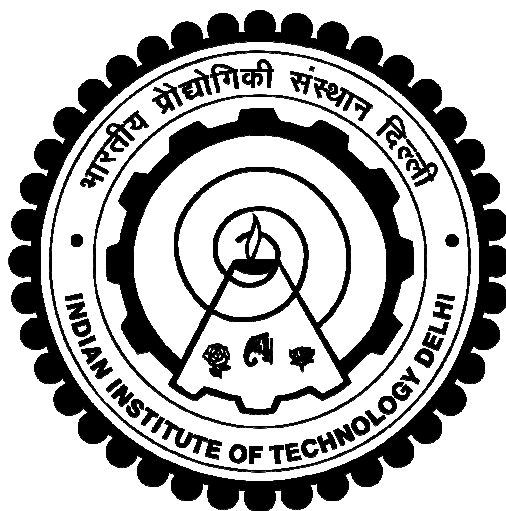


DEVELOPMENT OF BOTANICAL FORMULATIONS FOR INDOOR PEST CONTROL

NITIN CHAUHAN



CENTRE FOR RURAL DEVELOPMENT AND TECHNOLOGY

INDIAN INSTITUTE OF TECHNOLOGY DELHI

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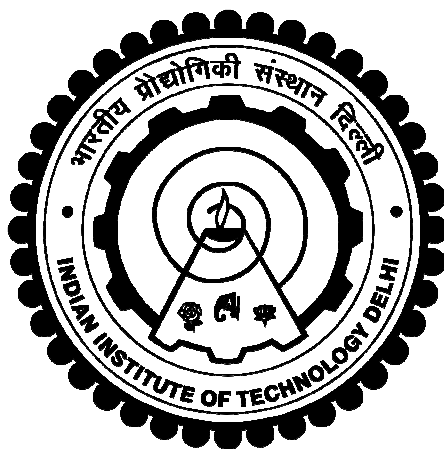
NITIN CHAUHAN

Centre for Rural Development and Technology

Submitted

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CERTIFICATE

This is to certify that the thesis entitled “**DEVELOPMENT OF BOTANICAL FORMULATIONS FOR INDOOR PEST CONTROL**” being submitted by **Mr. Nitin Chauhan** to the Indian Institute of Technology Delhi for the award of “**Doctor of Philosophy**” is a record of bonafide research work carried out by him. He has worked under our guidance and supervision and has fulfilled the requirements for the submission of this thesis. To the best of our knowledge the results contained in this thesis have not been submitted in part or full to any other university or institute for award of any degree or diploma.

(Dr. Anushree Malik)

Professor

Centre for Rural Development and Technology

Indian Institute of Technology Delhi

New Delhi- 110016

(Dr. Satyawati Sharma)

Professor

Centre for Rural Development and Technology

Indian Institute of Technology Delhi

New Delhi- 110016

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Now, this is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning.

Nitin Chauhan

ABSTRACT

Indoor environment is often inhabited by housefly, *Musca domestica* L. (Diptera: Muscidae) and mosquitoes associated with vectoring of various harmful pathogens especially in rural/semi-urban areas. The present study utilized some plant extracts i.e., *Jatropha curcas* (Malpighiales: Euphorbiaceae), *Datura stramonium* (Solanales: Solancea) and essential oils such as *Mentha piperita* (Lamiales: Lamiaceae), *Eucalyptus globulus* (Myrtales: Myrtaceae), *Cymbopogon citratus* (Poaceae: Poales), and *Citrus sinensis* (Myrtales: Myrtaceae) for evaluating the efficacy against housefly (*M. domestica*) and mosquito (*Anopheles stephensi*). The preliminary screening of plant extracts (*J. curcas* and *D. stramonium*) was carried out through larvicidal, pupicidal and adulticidal assays against housefly. The results indicated a superior insecticidal activity of hexane leaf extract of *J. curcas* with LC₅₀ of 0.27, 8.88 and 3.0 mg/cm² against larval, pupal and adult stages of housefly, respectively. The chemical analysis (GC-MS) of *J. curcas* hexane leaf extract revealed the presence of trans-phytol (60 %) and squalene (28 %) as the major components responsible for efficient anti-housefly activity. Further, the aqueous *J. curcas* leaf extract was utilised for the synthesis of silver nanoparticles (Jc-AgNps) which showed significant larvicidal (LC₅₀: 9 mg/ml), pupicidal (LC₅₀: 12.7 mg/ml) and adulticidal (LC₅₀: 17.5 mg/ml) activity against *M. domestica*. The larvicidal assay of Jc-AgNps showed the LC₅₀ of 1.02 ppm against *A. stephensi*. Moreover, the microscopic (SEM, TEM and AFM) and other analytical techniques (Zeta potential, DLS, FTIR, XRD, UV-vis) established the stability and nano size (43 nm) with spherical shape and smooth surface of developed Jc-AgNps.

