In vitro & Ex vivo Acetylcholinesterase Inhibitory Activity of Morinda citrifolia Linn (Noni) Fruit Extract

Srikanth Jeyabalan1*, Kavimani Subramanian2, Uma Maheswara Reddy Cheekala3, Chitra Krishnan4

ABSTRACT
Background: Psychological problem is a key medical issue for numerous neuropsychiatric and neurodegenerative diseases, for example, schizophrenia, Alzheimer’s, dementia, seizure and Parkinsonism. Morinda citrifolia (Noni) has been utilized for a considerable length of time to cure or counteract assortment of diseases by conventional therapeutic professionals in Hawaii and Polynesia. Objective: The present study is focused to identify the neuroprotective activity of Morinda citrifolia fruit extract (MCFE) on in vitro and ex vivo animal model by inhibition of acetylcholinesterase (AChE), an enzyme target used for the treatment of Alzheimer’s disease. Methods: Acetylcholinesterase inhibition assay was performed in in vitro & ex vivo methods as described by Elman et al. In vitro antioxidant assay of the extract was performed by DPPH free radical scavenging activity & nitric oxide scavenging activity. Statistical analysis used: Statistical analysis was carried out using non linear regression analysis for plotting the line of best fit for the observed values using GraphPad Prism software. Results: By performing in vitro antioxidant assay the IC50 value of the standard quercetin was found to be 46.22 µg/ml as compared to the MCFE which has an IC50 value of 43.14 µg/ml for DPPH free radical scavenging activity. Similarly the IC50 value of the standard ascorbic acid was found to be 81.85 µg/ml as compared to the MCFE which has an IC50 value of 148.0 µg/ml for nitric oxide scavenging activity. Acetylcholinesterase inhibition assay was performed by in vitro method and the IC50 value of MCFE and neostigmine was found to be 31.84 µg/ml & 19.71 µg/ml respectively. Conclusions: The present study investigated the neuroprotective activity of MCFE and it was identified by both in vitro and ex vivo techniques that the phytoconstituents in the plant can improve the learning and memory function by inhibiting the acetylcholinesterase.

Key words: Morinda citrifolia, Noni, Acetylcholinesterase, Neuroprotective activity, in vitro, ex vivo.

Key Messages: The present study investigated the neuroprotective activity of Morinda citrifolia and it was identified by both in vitro and ex vivo techniques that the phytoconstituents in the plant can improve the learning and memory function by inhibiting the acetylcholinesterase. Further the antioxidant potential of the plant was also evident from the DPPH and nitric oxide scavenging activity. Future studies may be designed for chronic administration of Morinda citrifolia to further investigate the effect on in vivo experimentation and also to identify the safety and efficacy parameters at both preclinical and clinical stages.

INTRODUCTION
Psychological problem is a key medical issue for numerous neuropsychiatric and neurodegenerative disorders like schizophrenia, Alzheimer’s, dementia, seizure and Parkinsonism. Cholinergic framework is considered as one of the key part in the control of learning and memory functions. Cholinesterase inhibitors increase the cholinergic transmission specifically by preventing acetylcholinesterase (AChE) which hydrolyses acetylcholine.1 Incredible significance has been given for the identification of neurotransmitter component concerned in the characteristic indication of neurological and psychiatric disorders.2 Acetylcholinesterase has been ended up being the most conceivable remedial focus for the indicative management of Alzheimer’s disease. Acetylcholinesterase is a constituent of the α/β hydrolase protein super family, playing a significant role in acetylcholine-interceded neurotransmission. Lately, the part of AChE inhibitors was reassessed from neurotoxins to neuron-defensive in the disorders with disruption in cholinergic transmission.3

Besides, research in animal models has demonstrated that the combination therapy with memantine and the AChE inhibitors can enhance memory than either treatment alone with the single drug. In the clinical setting, blend treatment

with memantine and an AChE inhibitor has proved to be an appreciated progress for the treatment of patients with Alzheimer’s disease. Mankind is gifted with plenty of plant-based natural sources of drugs. The various collections of bioactive nutrients available in these natural food plays an essential function in avoidance and healing of various neurodegenerative diseases, such as Alzheimer’s, Parkinsonism, and other neuronal disorders. Aggregated confirmation recommends that the phytoconstituents, for example, polyphenolic cell reinforcements found in natural products, vegetables, herbs, and nuts, may conceivably frustrate neurodegeneration, and improve memory and intellectual capacity.

