1): 19-22.
- [45]. Juliana CNC, Vasanti M, Weiping J, Takashi K, Chittaranjan SY, Kun-Ho Y and Frank BH. Diabetes in Asia: Epidemiology, Risk Factors, and Pathophysiology. *American Medical Association*, 2009; 301(20): 2129-2140 Rathod N, Raghuvveer I, Chitme HR and Ramesh C. Antidiabetic Activity of *Nyctanthes Arborescens*. *Pharmacognosy Magazine*, 2008; 4 (16): 335-340. |
- [46]. Fuglie LJ. 1999. *The Miracle Tree: Moringa oleifera: Natural Nutrition for the Tropics*. Church World Service, Dakar, pp: 68. Revised in 2001 and published as *The Miracle Tree: The Multiple Attributes of Moringa*, pp: 172.
- [47]. Anwar F, Latif S, Ashraf M and Gilani AH. *Moringa oleifera*: a food plant with multiple Medicinal uses. *Phytother Res.*, 2007; 21: 17–25.
- [48]. Ramachandran, C., Peter, K. V., & Gopalakrishnan, P. K. (1980). Drumstick (*Moringa Oleifera*): a Multipurpose Indian vegetable. *Economic botany*, 276-283.
- [49]. Tollo, B., Chougourou, D. C., & Todohoue, C. M. (2016). Anti-Hyperglycaemic and Lipid Profile Regulatory Properties of *Moringa Oleifera* in Subjects At Early Stages of Type 2 Diabetes Mellitus. *Emj European Medical Journal*, 99-105.
- [50]. Kumar, P. K., & Mandapaka, R. T. (2013). Effect of moringa oleifera on blood glucose, Ldl levels In types ii diabetic obese people. *Innov. J. Med. Health Sci*, 3, 23-25.
- [51]. Sugunabai J et al. Antidiabetic efficiency of *Moringa oleifera* and *Solanum nigrum*. *Int J Pharm Pharm Sci*. 2014;6(Suppl 1): 40-2.
- [52]. Olagbemide, P. T., & Philip, C. N. A. (2014). Proximate analysis and chemical Composition of Raw and defatted *Moringa oleifera* kernel. *Advances in Life Science and Technology*, 24, 92-99.
- [53]. Verma, A. R., Vijayakumar, M., Mathela, C. S., & Rao, C. V. (2009). In vitro and in vivo Antioxidant properties of different fractions of *Moringa oleifera* leaves. *Food and Chemical Toxicology*, 47(9), 2196-2201.

- [54]. Al-Malki, A. L., & El Rabey, H. A. (2015). The antidiabetic effect of low doses of Moringa Oleifera Lam. Seeds on streptozotocin induced diabetes and diabetic nephropathy inM ale rats. *BioMed research international*, 2015.
- [55]. Tahiliani, P., & Kar, A. (2000). Role of Moringa oleifera leaf extract in the regulation of Thyroid Hormone status in adult male and female rats. *Pharmacological research*, 41(3), 319-323.
- [56]. Afrisham, R., Aberomand, M., Ghaffari, M. A., Siahpoosh, A., & Jamalana, M. (2015). Inhibitory Effect of Heracleum persicum and Ziziphus jujuba on Activity of AlphaAmylase. *Journal of Botany*, 2015.
- [57]. Kooti, W., Farokhipour, M., Asadzadeh, Z., Ashtary-Larky, D., & Asadi-Samani, M (2016). The Role of medicinal plants in the treatment of diabetes: a systematic review. *Electronic physician*, 8(1), 1832.
- [58]. Kavishankar, G. B., Lakshmidhevi, N., Murthy, S. M., Prakash, H. S., & Niranjana, S. R.(2011). Diabetes and medicinal plants-A review. *Int J Pharm Biomed Sci*, 2(3), 65-80.
- [59]. Abd El Latif, A., El Bialy Bel, S., Mahboub, H.D., Abd Eldaim, M.A., 2014. Moringa oleifera leaf Extract ameliorates alloxan-induced diabetes in rats by regeneration of beta cells and Reduction of pyruvate carboxylase expression. *Biochemistry and Cell Biology* 92, 413–419.
