

### **Academic Qualifications**

<i>Ph.D. (Applied Chemistry):</i>	Indian Institute of Technology Delhi (2009 - 2013) 'An Integrated Approach for Mahua Seed Cake Utilization' CGPA: 9.75/10
<i>M.Sc. (Chemistry)</i> :	Indian Institute of Technology Delhi (2007-2009) CGPA: 8.68/10
<i>B.Sc. (H) Chemistry</i> :	St. Stephen's College, Delhi University (2004-2007) 87.48%; Topper

### **Teaching Experience (~6 years)**

July 2017- May 2019:	Assistant Professor ( <i>Adhoc</i> ), St. Stephen's College, DU
Jan 2017 – May 2017:	Assistant Professor ( <i>Guest</i> ), Miranda House, DU
July 2016 – May 2017:	Assistant Professor ( <i>Adhoc</i> ), SGTB Khalsa College, DU
Jan 2016 – May 2016:	Assistant Professor ( <i>Adhoc</i> ), St. Stephen's College, DU
July 2015 – Dec 2015:	Assistant Professor ( <i>Adhoc</i> ), Daulat Ram College, DU
Jan 2014 – May 2015:	Assistant Professor ( <i>Adhoc</i> ), St. Stephen's College, DU
Aug 2013 – Nov 2013:	Assistant Professor ( <i>Guest</i> ), St. Stephen's College, DU
Aug 2013 – Nov 2013:	Assistant Professor ( <i>Guest</i> ), Sri Aurobindo College, DU

### **Academic Awards and Honors**

- **Cumulative Impact Factor of 34.694** for publications published in International journals
- Qualified Joint **CSIR-UGC** examination in chemical sciences and awarded eligibility for Lecturership (**NET**) in 2009
- Recipient of **CSIR Junior (JRF) and Senior (SRF) Research Fellowships**
- **Life Time Member** of Indian Science Congress Association
- **1<sup>st</sup> rank** holder in B.Sc. Chemistry (H) at St. Stephen's College (2004-2007)
- **2<sup>nd</sup> rank holder** in B.Sc. Chemistry (H) at Delhi University (2004-2007)
- Awarded "The **Sumitomo – St. Stephen's College Scholarship for Academic Excellence**" for all three years from 2004-2007
- Awarded "B.R. Katyal Scholarship" for **Best Student in Chemistry Department** at St. Stephen's, DU
- Awarded "**Science Meritorious Award**" from Delhi University for three years (2004-2007)
- **3<sup>rd</sup> rank** holder in M.Sc. Chemistry at **IIT Delhi** (2007-2009)