The efficiency of essential oils and blends was studied using larvicidal and repellency activities against *M. domestica*, and larvicidal assay against *A. stephensi*. *M. piperita* was found to be the most effective larvicidal agent against *M. domestica* and *A. stephensi* with LC₅₀ values of 0.66 µl/cm² and 44.66 ppm, respectively, after 48 h. Addition of mentha oil

to other oils (*C. citratus*, *E. globulosa* and *C. sinensis*) improved their larvicidal activity. The repellency of adult housefly in lab studies showed superior activity of *M. piperita* (RC₉₅: 0.009 $\mu\text{l}/\text{cm}^2$) and (70:30) blend of *M. piperita* + *C. citratus* (RC₉₅: 0.009 $\mu\text{l}/\text{cm}^2$). Incidentally, the selected blend (*M. piperita*+ *C. cymbopogan*; 70:30) of essential oils was more acceptable by the users due to pleasant aroma as compared to a single oil. The GC-MS analysis showed the presence of active components such as menthol and menthone in *M. piperita* oil, whereas *C. citratus* oil was found to contain citral as main component.

On the basis of results obtained from various bioassays and also from user's feedback, different essential oil based formulations (herbal mat, stick or *dhoopbatti*, emulsion and vaporiser) were developed with different usage options suiting the feasibility of the users in both rural and urban/semi urban areas. The products were tested successfully in lab and pilot/semi field levels, with appreciable protection efficacy and time (up-to 4- 8 h). Under semi enclosed set ups (rural kitchens, $\sim 6 \text{ m}^3$), results showed slight variation in repellency for herbal mat ($60 \pm 5 \%$), *dhoopbatti* ($50 \pm 5 \%$), vaporiser ($70 \pm 5 \%$) and O/W emulsion (100 ml: $55 \pm 5 \%$) against adult housefly. On the other hand, the enclosed indoor setup (10 $\times$ 10 ft.) for mosquitoes repellency showed the repellency pattern as, mat: $85 \pm 5 \%$; *dhoopbatti*: $80 \pm 5 \%$; vaporiser: $95 \pm 5 \%$; emulsion: $90 \pm 5 \%$. The economic analysis of developed formulation was also performed in order to visualise the market potential for their commercialisation. Besides, post field testing, people's feedback on performance of products was very encouraging indicating general acceptance for regular use.

सारांश

अन्तर्वासी वातावरण प्रयातः मक्खियों (*Musca domestica* L) एवं मच्छरों के प्रकोप से प्रभावित रहता है। यह घरेलू कीट आमतौर पर ग्रामीण एवं अर्ध-नगरीय क्षेत्रों में विभिन्न प्रकार की बीमारियों के कारक है। प्रस्तुत अध्ययन में विविध वनस्पतिक अवयवों जैसे: *Jatropha curcas* (Malpighiales: Euphorbiaceae), *Datura stramonium* (Solanales: Solancea) एवं सगंध तेल जैसे: *Mentha piperita* (Lamiales: Lamiaceae), *Eucalyptus globulus* (Myrtales: Myrtaceae), *Cymbopogon citratus* (Poacea: Poales), एवं *Citrus sinensis* (Myrtales: Myrtaceae) की कीट विरोधी क्षमता का आकलन किया गया। प्रारम्भिक प्रयोग में *J. curcas* और *D. stramonium* का प्रभाव मक्खियों के विभिन्न अवस्थाओं जैसे: लार्वा, प्युपे एवं एडल्ट पर जांचा गया। परिणामों से सिद्ध हुआ की *J. curcas* की पत्तियों का हेक्सेन उद्धरण अन्य अवयवों में सबसे श्रेष्ठतर है। *J. curcas* का LC₅₀ मान लार्वा, प्युपे एवं एडल्ट पर 0.27, 8.88 एवं 3 mg/ml पाया गया। हेक्सेन उद्धरण के रासायनिक विश्लेषण में transphytol और squalene जैसे घटक अधिक मात्रा में पाए गए जो की मक्खियों के नियंत्रण में लाभकारी है। आगामी अध्ययन में *J. curcas* की पत्तियों को सिल्वर धातु के नैनो कड़ों के निर्माण हेतु उपयोग में लाया गया। परीक्षणों से सिद्ध हुआ की *J. curcas* की पत्तिया बहुत ही कुशलता से सिल्वर धातु के नैनो कड़ों को बना सकती है जो की मक्खियों की विभिन्न अवस्थाओं को सुगमता से नियंत्रित कर सकते है। LC₅₀ मान दर्शाते है की सिल्वर धातु के नैनो कड़ मक्खियों के लार्वा (9 mg/ml), प्युपे (12.7 mg/ml), एडल्ट (17.5 mg/ml) एवम *A. stephensi* के लार्वा (1.02 ppm) को बहुत ही सार्थकता से नियंत्रित कर सकते है। सिल्वर के नैनो कड़ों के सफल परीक्षण के पश्चात, आगे की कार्यवाही में सूक्ष्मदर्शी उपकरण जैसे: SEM, TEM, AFM एवं अन्य विश्लेषणात्मक उपकरण जैसे: Zeta potential, DLS, FTIR, XRD, UV-vis का उपयोग किया गया। परीक्षणों से यह ज्ञात हुआ की सिल्वर धातु के कड़

