

# A Review of Pharmacognostical Studies on *Moringa oleifera* Lam. flowers

Tom Mathew Kalappurayil\*, Benny Pulinilkumthadathil Joseph

## ABSTRACT

*Moringa oleifera* Lam. of the family Moringaceae, popularly called 'miracle tree' is a native of sub Himalayan tracts of Northern India and is widely cultivated in tropical and subtropical regions. Research on *Moringa* mainly pivoted around its leaves and seeds because of their immense nutraceutical potential but recently there is a greater interest in flowers too, mostly inspired by the positive outcomes of several pharmacognostical studies on flowers. *Moringa* flower is a rich reservoir of bioactive phytochemicals and crude flower extracts showed promising antibacterial, antifungal, anti larval, antioxidant, anti inflammatory and anticancer properties. This review concisely presents the various phytochemicals identified and isolated as well as the various bioassays employed to validate the therapeutic potential of flower. It is prepared after a detailed search on Google scholar. Reports on *Moringa oleifera* flower were sorted and tabulated based on the bioassays performed and solvents used for extraction. A grading pattern is adopted for comparing efficiency of different extracts in eliciting bioactivities. Many of these studies are at the preliminary stage but two of them present advanced mechanisms. First is the presence of a proteinaceous larvicidal compound 'MoFTI' in the flower capable of inhibiting larval trypsin of *Aedes aegypti*. The second describes flower extract's anti inflammatory mechanism effecting via NF-KB pathway and consequent suppression of inflammatory mediators' activation, but short of identifying lead compound/compounds behind this effect. Thus authors suggest further studies to elucidate the detailed mechanisms, identify and isolate the active compound or compounds of synergism behind the many therapeutic potential of the *Moringa* flower extracts.

**Key words:** Extracts, *Moringa*, Flower, Bioactivity, Phytochemicals, GCMS, Bioassay, Therapeutic.

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## INTRODUCTION

Pharmacognostical studies on *Moringa oleifera* LAM. has begun as early in 1950s which led to the discovery of antibacterial pterygospermin in the plant.<sup>1</sup> Recent research helped to validate many of *M. oleifera*'s traditional claims such as antibacterial and antitumor properties. For instance, Jed W Fahey (2005) refers to two molecules from this plant, 4-(L-rhamnopyranosyloxy) benzyl isothiocyanate and Niazimicin of being active against *Helicobacterium pylori* and tumor growth respectively, but recommends rigorous research of international standard essential before moving to full biomedical endorsement of *M. oelifera*. Hitherto such investigations mainly concentrated on leaves due to its proven potential as an exceptional nutraceutical.<sup>2</sup> On other hand *Moringa* flowers received little attention of researchers in spite of its significant nutritional and traditional healing properties.<sup>3</sup> 'Muringa Poovu thoran' is a tasty and a seasonal dish of Malayalees made from *Moringa* flowers. In other parts of world too, flowers are favorite ingredients of various dishes such as lasagna, omelet, soups, sea foods, pasta dishes,

pizza pakoras etc or eaten raw as salads, or used for making tea and honey.<sup>4</sup> Bhavaprakasa of Bhava Misra, an important treatise on Ayurveda depicts Shigru flowers (*Moringa* flowers) as Drusti Pathya meaning wholesome food for eyes.<sup>5</sup> Anwar *et al* made a concise presentation of common medicinal uses of different parts of *Moringa oleifera* with an impressive list assigned to flower alone that include its high medicinal value as a stimulant, aphrodisiac, abortifacient and cholagogue. This study starts with a short description on morphology and anatomy of the flowers, major phytochemicals present, and compounds identified and isolated. Bioassays of flowers conducted in different extracts are then presented in a tabular form so as to make an easy assessment on the pharmacognostical prospects of the flower.

Review was prepared based on a detailed search on google scholar for *Moringa oleifera* related reports. Reports were sorted based on the bioassays performed. Those activities are tabulated against solvents used in the extraction of phytochemicals from flowers. A grading pattern is adopted for comparing efficiency of these extracts in eliciting bioactivities. Abbreviations

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H, M, L and N were used for noting the High, Medium, Low and Nil activity of extracts. These comparisons are true on results obtained from a single assay, but not necessarily between different assays. Nevertheless they are helpful in understanding the efficiency of solvents in eliciting a particular bioactivity.