**Publications** (Cumulative Impact Factor: **34.694**)

1. **Aditi Gupta**, Ashwani Kumar, Satyawati Sharma, **2019**. *Madhuca indica* triterpenoids: isolation, characterization and structural-biological activity relationships. *Under Review*. Scientific Reports. **(Impact Factor 4.122)**
2. Alakesh Bisai, Vishnumaya Bisai, Saina, Shaheeda MK, **Aditi Gupta**, , **2019**. Biosynthetic Relationships and Total Syntheses of Naturally Occurring Benzo[c]phenanthridine Alkaloids. Asian Journal of Organic Chemistry, ISSN: 2193-5815. DOI: <https://doi.org/10.1002/ajoc.201900244>. **(Impact Factor 2.496)**
3. Vishnumaya Bisai, **Aditi Gupta**, Alakesh Bisai, **2018**. Naturally occurring Taiwaniaquinoids: Biosynthetic relationships and synthetic approaches. Arkivoc, ISSN: 1551-7012, vi, 1-28. **(Impact Factor 1.165)**
4. **Aditi Gupta**, Abhishek Sharma, Ritika Pathak, Ashwani Kumar, Satyawati Sharma, **2018**. Solid State Fermentation of Non-Edible Oil Seed Cakes for Production of Proteases and Cellulases and Degradation of Anti-Nutritional Factors. Journal of Food Biotechnology Research, 2, 1:4.
5. **Aditi Gupta**, Satyawati Sharma, Ashwani Kumar, Parvaiz Ahmad, Pravej Alam, **2016**. Enhancing nutritional contents of *Lentinus sajor-caju* using residual biogas slurry waste of detoxified mahua cake mixed with wheat straw. Frontiers in Microbiology, ISSN: 1664-302X, 7, 1529-1541 **(Impact Fact 4.076)**
6. Ashwani Kumar, Joanna Dames, **Aditi Gupta**, Satyawati Sharma, Jack Gilbert, Parvaiz Ahmad, **2014**. Current developments in arbuscular mycorrhizal (AM) fungal research and its role in salinity stress alleviation: A Biotechnological Perspective. Critical Reviews in Biotechnology, ISSN: 0738-8551, 35 (4), 461-474. **(Impact Factor 7.178)**
7. **Aditi Gupta**, Ashwani Kumar, Satyawati Sharma, VK Vijay, **2013**. Comparative Evaluation of Raw and Detoxified Mahua seed cake for Biogas production. Applied Energy, ISSN: 0306-2619, 102, 1514-1521. **(Impact Factor 7.9)**
8. **Aditi Gupta**, Satyawati Sharma, Supradip Saha, Suresh Walia, **2013**. Yield and nutritional content of *Pleurotus sajor caju* on wheat straw supplemented with raw and detoxified mahua cake. Food Chemistry, ISSN: 0308-8146, 141, 4231-4239. **(Impact Factor 4.946)**
9. **Aditi Gupta**, Rohit Chaudhary, Satyawati Sharma, **2012**. Potential Applications of Mahua (*Madhuca indica*) Biomass. Waste and Biomass Valorization, ISSN: 1877-2641, 3, 175– 189. **(Impact Factor 1.874)**
10. **Aditi Gupta**, Satyawati Sharma, SN Naik, **2011**. Biopesticidal value of selected essential oils against pathogenic fungus, termites and nematodes. International Biodeterioration and Biodegradation, ISSN: 0964-8305, 65, 703-707. **(Impact Factor 3.562)**
11. Ritu Gothwal, **Aditi Gupta**, Ashwani Kumar, Satyawati Sharma, BJ Alappat, **2012**. Feasibility of dairy waste water (DWW) and distillery spent wash (DSW) effluents in increasing the yield potential of

*Pleurotus flabellatus* (PF 1832) and *Pleurotus sajor-caju* (PS 1610) on bagasse. 3 Biotech, ISSN: 2190-572X, 2, 249–257. (**Impact Factor 1.497**)

12. Satyawati Sharma, Abhishek Sharma, **Aditi Gupta**, Shivdhar Mishra, Padma Vasudevan, **2012**. Effect of biofertilizers on fodder crops under rain fed conditions in semiarid area. International Journal of Environmental Sciences, ISSN: 0976 – 4402, 1, 87-96.

### **International/National Conferences**

1. **Aditi Gupta, 2019**. Driving Waste Towards Zero: A Holistic Approach for Utilization of Non-edible Oil Seed Cakes, National Seminar on Technology for Environmental Sustainability, Socio-economic Responsibilities and Associated Entrepreneurial Opportunities of 21<sup>st</sup> Century, Sri Aurobindo College, Delhi University, March 8-9, 2019, Oral presentation 38, Pg. 57.
2. **Aditi Gupta**, Satyawati Sharma, **2016**. Bioactivity of *Madhca indica* triterpenoids. Green Chemistry in Environmental Sustainability & Chemical Education (ICGC-2016), Daulat Ram College, Delhi University, India, November 17-18, 2016, Pg. 34.
3. **Aditi Gupta**, Sangeeta Pegu, Satyawati Sharma, B.J. Alappat, **2016**. Residual Biogas Slurry for Mushroom Cultivation: A Step towards Solid Waste Management. **24<sup>th</sup> European Biomass Conference and Exhibition, Amsterdam, The Netherlands, June 6-9, 2016**, 1 BV. 4.84, Page 186.
4. **Aditi Gupta**, Ritika Pathak, Satyawati Sharma, **2016**. Waste Management through Solid State Fermentation. **First Prize** in oral presentation at National Seminar on Emerging Economics and Challenges to Sustainability towards Developing Nations, Sri Aurobindo College, Delhi University, India, March 29-30, 2016, OP 41, Page 48.
5. **Aditi Gupta, 2015**. Solid Waste Management of Non-edible Oil Cakes: A Holistic Approach. **Invited lecture** at National Symposium on Horizons of Light in Molecules, Material and Daily Life, held at department of Chemistry, Dr. H.S. Gour Vishwavidyalaya, Sagar, India, December 18-19, 2015, Pg 61.
6. **Aditi Gupta**, Satyawati Sharma, **2014**. Extraction of Active Components and Potential Applications of Mahua Seed Cake. **101<sup>st</sup> Indian Science Congress, Jammu, India**, February 3-7, 2014, Section XIV: Plant sciences, Page 263.
7. **Aditi Gupta**, Satyawati Sharma, **2013**. An Integrated Approach for *Madhuca indica* (mahua) Seed Cake Utilization. **28<sup>th</sup> International Conference on Solid Waste Technology and Management, Philadelphia, USA**, March 10-13, 2013, Page 3A.