- [60]. Ahmad, J., Khan, I., Johnson, S.K., Alam, I., Din, Z.U., 2018. Effect of incorporating Stevia and Moringa in cookies on postprandial glycemia, appetite, palatability, and gastrointestinal wellbeing. *Journal of the American College of Nutrition* 37, 133–139.
- [61]. Al-Asmari, A.K., Albalawi, S.M., Athar, M.T., Khan, A.Q., AlShahrani, H., Islam, M., 2015.
- [62]. Moringa oleifera as an anti-cancer agent against breast and colorectal cancer cell Lines. *PLoS One* 10, e0135814. Alhakmani, F., Kumar, S., Khan, S.A., 2013.
- [63]. Estimation of total phenolic Content, in-vitro Antioxidant and anti-inflammatory activity of flowers of Moringa oleifera. *Asian Pacific Journal of Tropical Biomedicine* 3, 623–627.
- [64]. Al-Malki, A.L., El Rabey, H.A., 2015. The antidiabetic effect of low doses of Moringa oleifera Lam. Seeds on streptozotocin induced diabetes and diabetic nephropathy in male Rats. *BioMed Research International* 13.
- [65]. Amaglo, N.K., Bennett, R.N., Curto, R.B.L., Rosa, E.A., Turco, V.L., Giuffrida, A., Curto, A.L., Crea, F., Timpo, G.M., 2010. Profiling selected phytochemicals and nutrients in different tissues of The multipurpose tree Moringa oleifera L., grown in Ghana. *Food Chemistry* 122, 1047–1054.
- [66]. Araujo, L.C., Aguiar, J.S., Napoleao, T.H., Mota, F.V., Barros, A.L., Moura, M.C., Coriolano, M.C., Coelho, L.C., Silva, T.G.,
- [67]. Paiva, P.M., 2013. Evaluation of cytotoxic and antiinflammatory Activities of extracts and lectins from Moringa oleifera seeds. *PLoS One* 8, e81973.
- [68]. Arun Giridhari, V., Malathi, D., Geetha, K., 2011. Anti diabetic property of drumstick (Moringa Oleifera) leaf tablets. *International Journal of Health and Nutrition* 2, 1–5.
- [69]. Atawodi, S.E., Atawodi, J.C., Idakwo, G.A., Pfundstein, B., Haubner, R., Wurtele, G., Bartsch, H., Owen, R.W., 2010. Evaluation of the polyphenol content and antioxidant properties of Methanol extracts of the leaves, stem, and root barks of Moringa oleifera Lam. *Journal of Medicinal Food* 13, 710–716.
- [70]. Bajpai, M., Pande, A., Tewari, S.K., Prakash, D., 2005. Phenolic contents and antioxidant Activity of some food and medicinal plants. *International Journal of Food Sciences and Nutrition* 56, 287–291.
- [71]. Bennett, R.N., Mellon, F.A., Foidl, N., Pratt, J.H., Dupont, M.S., Perkins, L., Kroon, P.A..2003. Profiling glucosinolates and phenolics in vegetative and reproductive tissues of the Multipurpose trees Moringa oleifera L. (horseradish tree) and Moringa stenopetala L. *Journal Of Agricultural and Food Chemistry* 51, 3546–3553.
- [72]. Berkovich, L., Earon, G., Ron, I., Rimmon, A., Vexler, A., Lev-Ari, S., 2013. Moringa oleifera Aqueous leaf extract downregulates nuclear factor-kappa B and increases cytotoxi Effect of Chemotherapy in pancreatic cancer cells. *BMC*
- [73]. *Complementary and Alternative Medicine* 13, 212. Bohn, S.K., Ward, N.C., Hodgson, J.M., Croft, K.D., 2012. Effects of tea and coffee on Cardiovascular disease risk. *Food and Function* 3, 575–591.

- [74]. Bundy, J.D., Li, C., Stuchlik, P., Bu, X., Kelly, T.N., Mills, K.T., He, H., Chen, J., Whelton, P.K. He, J., 2017. Systolic blood pressure reduction and risk of cardiovascular disease And mortality: a Systematic review and network meta-analysis. *JAMA Cardiology* 2,775–781.