## THE MORINGA FLOWER

### *Morphology and anatomy*

Flowers are fragrant yellowish white, bisexual born in 10 to 25 cm long axillary, compound inflorescence called panicles. Individual flowers slightly zygomorphic have dimensions of about 1 cm length by 2 cm breadth set in a basal cup of thalamus namely hypanthium. Sepals and petals are five in numbers, free, unequal, reflexed and spatulate. Stamens five, dorsifixed filaments of different lengths with posterior ones longest with yellow one celled anthers bending downwards There are five staminodes alternating with the stamens forming an outer whorl. The gynoecium is tricarpeal syncarpous borne on a small gynophore. The ovary continues into a long style which protrude out of anthers and end in creamy white and pitted stigma. Reports suggest a pollen presentation mechanism for behind the overall logistics<sup>6-9</sup> There are two peaks of flowering October-November rainy season and April-May summer season.<sup>10</sup>

### *Phytochemistry*

Proximate analysis found that percentage of dry weight of proteins in flowers is 18.92, ash 9.68, lipids 2.91, dietary fibre 32.45 and non structural carbohydrate 36.04 which suggest a comparable nutritional profile for leaves and flowers.<sup>11</sup> Total Antioxidant Content of flower is also found higher than other plant parts.<sup>12</sup> Flower contains all the 20 amino acids and the percentage of essential to nonessential amino acids is almost equal.<sup>13</sup> The vitamin C content in flowers was found to be in highest 77.502 to 224.672 mg/100 g when compared to other parts.<sup>14</sup> A number of qualitative analysis of various flower extracts confirmed the presence of saponins, tannins, alkaloids, flavonoids, steroids, glycosides, terpenoids and phenols etc though there are some slight differences in reports, most probably arising out of protocols followed for sample preparation and extraction.<sup>15-21</sup> Most of them air dried fresh flowers, powdered and macerated with occasional soxhlation and employed distilled water, methanol, acetone, ethyl acetate, chloroform or hexane etc for extraction. The yield for various solvents is found to be in the order of Aqueous> Methanol> Ethanol> Acetone> Ethyl acetate> Hexane. Preferred solvent is methanol as it found to contain the most bioactive fractions. Generally the phytochemical composition depends on the geographical location and age of the plant and extraction protocols.<sup>3</sup>

### Major compounds identified

Modern analytical tools were employed to profile the phytochemical composition of Moringa flowers. Gas Chromatography Mass spectrometry (GCMS) done on methanol extract of flowers identified 26 compounds in which ethyl oleate, quinic acid and cis -9- hexadecenal are the major constituents with reported anticancer, anti inflammatory, antioxidant properties.<sup>22</sup> Simultaneous distillation-extraction and capillary gas chromatography/mass spectrometry of flower volatile compounds identified Seventy-four molecules in which the major compounds are (E)-nerolidol (13.33%)  $\alpha$ -terpineol (7.8%) and benzyl isothiocyanate (6.4%).<sup>23</sup> When freeze-dried samples were used for extraction and analysis by HPLC-DAD-electrospray mass spectrometry showed presence of 22 compounds that include Glucosinolates such as benzyl glucosinolate, 4-hydroxybenzyl glucosinolate, 4-O-( $\alpha$ -L-rhamnopyranosyloxy)-benzyl glucosinolate, 4-O-( $\alpha$ -L-acetyl rhamnopyranosyloxy)-benzyl glucosinolate; phenolics such as 5-Caffeoylquinic acid, 3-Caffeoylquinic acid; flavonoids such as Quercetin 3-O-rutinoside, Quercetin 3-O-glucoside, Quercetin 3-O-(6''-malonyl glucoside) Kaempferol 3-O-glucoside, Kaempferol

3-O-rutinoside, Kaempferol 3-O-(6''-malonyl glucoside) and Isorhamnetin 3-O-(6-malonyl glucoside).<sup>24</sup> When hydroethanolic crude flower extracts is subjected to HPLC- DAD-ESI MS/MS analysis the list of tentative compounds include Quinic acid, 4-p coumaroylquinic acid, Quercetin 3 O acetyl glucoside, Kaempferol-3-O acetyl hexoside, Octadecenoic acid, Heneicosanoic acid, Behenic ( docosanoic) acid.<sup>25</sup> Presence of a proteinaceous Trypsin inhibitor or MoFTI in aqueous flower preparations was reported.<sup>21</sup> Backed by this impressive biochemical profile, attempts begin to isolate purify and characterize these compounds but so far the list include only a few -rhamnetin 3-O-(2''-galloyl)- $\beta$ -D-galactopyranosyl-4'- $\beta$ -D-xylopyranoside,<sup>26</sup> Kaempferol-7-O- $\beta$ -D-alloside,<sup>27</sup> quercetin 3-O- $\alpha$ -L rhamnosyl (1 $\rightarrow$ 6)  $\beta$  D-glucoside,<sup>28</sup> and a proteinaceous MoFTI.<sup>29</sup> On the other hand crude flower extracts has been put into all sort of pharmacognostical studies with several promising outcomes in the way. The scope of such studies can be easily accessed from the Table 1.