8. **Aditi Gupta**, Rohit Chaudhary, Satyawati Sharma, **2012**. Potential Applications of Mahua (*Madhuca indica*) Biomass. **Second International Conference on Recycling and Reuse of Materials, Kottayam, Kerela**, August 5-7, 2012, 23.
9. **Aditi Gupta**, Satyawati Sharma, VK Vijay, **2011**. Utilization of Non-Traditional Biomass for Biogas Production. **19<sup>th</sup> European Biomass Conference and Exhibition, Berlin, Germany**, June 6-10, 2011, 2088-2094.

### Book Chapters

1. Ashwani Kumar, **Aditi Gupta**, MM Azooz, Satyawati Sharma, Parvaiz Ahmad, Joanna F. Dames, 2013. Genetic Approaches to Improve Salinity Tolerance in Plants. In: Salt Stress in Plants: Signalling, Omics and Adaptations. Editors: Parvaiz Ahmad, MM Azooz, MNV Prasad. **Springer Publication** New York, ISBN: 978-1-4614-6108-1, 63-78.
2. Parvaiz Ahmed, Ashwani Kumar, **Aditi Gupta**, Xan Hu, KR Hakeem, 2012. Polyamines: Role in plants under abiotic stress. In: Crop Production for Agriculture Improvement. Editors: Ashraf et al. **Springer Publication**, Netherlands, ISBN: 978-94-007-4116-4, 491-512.

### Publications: e-learning

Contributed as **co-author** for developing **MOOC's** and **e-content** for Classical Thermodynamics (11 modules), Adsorption (5 Modules) and Forensic Sciences (3 modules) in the e-PG Pathshala Project under UGC under the NMEICT mission of MHRD, Govt. of India, under the auspices of Centre for e-Learning, SGTB Khalsa College, University of Delhi.

### Workshops/Seminars/Conferences attended

1. National Workshop on Voice Culture and Voice Modulation', Guru Angad Dev Teaching Learning Centre of MHRD, SGTB Khalsa College, University of Delhi (March 7, 2019).
2. National Workshop on Molecular Docking, Dynamics & Biologics Discovery', Department of Chemistry, University of Delhi, sponsored by Schrodinger, Bangalore (August 9-10, 2018).
3. National Conference on 'Emerging Trends and Advances in Chemical Sciences', St. Stephen's College, DU (September 25-26, 2018).
4. 'National Conference on Scientific Innovation- A Head Start', St. Stephen's College, DU (April 5-6, 2018).

5. 'National Conference on Chemical Science: Opportunities & Challenges', St. Stephen's College, DU (March 19-20, 2018).
6. Science Conclave: Research on the Frontiers, held at Miranda House, DU (January 10-12, 2018).
7. **Resource Person** at the Support Staff Empowerment Workshop (SSEW-2017) on basic Computer Skills held at St. Stephen's College, DU (November 24, 2017)
8. Workshop on Active Learning as a transformational tool for the University classroom, DS Kothari Centre for Research and Innovation in Science Education, Miranda House, DU (May 15, 2017)
9. National Seminar on e-Learning and MOOCs in Higher Education, SGTB Khalsa College, DU (March 29, 2017)
10. National Seminar on "New Roles of Teachers in technology-driven Higher Education", SGTB Khalsa College, DU, in collaboration with The British Council (March 1, 2017)
11. Indo-UK Scoping Workshop on Development of Rural Biorefineries in India: from Waste to Wealth: Green Chemistry Network Centre, University of Delhi (Feb 20, 2017)
12. Drug Discovery Technology- Computational Approaches in Drug Discovery & Design: Department of Biomedical Sciences in collaboration with Biodiscovery Group, India: SRCASW, DU, (January 12-13, 2017)
13. National Workshop on Subject Specific ICT Skills for Chemistry Educators: GAD TLC, SGTB Khalsa College, DU (January 19, 2016)
14. 'Workshop on Basic ICT skills for educators (e-content development and assessment tools)': GAD TLC, SGTB Khalsa College, DU (August 30-31, 2016)
15. 'Recent Trends in Technical Terminology in Science: Sri Aurobindo College, DU (February 16-17, 2016)
16. 'RSC Workshop on Chemistry for Tomorrow's World: New Delhi (December 2-3, 2015)
17. **Resource Person** in the In-House Skill Development Course on Green Formulation of Cosmetics and Perfumeries: Daulat Ram College, DU (December 14-15, 2015)
18. 'Biogas Slurry Utilization and Biomanure Management': CRDT, IIT Delhi (February 12-13, 2013)