Phytochemicals from medicinal plants assume a fundamental part in maintaining the mental balance regulated by the function of receptors for the major inhibitory neurotransmitters. As per study, the natural pharmaceuticals utilized as a part of Ayurvedic and Chinese medicines contain various phytoconstituents with neuroprotective impact which may be helpful in neuropsychiatric and neurodegenerative disorders.

Morinda citrifolia Linn belongs to the family Rubiaceae and habituated to Sub-himalayan tracts, Darjeeling, Konkan and Andamans. The Indian Mulberry is commonly known as ashuya, akshi & atchy in Ayurveda & nunaa, togaru in Siddha. Morinda citrifolia (Noni) has been utilized for a considerable length of time to cure or counteract assortment of diseases by conventional therapeutic professionals in Hawaii and Polynesia.

A complete review on Morinda citrifolia was performed by Assi et al in 2016 which described the antimicrobial and antiseptic activity, antifungal activity, antioxidant activity, anti-inflammatory activity, anti-arthritis activity, anti-cancer activity, anti-diabetic activity, wound healing activity, memory enhancing activity, anti-inflammatory activity, analgesic activity, gastric ulcer healing activity, anti-uric acid activity, gastric ulcer healing activity, anti-inflammatory activity, anti-viral activity, anti-parasitic activity, anti-tuberculosis activity, osteoporotic and otoscopic enhancer. These activities were carried out to the extent of in-vitro, in-vivo & clinical trial stages.

The neuroprotective effect of an ethyl acetate fruit extract of Morinda citrifolia (Rubiaceae) Linn at doses of 200 and 400 mg/kg, po was contemplated by Muralidharan et al. Past study by Pachauri et al. was intended to examine impact of Noni on memory, cerebral blood flow(CBF), oxidative stress and AChE action in scopolamine incited amnesia mice model. Harada et al. inspected the impact of the juice of Morinda citrifolia (Noni juice) on the brain damage brought about by ischemic stress in mice. In our past study we reported the antiplatelet activity of Morinda citrifolia Linn fruit extract against seizures instigated by Maximal Electro Shock (MES) technique in rats.

Köktürk et al assessed the neuroprotective impacts of Morinda citrifolia L. (Rubiaceae), regularly known as Noni, and memantine on hydrocephalus-actuated neurodegenerative disorders. Pandy et al showed the antilodopaminergic impact of Morinda citrifolia Linn. The discoveries by Muto et al recommended that the association of Noni fruit juice shields brain from stress-instigated impeding of psychological capacity and that this defensive impact might be identified with change in stress-initiated diminishes in vein thickness in the hippocampal dentate gyrus.

Harada et al recommended that Noni juice could encourage insulin discharge after ischemic stress and may reduce the advancement of glucose intolerance. These components may add to the neuronal defensive impact of Noni juice against ischemic stress. Pachauri et al proposed the useful impacts of Noni organic product against streptozotocin-induced memory weakness, which might be ascribed to enhanced mind vitality system, cholinergic neurotransmission and antioxidative activity. One of the previous study reported in silico acetylcholinesterase inhibitory activity of Morinda citrifolia. The present study is focused to identify the neuroprotective activity of MCFE on in vitro and ex vivo animal models by inhibition of acetylcholinesterase, an enzyme target used for the management of Alzheimer’s disease.