गोल आकर के साथ-साथ अतिसूक्ष्म (43 nm) स्तर के है। तथ्य यह भी दर्शाते है की विकसित सूक्ष्म (नैनो) कढ़ शिल्लषाभीय (colloidal) अवस्था में स्थायित्व (stable) रहने में पूरी तरह से सक्षम है।

आगामी अन्वेषणो में सगंध तेलों की क्षमता का विश्लेषण किया गया, जिसके अंतर्गत चुने गए तेलों का प्रभाव घरेलू कीटो के विकर्षण एवं विभिन्न अवस्थाओं पर कीटनाशक प्रभाव के रूप में देखा गया। *M. piperita* सगंध तेल, अन्य सभी अमिश्रित एवं संयोजित तेलों की अपेक्षा अधिक दक्ष पाया गया। *M. domestica* एवं *A. stephensi* के लारवे का LC_{50} मान 48 घंटो के उपरान्त, $0.66\mu\text{l}/\text{cm}^2$ और 44.66 ppm पाया गया। आगामी अध्ययन में पाया गया की *M. piperita* का अन्य तेलों के साथ संयोजन उनकी कीटनाशक क्षमता में वृद्धि करने में भी उपयोगी है। विकर्षण परीक्षणों में *M. piperita* (RC_{95} : 0. 009 $\mu\text{l}/\text{cm}^2$) एवं (70:30) *M. piperita*+ *C. citratus* (RC_{95} : 0. 009 $\mu\text{l}/\text{cm}^2$) सगंध तेल अन्य सभी अमिश्रित एवं संयोजित तेलों की अपेक्षा श्रेष्ठ सिद्ध हुऐ। किये गए घरेलु उपयोगो के बाद उपयोगकर्ताओ ने *M. piperita*+*C. citrates* की सुगंध को *M. piperita* से ज्यादा पसंद किया। रासायनिक विश्लेषण में *M. piperita* तेल में menthol एवं menthone जबकि *C. citratus* में citral जैसे घटको की उपस्थिति का स्पष्टीकरण हुआ।

विभिन्न कीट विरोधी परीक्षणो एवं उपयोगकर्ताओं की परेशानियों और उनकी प्रतिक्रियाओं पर सोच विचार कर विविध प्रकार के सूत्रीकरणो की कल्पना एवं उत्थान पर कार्य शुरू किया गया। अनेको प्रयोगात्मक प्रयासों के पश्चात्, घरेलू कीट विरोधी हर्बल उत्पाद जैसे Mat, *Dhoopbatti*, Emulsion एवं Vaporiser की संरचना की गई, जो की ग्रामीण एवं अर्ध-नगरीय क्षेत्रों के उपभोक्ताओं की सहजता और सुगमता पर आधारित थी। विकसित किये गए हर्बल उत्पादो की संरक्षण क्षमता (4 - 6 घंटे) विविध लघु रूपी कक्षों एवं विभिन्न घरेलू क्षेत्रों (ग्रामीण, अर्ध-शहरी, शहरी) में सफलतापूर्वक देखी गई। ग्रामीण रसोई घरो (6 m^3) में मक्खियों पर किये गए परीक्षणों में हर्बल उत्पाद जैसे Mat ($60\pm 5\%$), *Dhoopbatti* ($50\pm 5\%$),

Emulsion (55 ± 5 %) एवं Vaporizer (70 ± 5 %) की उत्तम विकर्षण क्षमता का स्पष्टीकरण हुआ। वहीं दूसरी ओर, मच्छरों पर अन्तर्वासी विकर्षण परीक्षणों में भी Mat (85 ± 5 %), *Dhoopbatti* (80 ± 5 %), Emulsion (95 ± 5 %) एवं Vaporizer (95 ± 5 %) अत्यंत लाभकारी सिद्ध हुए। विकसित उत्पादों के व्यापारीकरण एवं पहले से उपलब्ध उत्पादों से तुलनात्मक अध्ययन के लिए सभी हर्बल उत्पादों का आर्थिक विश्लेषण भी प्रस्तुत अनुसंधान कार्य में किया गया है। विकसित हर्बल उत्पादों की दक्षता, उपभोक्ताओं द्वारा किये गए घरेलू परीक्षण पर प्रतिपुष्टि एवं स्वीकृति अत्यन्त सराहनीय और संतोषजनक पाई गयी।

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