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MS-Office, MS-Windows, BASIC, SPSS software, Sigma Plot, Chem Draw, Chem Sketch, Argus Lab

*Instruments/Techniques:* HPLC, TLC, Column chromatography, UV-Vis Spectrophotometer, Flame Photometer, Techniques for nutrient and fiber analysis, microbial techniques

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# Solid State Fermentation of Non-Edible Oil Seed Cakes for Production of Proteases and Cellulases and Degradation of Anti-Nutritional Factors

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## Abstract

In the present scenario of depleting energy resources and search for eco-friendly and economically viable alternatives, bio-diesel has gained worldwide attention. Non-edible oils over edible oil hold the potential to act as sustainable sources for the production of bio-diesel. Removal of oil left behind a major part of the seed material as seed cake. The latter is generally regarded as waste because of its anti-nutritional content. In the present study, two de-oiled seed cakes, *Madhuca indica* (mahua) and *Jatropha curcas* (jatropha) were used for the growth of *Paecilomyces variotii*, to produce proteases and cellulases, respectively. These enzymes are already known to have considerable industrial importance. At an initial moisture content of 50% and temperature 30°C, maximum protease activity of 52.5 U/g and cellulase activity 27.3 U/g was recorded from *A. niger* and *P. variotii* respectively. HPLC studies showed 67.9-71.5% degradation of saponins, the major anti-nutritional factors present in mahua cake. This study proved beneficial for management of oil seed cakes via solid state fermentation, producing enzymes as value added products.

**Keywords:** Cellulases; Jatropha cake; Mahua cake; Proteases; Saponins

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## Introduction


The world population is increasing at a great pace [1]. Conservation of fossil fuels and utilization of renewable and non-traditional sources of energy have become the prime needs of the hour [2-5]. In order to establish a sustainable future, biofuel production from non-edible oils has gained worldwide consensus [6,7]. Extraction of oil from seeds generates large quantities of seed cake. The presence of several anti-nutritional and toxic components in these de-oiled cakes limits their use as quality fertilizers or animal feeds, rendering most of it as a waste [8,9]. Management and disposal of these cakes therefore becomes a major problem, posing serious environmental threats [10]. However, these cakes are a rich source of nutrients, viz., protein, sugars, etc. [11-15]. Nutrient composition of these cakes makes them noteworthy to be explored for their potential to produce various enzymes, antibiotics, vitamins and antioxidants, etc. possessing wide industrial as well as biotechnological applications [16]. The present paper attempts to address the management of

two de-oiled seed cakes, *Madhuca indica* (mahua) and *Jatropha curcas* (jatropha), via solid state fermentation (SSF), producing proteases and cellulases as value added products.

Mahua and jatropha are tropical plants, belonging to the family Sapotaceae and Euphorbiaceae, respectively. They are extensively cultivated in Asian and Australian continents for their oil bearing seeds. Mahua and jatropha oils have been extensively used for biodiesel production [2]. After the expulsion of oil from its seed, ~60% of the material is left as de-oiled seed cake [8]. These seed cakes are rich in nutrients but contain several anti-nutritional factors, viz., saponins and tannins in mahua cake (MC)

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# Enhancing Nutritional Contents of *Lentinus sajor-caju* Using Residual Biogas Slurry Waste of Detoxified Mahua Cake Mixed with Wheat Straw