**SUBJECTS AND METHODS**

Chemicals

1,1 Diphenyl –2-picryl hydrazyl hydrate (DPPH), was obtained from Himedia, Mumbai, quercetin, ascobic acid, was obtained from SRL, Mumbai, trichloroacetic acid, Acetylthiocholine iodate, 5,5 - Dithiobis [2-nitrobenzoic acid], sodium nitroprusside, Griess reagent, Bovine serum albumin, Folin catechaeu reagent were purchased from SD Fine Ltd, Mumbai. All other chemicals used in the study was procured from local suppliers and of analytical grade.

Plant Extract

The full spectrum standardized extract of Morinda citrifolia fruit was obtained from Amsgar Goa Pvt Ltd, Goa. The plant was authenticated by Dr Laxmi Morajkar, Head Ayurveda Division (Voucher specimen Number: AGPL/039/13-14). Morinda citrifolia fruits were shade dried and kept in an air tight container. Extraction was carried out with water and ethanol in a ratio of 80:20 by a simple maceration technique. The hydro alcoholic solvent of 1 liter was added to the shade dried plant powder of 100 g and placed on a mechanical shaker for a period of 4 hours. Then the solution was filtered through Whatman No.1 filter paper. The filtrate concentrated using flash evaporator and further processed to dryness in vacuum desiccators. 4.5 g was the percentage yield of the hydroalcholic extract of Morinda citrifolia.

**Animals**

The ex-vivo study was performed using Swiss albino mice of 20-25 g. The Swiss albino inbred colonies of mice was purchased from Venkateshwara enterprises, Bangalore. The mice were adjusted and assimilated to controlled laboratory condition of Center of Toxicology and Developmental Research (CEPT) with temperature (23±2°C), humidity (50±5%) and 12 h light dark cycles. The experimental animals were randomized in to control and treatment groups and were placed in a sanitized polypropylene cages containing sterile paddy husk as bedding. The animals were freely accessed to standard pellets and water ad libitum. All the studies conducted were approved by the Institutional Ethical Committee, Sri Ramachandra University, Chennai, (IAEC/XLIII/SRU/424/2015).

**In vitro antioxidant activity**

DPPH radical scavenging assay

The free radical scavenging activity of the plant extracts was examined by the tactic given by Yohozowa et al using staining of ethanolic solution of 1, 1-diphenyl-2-picrylhydrazyl radical (DPPH). Quercetin was used as a positive control and the ethanolic solution of DPPH was used as a control. The reaction mixture containing 1.9 ml of freshly prepared DPPH (200µM in ethanol) with various concentrations of the sample MCFE (25-800 µg/ml) was shaken. Discolorations were measured at 517 nm by using UV Spectrophotometer after incubation of mixture for 20 min at room temperature. The level of discoloration indicates the free radical scavenging effectiveness of the substances. The Percentage of DPPH free radical scavenging activity was calculated by the following formula:

\[
\text{Percentage DPPH inhibition} (%) = \left( \frac{(A_{\text{blank}} - A_{\text{sample}})}{(A_{\text{blank}} - A_{\text{control}})} \right) \times 100
\]

Where A_{blank}, A_{sample}, and A_{control} are the absorbance of blank, sample and control, respectively. The half maximal inhibitory concentration (IC_{50}) was calculated from the Prism (GraphPad 5.0, Dose-response - Inhibition) curve obtained by plotting the percentage inhibition against the log concentration.
Nitric oxide radical scavenging assay

The sample MCFE (25-800 mg/ml) with nitric oxide was determined by the nitrite detection method described by Alderton et al. The nitric oxide was generated from 100 nM sodium nitroprusside in 10 mM phosphate buffer (pH 7.4) and measured by Griess reaction. The reaction mixture containing 10 mM sodium nitroprusside in phosphate buffer. Griess reagent was added to the aliquot to homogenize after the incubation at 37°C for 4 hours. The amount of nitrite formed was measured at 546 nm and referred to the absorbance of standard nitrates. The mixture without the sample extract was used as control and compared with that of the Ascorbic acid as standard.