### *Pharmacognostical studies*

Most of pharmacognostical studies on Moringa flowers are reported recently. These studies are summarized in the Table 1 in which bioassays performed, solvent extracts employed, results obtained and significance of each study are shown. To compare the efficiency of extract in eliciting a particular bioactivity, four abbreviations 'H', 'M', 'L' and 'N' are used where H stands for high activity, M for medium, L for low and N for nil activity. The numbers accompanying each of this letters denote the corresponding reference.

## DISCUSSION

It is evident that Moringa flower is under extensive phytochemical and pharmacological studies for the last couple of years. There are several studies supporting the therapeutic potential of moringa flower. They employed different extracts and covered diverse assays such as antibacterial, antifungal, anti protozoan, larvicidal, antioxidant, anti inflammatory, hepatoprotective, anticancer, osteo protective, uterotonic, antisickling, biofortification, bioremediation and nanoparticle synthesising properties. To make comparison of solvent efficiency easier, abbreviations H, M L and N were used, corresponding to the high, medium, low and nil activities. Within a report these comparisons are true and indicate their relative efficiency but not necessarily for different reports. Antibacterial studies against of 15 species by either disc or agar well diffusion found methanol and ethanol extracts producing high inhibition zones. Dichloromethane a non polar solvent is also reported to possess antibacterial activity. Antifungal properties were reported for chloroform extracts while ethyl acetate extract is active against protozoan *Leishmania donovani*. Mosquito larvicidal activity of flower extract is studied elaborately and a proteinaceous Trypsin inhibitor Factor isolated from flower is held responsible for the property. Interestingly larvicidal effect is noted for methanol and ethyl acetate extract too. There are several notable studies on the antioxidant properties of aqueous, methanol, ethanol and acetone extracts of flower. Antioxidant assays such as DPPH, FRAP and TEAC proved that flower has highest total antioxidant content than other plant parts. Though anti inflammatory studies were few, positive results were observed for several parameters such as activation of anti inflammatory mediators and suppression of pro inflammatory mediators. Hepato protective nature of flower extract is essentially an extension of its anti inflammatory and antioxidant potential and they produced good results *in vivo* with mice models. Bone protective potential of the methanol and ethanol extracts tested osteoblast stimulating potential and overall effect is promising. Uterotonic and anti sickling potential of flower yielded positive results Non-traditional application of flower extracts especially in dairying, bioremediation, biofortification and nanoparticle synthesis

**Table 1a: Bioassays on Moringa flower extracts**

No	Bioactivity	Test cell /organism/ materials	Parameters tested	Activity of extracts										Comments			
				AQ	EH	MH	AC	EA	CL	DM	PE	PR					
1	Antibacterial	E. coli	Zone of Inhibition (Disc diffusion / Agar well diffusion)	N <sup>30</sup>	H <sup>30</sup> L <sup>31</sup>	H <sup>30</sup> , H <sup>16</sup>							N <sup>30</sup>		Flower has antibacterial properties. Detailed studies are required to identify the compounds involved and elucidate the mechanism of action		
		S. aureus		M <sup>30</sup>	H <sup>30</sup> L <sup>31</sup>	H <sup>30</sup> M <sup>32</sup>	M <sup>32</sup>							N <sup>30</sup>			
		B. subtilis			M <sup>31</sup>	H <sup>16</sup>											
		P. aeruginosa				M <sup>16</sup>											
		P. vulgaris				M <sup>16</sup>											
		K. pneumoniae															
		A. hydrophila		M <sup>33</sup>	M <sup>33</sup>												
		M. luteus		M <sup>33</sup>	H <sup>33</sup>	M <sup>33</sup>											
		S. epidermidis				M <sup>32</sup>	M <sup>32</sup>										
		G. vaginalis				M <sup>32</sup>	M <sup>32</sup>	H <sup>32</sup>									
		E. faecalis				H <sup>32</sup>	H <sup>32</sup>	M <sup>32</sup>									
S. agalactiae			M <sup>32</sup>	M <sup>32</sup>	M <sup>32</sup>												
P. acnes			M <sup>32</sup>	M <sup>32</sup>	M <sup>32</sup>												
C. macbinleys			H <sup>32</sup>	H <sup>32</sup>	M <sup>32</sup>												
B. cereus			H <sup>32</sup>	H <sup>32</sup>	M <sup>32</sup>												
2	Anti protozoan	Leishmania donovani	growth inhibition												Highly promising activity but need more studies		
				L <sup>34</sup>													
3	Antifungal	Candida spp Hortaea werneckii	lowest MIC in broth microdilution		M <sup>35</sup>										Suggest further studies		
				L <sup>34</sup>	M <sup>35</sup>												
4	Wormicidal	Schistosoma mansoni	Mortality	N <sup>15</sup>											No activity		
5	Insecticidal	Bruchid beetles	inhibition of egg laying inhibition of egg hatching adult mortality		H <sup>36</sup>										Scope for detailed studies		
					H <sup>36</sup>												