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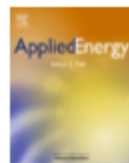
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Residual biogas slurries (BGS) of detoxified mahua cake and cow dung were used as supplements to enhance the yield and nutritional quality of *Lentinus sajor-caju* on wheat straw (WS). Supplementation with 20% BGS gave a maximum yield of 1155 gkg<sup>-1</sup> fruit bodies, furnishing an increase of 95.1% over WS control. Significant increase ( $p \leq 0.05$ ) in protein content (29.6–38.9%), sugars (29.1–32.3%) and minerals (N, P, K, Fe, Zn) was observed in the fruit bodies. Principle component analysis (PCA) was performed to see the pattern of correlation within a set of observed variables and how these different variables varied in different treatments. PC1 and PC2 represented 90% of total variation in the observed variables. Moisture (%), lignin (%), celluloses (%), and C/N ratio were closely correlated in comparison to Fe, N, and saponins. PCA of amino acids revealed that, PC1 and PC2 represented 74% of total variation in the data set. HPLC confirmed the absence of any saponin residues (characteristic toxins of mahua cake) in fruit bodies and mushroom spent. FTIR studies showed significant degradation of celluloses (22.2–32.4%), hemicelluloses (14.1–23.1%) and lignin (27.4–39.23%) in the spent, along with an increase in nutrition content. The study provided a simple, cost effective approach to improve the yield and nutritional quality of *L. sajor-caju* by resourceful utilization of BGS.

**Keywords:** biogas slurry, detoxified mahua cake, *Lentinus sajor-caju*, saponins, wheat straw

## INTRODUCTION

Over the past few years, biogas has become an attractive renewable energy source in many nations across the globe (Chandra et al., 2011; Gupta et al., 2012; Barik and Murugan, 2015). Besides cow dung (CD), the traditional raw material, different kinds of agricultural products, viz., leaf litter, seed cakes, grasses, straw, husk, aquatic plants, biomass residues, etc., alone or in combination with CD, have also been evaluated for their potential to produce biogas (Gupta et al., 2011; Chaikitkaew et al., 2015; Chanakya et al., 2015; Cotana et al., 2015). After the anaerobic digestion process is complete, a large amount of residual biogas slurry (BGS) is obtained, whose management and



# Comparative evaluation of raw and detoxified mahua seed cake for biogas production

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## HIGHLIGHTS

- Mahua seed cake has the potential to produce biogas.
- Simple water treatments significantly removed the toxins from mahua cake.
- 50(Detoxified MC):50(CD) combination was found optimum for maximum biogas production.
- Biogas slurry produced possesses good manurial values.

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## ABSTRACT

Non-edible oils are progressively being utilized for production of bio-diesel around the world which embraces the future assurance towards renewable energy. After the extraction of oil, 50–60% of the material, termed as de-oiled seed cake, goes waste due to the presence of toxins. The present paper evaluates the use of raw and detoxified (water treated; detoxified up to 75%) non-edible oil seed cake, *Madhuca indica*, for biogas production. Different treatments comprising of varying proportions of raw/detoxified mahua seed cake (MC) and cow dung (CD) were designed. Detoxified cake(s) produced significantly better results compared to raw cake. Combination of 50% hot water detoxified MC and 50% CD gave maximum biogas production of 442 L/kg total solids with 58.5–60% methane content. This gave an increase of 125% over CD, along with 33.15% and 34.05% reduction in total solids (TS) and volatile solids (VS), respectively. Significant reduction in celluloses (34.46%) and hemicelluloses (29.76%) and an increase in the nutrients (N,P,K) of the digested slurry were obtained for the same. Anaerobic digestion of mahua cake, detoxified by simple water treatments, offers one of the viable methods for waste to energy generation.

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## 1. Introduction

The growing worldwide concerns over environment, health and monetary aspects have triggered a search for efficient and economic renewable sources of energy production. Agricultural sector holds the potential for development of one of the major sources of renewable energy, i.e. bio-fuels [1,2]. Worldwide, more than 95% of bio-diesel production takes place from edible oils that may result in depletion of food supply leading to economic imbalance [3]. A sustainable solution to overcome this problem might be the use of non-edible oils for bio-fuel production [4]. Non-edible oil seeds are increasingly being cultivated to yield considerable quantity of oil which can be used for the production of bio-diesel [5]. After the expulsion of non-edible oil, approximately 60% is left as toxic de-oiled seed cake [1]. This generates a considerable amount of biomass, which can neither be used as a cattle feed nor as a good

quality fertilizer owing to its toxicity. Various applications are continuously being explored to exploit the nutritive content of these seed cakes [1,5–7]. Oil seed cakes contain high amounts of volatile solids, proteins and starchy material, which make them a suitable feedstock for biogas generation [8,9]. Recently, biogas is becoming an attractive source of energy in many nations across the globe because it can be used to fuel a car or to power a city bus [10]. An integrated anaerobic waste valorization process is also an interesting option for energy generation from non-edible oil seed cakes [11]. Anaerobic digestion and composting of waste seed cake can be considered as a sustainable solution to reduce the volume of waste along with reduction in emission of greenhouse gases into the atmosphere [12]. Chandra et al. [4] recorded average specific methane production potential of oil seed cake of jatropha (394 L/kg total solids) and karanja (427 L/kg total solids), respectively.