The Percentage of Nitric oxide free radical scavenging activity was calculated by the following formula:

\[
\text{Percentage Nitric oxide free radical inhibition (\%) = \frac{(A_{\text{blank}} - A_{\text{sample}})}{(A_{\text{blank}} - A_{\text{control}})} \times 100
\]

Where \( A_{\text{blank}} \), \( A_{\text{sample}} \) and \( A_{\text{control}} \) are the absorbance of blank, sample and control, respectively. The half maximal inhibitory concentration (IC\(_{50}\)) was calculated from the Prism (GraphPad 5.0, Dose-response - Inhibition) curve obtained by plotting the percentage inhibition against the log concentration.

Anticholinesterasic activity assays

AChE assay was assessed by using the colorimetric method as explained by Ellman et al, with slight modifications aclimatized for the enzymatic activity in supernatants of mice brain.

**In vitro inhibition of AChE enzyme**

AChE inhibition of MCFE was considered by the proposed method by Ellman et al with slight modifications. AChE activity was evaluated using the Acetylthiocholine iodide as substrate and 5, 5'- Dithiobis [2-nitrobenzoic acid] as a chromogen. The mice brain homogenate was sourced as acetylcholinesterase enzyme. Male mice of Swiss albino strain of about 20g body weight sacrificed by exerting cervical dislocation. The brain was excised immediately and homogenized using 0.1 mM sodium phosphate buffer (pH 7.0) and stored at -80°C till the use. MCFE (50-800 µg/ml) mixed in 2.6ml of 0.1mM sodium phosphate buffer (pH 7.0) and 5 µl of brain homogenate containing crude enzyme. The mixture was incubated for 5 min at 25°C. The reaction was initiated by adding 20 µl of Acetylthiocholine iodide. The inhibition of AChE was measured at 412 nm; the yellow colour formation indicates the hydrolysis of acetylthiocholine into 2-thioglycerol and Ellman's reagent (10 mM DTNB) and Acetylthiocholine iodide (0.8 mM).

The Percentage of inhibition of AChE enzyme was calculated by using the following formula:

\[
\text{Percentage AChE inhibition (\%) = \frac{(A_{\text{blank}} - A_{\text{sample}})/(A_{\text{blank}} - A_{\text{control}}) \times 100}
\]

Where \( A_{\text{blank}}, A_{\text{sample}} \) and \( A_{\text{control}} \) are the absorbance of blank, sample and control, respectively. The half maximal inhibitory concentration (IC\(_{50}\)) was calculated from the Prism (Graph Pad 5.0, Dose-response - Inhibition) curve obtained by plotting the percentage inhibition versus the log concentration.

Statistical analysis

All activities were carried out in triplicate and the data were expressed as mean ± standard error mean (S.E.M.). The inhibitory concentration of free radicals by 50%, (IC\(_{50}\)) was graphically evaluated by a non linear regression method using Graph Pad Prism (Ver. 5.0) software. ANOVA followed by Duncan’s multiple range tests was used to compare the treatments and control groups. Dose response relationship was obtained by linear regression. 95% (p<0.05) confidence level were considered as statistically significant.

**RESULTS & DISCUSSION**

**In vitro antioxidant assay**

The results of the DPPH and nitric oxide free radical scavenging activity were reported in Table 1 and the IC\(_{50}\) values obtained are shown in Figure 1 & 2. It is very clear from the Table that the standard for DPPH free radical scavenging activity quercetin produced maximum percentage inhibition of 88.12±1.04 as compared to that of the MCFE which produced an inhibition of 76.77±1.10. The standard ascorbic acid produced a maximum percentage inhibition of the nitric oxide free radicals of 94.75±0.36 at a dose of 800 µg/ml as compared to that of the MCFE which produced an inhibition of 71.74±0.60. Further all the standards and MCFE produced a dose dependent inhibition of DPPH and nitric oxide free radicals. This is evident from Figure 1 which was used to determine the IC\(_{50}\) value. The IC\(_{50}\) value of quercetin was found to be 46.22 µg/ml as compared to the MCFE which has an IC\(_{50}\) value of 43.14 µg/ml for DPPH free radical scavenging activity [Figure 2]. Similarly the IC\(_{50}\) value of ascorbic acid was found to be 81.85 µg/ml as compared to the MCFE which has an IC\(_{50}\) value of 148.0 µg/ml for nitric oxide scavenging activity.