Table 1b: Bioassays on Moringa flower extracts

No	Bioactivity	Test cell /organism/materials	Parameters tested	Activity of extracts								Comments			
				AQ	EH	MH	AC	EA	CL	DM	PE		PR		
6	Anti larval	Aedes aegypti	Larval mortality	M <sup>37</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	H <sup>29</sup>	MoFTI has been identified as the larvicidal principle. It is a trypsin inhibitor. Several parameters are under study.		
		C. quinquefasciatus		L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>	L <sup>38</sup>			
		Anopheles gambiae		M <sup>38</sup>	M <sup>38</sup>	M <sup>38</sup>	M <sup>38</sup>	M <sup>38</sup>	M <sup>38</sup>	M <sup>38</sup>	M <sup>38</sup>	M <sup>38</sup>		H <sup>38</sup>	
		Anopheles stephansi		M <sup>39</sup>	M <sup>39</sup>	M <sup>39</sup>	M <sup>39</sup>	M <sup>39</sup>	M <sup>39</sup>	M <sup>39</sup>	M <sup>39</sup>	M <sup>39</sup>		H <sup>29</sup>	
7	Mollusci-cidal	Biomphalaria glabrata	Larval trypsin inhibition	H <sup>37</sup>									Need further studies		
				H <sup>29</sup>											N <sup>29</sup>
8	Uterotonic	Buffalo myometrium	Pupicidal activity	N <sup>29</sup>									do		
				H <sup>15</sup>											
9	Anticancer	PC3 cell lines	Delay embryo development adult mortality	H <sup>15</sup>									Studies are few but promising		
				H <sup>40</sup>											
10	Antioxidant	DPPH free radicals	Scavenging										Highly investigated area. High amount of phenolics in various extracts and synergism suggested for antioxidant activity. Recommend flower as a valuable nutraceutical		
				H <sup>43</sup>	H <sup>44</sup>	H <sup>45</sup>	M <sup>45</sup> L <sup>45</sup>								
				H <sup>12</sup>	H <sup>46</sup>	M <sup>46</sup>									
				M <sup>44</sup>	H <sup>33</sup>	M <sup>45</sup>									
		Hydrogen peroxide radicals	Scavenging	H <sup>43</sup>											
				M <sup>45</sup>											
		Ferric ion (FRAP)	Reduction power	M <sup>45</sup>											
				M <sup>44</sup>											
		ABTS cation sol. Hydroxyl radicals H <sub>2</sub> O <sub>2</sub> damaged RBC Bipyridyl assay	Scavenging(Trolox equivalent) Scavenging Anti heamolysis Metal chelating	L <sup>33</sup>											
				H <sup>12</sup>	M <sup>46</sup>	H <sup>12</sup>								L <sup>12</sup>	
	M <sup>46</sup>			H <sup>46</sup>											
	M <sup>46</sup>			H <sup>46</sup>											