*Madhuca indica*, commonly known as mahua, is extensively cultivated in central and southern parts of India for its oil bearing seeds. The annual production of seed in the country is around 0.50 million tons [1,5,6]. After the extraction of oil, much of the

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## Yield and nutritional content of *Pleurotus sajor caju* on wheat straw supplemented with raw and detoxified mahua cake



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### ABSTRACT

The effect of supplementation of wheat straw (WS) with raw/detoxified mahua cake (MC) on yield and nutritional quality of *Pleurotus sajor caju* was studied. Raw cake significantly enhanced the yield compared to control and could be tolerated up to a 10% addition. Detoxification further improved the mushroom yield giving a maximum of 1024.7 g kg<sup>-1</sup> from WS supplemented with 20% saponin free detoxified mahua cake. Chemical analysis of fruit bodies revealed that they are rich in proteins (27.4–34.8%), soluble sugars (28.6–32.2%) and minerals. Glucose, trehalose and glutamic acid, alanine were the major sugars and amino acids detected by HPLC analysis, respectively. HPLC studies further confirmed the absence of saponins (characteristic toxins present in MC) in both fruit bodies and spent. Degradation of complex molecules in spent was monitored via FTIR. The study proved beneficial for effective management of agricultural wastes along with production of nutrient rich and saponin free fruit bodies/spent.

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### 1. Introduction

Bioconversion of agricultural wastes is an economically viable method for eco-friendly disposal, along with proper utilisation for producing value added products. Mushroom cultivation is one such method capable of not only biodegradation and bioremediation of agro-wastes, but also biotransformation into proteinaceous food (Bisaria, Madan, & Bisaria, 1987a). In a nutshell, the purpose is towards ideal utilisation of agro-wastes along with production of nutritious food. Besides their excellent taste, edible mushrooms have a great biotechnological potential, due to their capacity to produce enzymes, medicines, to act in bioremediation and other uses.

*Pleurotus* spp., commonly known as oyster fungus, is the third largest commercially important mushroom species appreciated for its delicious taste, high vitamin, protein, carbohydrate, mineral but low fat content. They are known to degrade large insoluble components of lignocellulosic materials and hence play a significant role in their bioconversion to foods and dietary supplements (Bisaria et al., 1987a). Due to a large variety of non-specific lignocellulosic enzymes produced by them, they can be cultivated on a number of agricultural wastes, besides the traditional rice and wheat straw (WS) substrates (Zhang, Li, & Fadel, 2002). These lignocellulosic materials are generally low in protein content, and therefore it has become a common practise to supplement *Pleuro-*

*tus* substrates with nitrogen/protein rich materials, such as alfalfa meal, soyabean cake, cotton wastes, olive wastes, etc., in order to shorten the crop period and/or enhance the mushroom productivity (Bisaria et al., 1987a; Gothwal, Gupta, Kumar, Sharma, & Alappat, 2012; Kalmis, Azbar, Yildiz, & Kalyoncu, 2008; Mane, Patil, Syed, & Baig, 2007; Rodriguez, Rivas, Polonia, & Wichers, 2010; Zervakis, Yiatras, & Balis, 1996). Naraian, Sahu, Kumar, Garg, Singh and Kanaujia (2009) cultivated *Pleurotus florida* on corn cobs supplemented with nitrogen rich additives, such as soyabean meal, groundnut seed cake and cotton seed cake, and concluded that the latter gave the highest yield. Bano, Shashirekha, and Rajarathnam (1993) observed that supplementation of rice straw with seed cakes of mustard, niger, sunflower, cotton and soyabean increased the yield, protein content and enzymatic activity of the oyster mushroom, *Pleurotus sajor caju*. Shashirekha, Rajarathnam, and Bano (2002) supplemented spent rice straw substrate of *P. sajor caju* with the above mentioned oil seed cakes and concluded that cotton seed powder supplementation significantly enhanced the yield and protein content of the mushrooms. It also reduced the spawn run period and the fruit bodies were free from any gossypol residues. Besides *Pleurotus* spp., other mushroom species have also been cultivated using oil seed cakes (Altieri, Esposito, Parati, Lobianco, & Pepi, 2009). However, to the best of our knowledge, no such studies have been performed on the use of mahua cake (MC) for mushroom cultivation.