**In vitro inhibition of AChE enzyme**

The values of in vitro anticholinesterase activity were tabulated in Table 2. The percentage inhibition values of MCFE were found to be in a dose dependent manner as represented in Figure 3. The maximum percentage inhibition was obtained at the dose of 800 µg/ml which produced a maximum inhibition of 76.77±1.10. Similarly the in vitro acetylcholinesterase inhibition assay of standard drug neostigmine was found to produce maximum inhibition of 88.12±1.04 at a dose of 800 µg/ml. The IC\(_{50}\) values of both MCFE and the standard drug were represented in Figure 3. The IC\(_{50}\) value of MCFE and neostigmine was found to be 31.84 µg/ml & 19.71 µg/ml respectively and this is evident from the analysis that
In vitro & ex vivo acetylcholinesterase inhibitory activity of Morinda citrifolia

Table 1: Inhibition profile of activities of fruit extract of Morinda citrifolia against nitric oxide production & DPPH radical scavenging activity as free radical scavengers

<table>
<thead>
<tr>
<th>Treatment groups</th>
<th>Dose (µg/ml)</th>
<th>Nitric oxide production (% inhibition)</th>
<th>DPPH decolouration (% inhibition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morinda citrifolia</td>
<td>25</td>
<td>15.07±0.38</td>
<td>58.85±0.09</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>17.50±2.15</td>
<td>62.51±0.05</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>22.79±1.66</td>
<td>65.34±1.93</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>26.26±1.51</td>
<td>68.65±0.41</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>28.73±1.29</td>
<td>72.84±0.68</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>71.74±0.60</td>
<td>76.77±1.10</td>
</tr>
<tr>
<td>Quercetin</td>
<td>25</td>
<td>-</td>
<td>52.12±0.72</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>-</td>
<td>67.28±0.46</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>-</td>
<td>75.98±0.95</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>-</td>
<td>81.82±1.02</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>-</td>
<td>84.54±1.24</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>-</td>
<td>88.12±1.04</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>25</td>
<td>73.28±0.90</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>89.99±0.36</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>91.01±0.78</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>90.51±2.18*</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>93.50±0.36*</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>94.75±0.36*</td>
<td>-</td>
</tr>
</tbody>
</table>

All assays were performed in triplicate. Enzyme inhibition is expressed as percentage of control. Each value represents mean±S.E.M.

Table 2: In vitro Anticholinesterase activity of Morinda citrifolia

<table>
<thead>
<tr>
<th>Treatment groups</th>
<th>Dose (µg/ml)</th>
<th>AChE inhibition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morinda citrifolia</td>
<td>25</td>
<td>58.85±0.09</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>62.51±0.05</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>65.34±1.93</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>68.65±0.41</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>72.84±0.68</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>76.77±1.10</td>
</tr>
<tr>
<td>Neostigmine</td>
<td>25</td>
<td>52.12±0.72</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>67.28±0.46</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>75.98±0.95</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>81.82±1.02</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>84.54±1.24</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>88.12±1.04</td>
</tr>
</tbody>
</table>

All assays were performed in triplicate. Enzyme inhibition is expressed as percentage of control. Each value represents mean±S.E.M.

Table 3: Effects of chronic administration of Morinda citrifolia (100 and 200 mg/kg p.o.) and neostigmine (0.5 mg/kg i.p.) on AChE activity in mice brain.