Table 1c: Bioassays on Moringa Flower Extracts

No	Bioactivity	Test cell /organism/ materials	Parameters tested	Activity of extracts								Comments		
				AQ	EH	MH	AC	EA	CL	DM	PE		PR	
11	Anti infla-mmatory	RAW264.7 macrophages	Inhibition of IFM mediators		H <sup>25</sup>								Involvement of NF- $\kappa$ B pathway confirmed, but what are the compounds involved?	
			Inhibition of proIFM cytokines		H <sup>25</sup>									
			Increasing antiIFM cytokines		H <sup>25</sup>									
			Protein denaturation		H <sup>47</sup>									
12	Hepato protective	Albino male rat	Inhibition of hindpaw edema	L <sup>49</sup>									Several experiments support hepatoprotective potential	
			reduction of liver tissue oxidative damage markers	H <sup>50</sup>	H <sup>44</sup> H <sup>51</sup> H <sup>52</sup> H <sup>50</sup>		H <sup>53</sup>							
13	Antiulcer	Aspirin ulcers in rats	decrease in ulcer index			L <sup>54</sup>							Many studies support osteo-protective potential of the flower	
14	Osteo protective	Arthritic Wistar rats	lowering of arthritic index		H <sup>55</sup>									
		SaOS2	Osteoblastogenic potential			H <sup>56</sup>								
		(STZ-OVX) rats.	reduction in osteoclastic bone markers and glucose			H <sup>57</sup>								
15	Antisickling	Deoxygenated RBC	in viro antisickling	H <sup>58</sup>		M <sup>58</sup>						Need further studies		
16	Bioremediation	Hexavalent chromium	reduction to trivalent chromium	H <sup>59</sup>										
17	Bio fortification	Fermented maize and millet blend	improvement in protein content	H <sup>60</sup>									Authors found novel applications for flower extracts	
			sensory improvement	H <sup>60</sup>										
18	Dairying	Azocaeasin & skim milk	Caseinolytic & milk clotting activity									H <sup>61</sup>		
19	Nanoparticle synthesis	1 M chloroauric acid [bmim] [BF4] fluid	Gold nanoparticle synthesis	H <sup>62</sup>										
			Hydroxyapatite nanoplates	H <sup>63</sup>										

were also attempted successfully. But we need more studies to arrive at a general conclusion on any such properties of the flower.

Table 1 shows that majority of the studies especially antimicrobial, antioxidant, anti-inflammatory assays came up with awesome results indicating the huge therapeutic potential *M. oleifera* flower, but these studies still remain in the preliminary stage of investigations. It is can be conclusively said that most of the biologically active secondary metabolites responsible for above said properties can be extracted with polar solvents such as methanol ethanol or acetone. Though there are slight discrepancies between reports on the potentiality of different extracts, it may be due to unavoidable variations in protocol followed for sample collection and preparation. There is huge gap in the number of biologically active phytochemicals identified v/s isolated. In fact all reports suggest further investigations to elaborate up on the bioactivity of the extracts as well as to identify any 'ace compound' in them. Consider the antioxidant, anti-inflammatory and hepatoprotective studies in which the same extract give positive results for several related assays. A detailed study well done on the anti-inflammatory potential of ethanol extract demonstrates multiple actions such as the Inhibition of NO and pro-inflammatory interleukins ( IL-6, IL-1  $\beta$ , TNF-  $\alpha$ , and PGE2) and at the same time helping formation of anti-inflammatory IL-10 and I $\kappa$ B- $\alpha$  expressions-all these acting in unison to ameliorate inflammatory damage via NF- $\kappa$ B pathway in macrophages. Here the authors are yet to specify any compound for this pharmacological effect. In the anticancer study, *in silico* investigation predicted ligand binding of several compounds such as Quinic acid, alpha-Tocopherol-beta-D-mannoside, (4-Hydroxyphenyl) acetonitrile, Ethyl Oleatemade from GC MS analysis of methanol flower extract, more effectively to different drug targets than control drugs in PC3 cell lines. Incorporating such novel assays will lend more light on the specific action of novel phytochemicals. Similarly their synergism in effecting a desirable outcome is also a good possibility and the probable reason behind many of the traditional therapeutic uses. Elucidating these synergistic pathways or tracing the ace compound is a huge challenge for researchers but worth the time and energy as it will lay a strong foundation for evidence based application of traditional medicine systems and development of numerous potential plant extracts into novel drugs.

## CONCLUSION

Flowers of *Moringa oleifera*, hitherto unexplored part of otherwise hugely investigated *Moringa oleifera* plant is a storehouse of valuable bioactive phytochemicals. Preliminary investigations into the antibacterial, antifungal, antiviral, antioxidant anti-inflammatory and anticancer investigations of various solvent extracts are highly promising. There is scope for detailed studies to elucidate the mechanism behind this high therapeutic potential of Moringa flower as well as to isolate purify and characterize the bioactive phytochemicals.

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## CONFLICT OF INTEREST

The author have no conflict of interest.

## ABBREVIATIONS USED

**AQ:** Aqueous; **EH:** Ethanol; **MH:** Methanol; **AC:** Acetone; **EA:** Ethyl acetate; **CL:** Chloroform; **DM:** Dichloromethane; **PE:** Petroleum ether; **PR:** Protein; **H:** Activity high; **M:** Medium; **L:** Low; **N-nil:** Blank cells-No reports found.

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