- [75]. Cao, Y., Ma, Z., Zhang, H., Jin, Y., Zhang, Y., Hayford, F., 2018. Phytochemical properties and Nutrigenomic implications of Yacon as a potential source of prebiotic: current evidence and Future directions. *Food* 7, 59.
- [76]. Chen, K.H., Chen, Y.J., Yang, C.H., Liu, K.W., Chang, J.L., Pan, S.F., Lin, T.B., Chen, M.J., 2012. Attenuation of the extract from *Moringa oleifera* on monocrotaline-induced pulmonary Hypertension in rats. *Chinese Journal of Physiology* 55, 22–30.
- [77]. Cheraghi, M., Namdari, M., Daraee, H., Negahdari, B., 2017. Cardioprotective effect of Magnetic hydrogel nanocomposite loaded N,α-L-rhamnopyranosyl vincosamide isolated From *Moringa oleifera* leaves against doxorubicin-induced cardiac toxicity in Rats: in vitro and In vivo studies. *Journal of Microencapsulation* 34, 335–341.
- [78]. Chumark, P., Khunawat, P., Sanvarinda, Y., Phornchirasilp, S., Morales, N.P., PhivthongNgam, L., Ratanachamnong, P., Srisawat, S., Pongrapeeporn, K.U., 2008. The in vitro And ex vivo Antioxidant properties, hypolipidaemic and antiatherosclerotic activitiesb Of water extract of *Moringa oleifera* Lam. Leaves. *Journal of Ethnopharmacology* 116, 439–446.
- [79]. Coppin, J.P., Xu, Y., Chen, H., Pan, M.-H., Ho, C.-T., Juliani, R., Simon, J.E., Wu, Q., 2013. Determination of flavonoids by LC/MS and anti-inflammatory activity in *Moringa Oleifera*. *Journal of Functional Foods* 5, 1892–1899.
- [80]. Das, N., Sikder, K., Ghosh, S., Fromenty, B., Dey, S., 2012. *Moringa oleifera* Lam leaf extract Prevents early liver injury and restores antioxidant status in mice fed with high-fat Diet. *Indian Journal of Experimental Biology* 50, 404–412.
- [81]. Das, N., Sikder, K., Bhattacharjee, S., Majumdar, S.B., Ghosh, S., Majumdar, S., Dey, S., 2013. Quercetin alleviates inflammation after short-term treatment in high-fat-fed mice. *Food and Function* 4, 889–898.
- [82]. Faizi, S., Siddiqui, B.S., Saleem, R., Siddiqui, S., Aftab, K., Gilani, A.-U.H., 1994. Isolation and Structure elucidation of new nitrile and mustard oil glycosides from *Moringa oleifera* And their Effect on blood pressure. *Journal of Natural Products* 57, 1256–1261.
- [83]. Faizi, S., Siddiqui, B.S., Saleem, R., Siddiqui, S., Aftab, K., Gilani, A.H., 1995. Fully acetylated Carbamate and hypotensive thiocarbamate glycosides from *Moringa oleifera*. *Phytochemistry* 38, 957–963.
- [84]. (Cao et al., 2018; Ma and Zhang, 2017; Ma and Lee, 2016; Ravichanthiran et al., 2018; Zhang et Al.2018)
- [85]. Emerging Risk Factors Collaboration. (2010). Diabetes mellitus, fasting blood glucose Concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective Studies. *The lancet*, 375(9733), 2215-2222
- [86]. Ridwanto, M., Indarto, D., & Hanim, D. (2020). Factors affecting fasting blood glucose In Patients with type 2 diabetes mellitus. *International Journal of Nutrition Sciences*, 5(1), 13-18.
- [87]. Jaiswal, D., Rai, P. K., Kumar, A., Mehta, S., & Watal, G. (2009). Effect of *Moringa Oleifera* Lam. Leaves aqueous extract therapy on hyperglycemic rats. *Journal of Ethnopharmacology*, 123(3), 392-396.