<table>
<thead>
<tr>
<th>Treatment groups</th>
<th>Dose (mg/kg)</th>
<th>AChE inhibition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neostigmine</td>
<td>0.5</td>
<td>62.1±2.5*</td>
</tr>
<tr>
<td>Morinda citrifolia</td>
<td>100</td>
<td>37.8±2.1*</td>
</tr>
<tr>
<td></td>
<td>200</td>
<td>46.8±2.9*</td>
</tr>
</tbody>
</table>

All assays were performed in triplicate. Enzyme inhibition is expressed as percentage of control (DMSO-treated mice). Each value represents mean±S.E.M. ANOVA followed by Duncan's test. * P < 0.05; significant from control.

is carried out using non linear regression analysis for plotting the line of best fit for the observed values in the Table 2 using statistical methods.

Ex vivo inhibition of AChE enzyme

The ex vivo AChE inhibition assay was tabulated in Table 3. The standard drug neostigmine showed a percentage inhibition of 62.1±2.5. The MCFE showed a percentage inhibition of 37.8±2.1 & 46.8±2.9 at a dose of 100 & 200 mg/kg respectively and this proved a dose dependent percentage inhibition of acetylcholinesterase activity. Further the data was analysed for significance of P value. The standard drug and MCFE treated group was compared with the control group. All the three treated groups showed a significant value of P < 0.05 as compared to that of control. This indicates that the activity of acetylcholinesterase enzyme has significantly decreased after treatment with the standard drug and MCFE. The present study investigated the neuroprotective activity of Morinda citrifolia and it was identified by both in vitro and ex vivo techniques that the phytoconstituents in the plant has the ability to improve the learning and memory function by inhibiting the acetylcholinesterase. Further the antioxidant potential of the plant was also evident from the DPPH and nitric oxide scavenging activity. Future studies may be designed for chronic administration of Morinda citrifolia to further investigate the effect on in vivo experimentation and also to identify the safety and efficacy parameters at both preclinical and clinical stages.

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In vitro & ex vivo acetylcholinesterase inhibitory activity of Morinda citrifolia fruit juice prevents ischemic neuronal damage through fruit extract.

REFERENCES


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Conflicting Interest (If present, give more details): Nil

ABBREVIATIONS USED

MCFE: Morinda citrifolia fruit extract; AChE: Acetylcholinesterase; IC50: Half maximal inhibitory concentration; DPPH: 1, 1-diphenyl-2-picrylhydrazyl radical; NO: Nitric oxide.
In vitro & ex vivo acetylcholinesterase inhibitory activity of Morinda citrifolia

SUMMARY

- The present study is focused to identify the neuroprotective activity of Morinda citrifolia fruit extract (MCFE) on in vitro and ex vivo animal model by inhibition of acetylcholinesterase (AChE), an enzyme target used for the treatment of Alzheimer’s disease.
- Acetylcholinesterase inhibition assay was performed by in vitro method and the IC$_{50}$ value of MCFE and neostigmine was found to be 31.84 µg/ml & 19.71 µg/ml respectively.
- In ex vivo AChE inhibition assay the standard drug neostigmine showed a percentage inhibition of 62.1±2.5. The MCFE showed a percentage inhibition of 37.8±2.1 & 46.8±2.9 at a dose of 100 & 200 mg/kg body weight of the animal respectively and this proved a dose dependent percentage inhibition of acetylcholinesterase activity.
- The present study investigated the neuroprotective activity of MCFE and it was identified by both in vitro and ex vivo techniques that the phytoconstituents has the ability to improve the learning and memory function by inhibiting the acetylcholinesterase.

ABOUT AUTHORS

At present Mr. J. Srikanth is working as Assistant professor in the Department of Pharmacology, Faculty of Pharmacy, Sri Ramachandra University and has got 8 years of teaching & research experience. He is currently pursuing Ph.D at Sri Ramachandra University. He has been awarded “Career Award for Young Teachers” (CAYT) - 2015 from All India Council for Technical Education (AICTE) for his Ph.D research proposal. He has also received “Growth and Advancement Towards Excellence” (GATE) – 2013 research project grant for young faculty from Sri Ramachandra University. His research area of interest includes Neuropharmacological screening of crude extracts, herbal & polyherbal formulations, In-silico docking analysis, Alternative to animal testing. He is a life member of APTI, LASA & SNCI.