- [88]. Ahmad, J., Khan, I., & Blundell, R. (2019). *Moringa oleifera* and glycemic control: A Review of Current evidence and possible mechanisms. *Phytotherapy research*, 33(11), 2841-2848
- [89]. 2848
- [90]. Olayaki, L.A., Irekpita, J.E., Yakubu, M.T., Ojo, O.O., 2015. Methanolic extract of *Moringa Oleifera* leaves improves glucose tolerance, glycogen synthesis and lipid metabolism In Alloxaninduced diabetic rats. *Journal of Basic and Clinical Physiology and Pharmacology* 26, 585–593.
- [91]. Omodanisi, E.I., Aboua, Y.G., Oguntibeju, O.O., 2017. Assessment of the antihyperglycaemic, Anti-inflammatory and antioxidant activities of the methanol extract of *Moringa oleifera* in Diabetes-induced nephrotoxic male Wistar rats. *Molecules* 22.

- [92]. Panda, S., Kar, A., Sharma, P., Sharma, A., 2013. Cardioprotective potential of N,α-L-tryptophan-tryptophanamide, an indole alkaloid, isolated from the leaves of *Moringa Oleifera* in isoproterenol induced cardiotoxic rats: in vivo and in vitro studies. *Bioorganic and Medicinal Chemistry Letters* 23, 959–962.
- [93]. Pari, L., Kumar, N.A., 2002. Hepatoprotective activity of *Moringa oleifera* on antitubercular Drug-induced liver damage in rats. *Journal of Medicinal Food* 5, 171–177.
- [94]. Purwal, L., Pathak, A., Jain, U., 2010. In vivo anticancer activity of the leaves and fruits of *Moringa oleifera* on mouse melanoma. *Pharmacology* 1, 655–665.
- [95]. Rajanandh, M., Satishkumar, M., Elango, K., Suresh, B., 2012. *Moringa oleifera* Lam. A Herbal Medicine for hyperlipidemia: a pre-clinical report. *Asian Pacific Journal of Tropical Disease* 2, S790–S795.
- [96]. Randriamboavonjy, J.I., Rio, M., Pacaud, P., Loirand, G., Tesse, A., 2017. *Moringa oleifera* Seeds Attenuate vascular oxidative and nitrosative stresses in spontaneously hypertensive rats. *Oxidative Medicine and Cellular Longevity* 2017, 4129459.
- [97]. Ravichanthiran, K., Ma, Z., Zhang, H., Cao, Y., Wang, C., Muhammad, S., Aglago, E., Zhang, Y., Jin, Y., Pan, B., 2018.
- [98]. Phytochemical profile of brown rice and its nutrigenomic implications. *Antioxidants* 7, 71
- [99]. Sadek, K.M., Abouzed, T.K., Abouelkhair, R., Nasr, S., 2017. The chemo-prophylactic efficacy of An ethanol *Moringa oleifera* leaf extract against hepatocellular carcinoma in Rats. *Pharmaceutical Biology* 55, 1458–1466.
- [100]. Sahakitpichan, P., Mahidol, C., Disadee, W., Ruchirawat, S., Kanchanapoom, T., 2011. Unusual Glycosides of pyrrole alkaloid and 4'-hydroxyphenylethanamide from leaves Of *Moringa Oleifera*. *Phytochemistry* 72, 791–795.
- [101]. Saini, R.K., Shetty, N.P., Giridhar, P., 2014. Carotenoid content in vegetative and reproductive Parts of commercially grown *Moringa oleifera* L. cultivars from India by LC–APCI–MS. *European Food Research and Technology* 238, 971–978. Saini, R.K., Sivanesan, I., Keum, Y.-S., 2016. Phytochemicals of *Moringa oleifera*: a review of Their nutritional, therapeutic and industrial Significance. *3 Biotechnology* 6, 203.
- [102]. Siddhuraju, P., Becker, K., 2003. Antioxidant properties of various solvent extracts of total Phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa Oleifera* Lam) leaves. *Journal of Agricultural and Food Chemistry* 51, 2144–2155.