MC is an important by-product of the *Madhuca indica* tree, generated after the expulsion of oil from its seeds. About 60–70% of seed material is left as seed cake which is rich in sugars

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# Biopesticidal value of selected essential oils against pathogenic fungus, termites, and nematodes

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## ABSTRACT

The biopesticidal potential of six plant-derived essential oils (mint [*Mentha arvensis*], ajwain [*Carum capricum*], lemongrass [*Cymbopogon citratus*], clove [*Eugenia caryophyllata*], cedarwood [*Cedrus deodara*], and eucalyptus [*Eucalyptus globulus*]) was evaluated against *Odontotermes obesus* (termites), *Fusarium oxysporum* (plant pathogenic fungi), and *Meloidogyne incognita* (nematodes). In the case of termites, a "no-choice" bioassay revealed that the mint oil gave the best results (100% mortality in 30 min with 10% oil and in 10 h with 0.12% oil) followed by the lemongrass and ajwain oils. The disc diffusion method was adopted to test the anti-fungal activity of the essential oils and it was found that the clove oil gave the maximum inhibition measured in terms of the average inhibition zone diameter ( $5.3 \pm 0.2$  cm with 10% oil and  $6.6 \pm 0.9$  cm with 20% oil), followed by the ajwain oil. To check the anti-nematicidal activity of the essential oil, in-vitro growth chamber experiments revealed that eucalyptus oil was the most efficient (100% mortality in 6 h with  $1000 \mu\text{l l}^{-1}$  oil and in 30 h with  $125 \mu\text{l l}^{-1}$  oil), followed by the ajwain oil. The use of the crude oils at low concentrations provided satisfactory results at the laboratory level against these pathogens, and needs further evaluation in field trials.

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## 1. Introduction

In recent years, a significant increase in the yield of food grains and other crops has been required to feed the world's growing population. However, various pests, including weeds, insects, and plant viruses, can reduce crop production by 25–50% (Pimentel et al., 1991; Oerke, 2006). According to Levetin and McMahon (2003), about 70% of crop diseases are caused by fungi. The extent of diseases caused by nematodes in the agricultural systems is far from fully understood. The yield losses by plant parasitic nematodes, in India alone, amount to billions of rupees every year. Termites also cause a huge amount of damage when they destroy wood and wooden products (Verma et al., 2009). Control and repair costs due to Formosan subterranean termites in New Orleans, for example, have been estimated to reach \$300 million annually (Suszkiv, 1998). In India, they are responsible for the loss of 15–20% of the maize yield and about 1478 million rupees (Joshi et al., 2005; Verma et al., 2009). Other countries as well experience significant crop losses caused by these pests, so controlling them is an important economic and agricultural issue.

The green revolution introduced the use of chemical pesticides for managing pests. To defeat plant diseases, farmers/growers have

to use heavy doses of chemical pesticides, which, although have an immediate effect, are not always affordable, and may have deleterious effects on plants, soil, and animals. Moreover, continued use leads to an increase in pest resistance and enhanced pest resurgence. In this context, efforts are being made worldwide to replace these chemicals with biological alternatives (biopesticides), which are less toxic to the environment.

Through the ages, plant-derived oils (essential as well as seed oils) have evoked interest as natural products that hold promise for their potential in pest management (Regnault-Roger, 1997; Isman, 2000; Akhtar, 2000; Oka et al., 2000; Zhu et al., 2001; Gandhi et al., 2006; Chaieb et al., 2007; Bakkali et al., 2008). Among the plant-derived oils, essential oils have been shown to possess insecticidal, anti-fungal, and antibacterial properties (Burt, 2004). The present paper describes testing the efficacy of selected plant-derived essential oils as biopesticides against termites (*Odontotermes obesus*), plant pathogenic fungus (*Fusarium oxysporum*), and plant nematode (*Meloidogyne incognita*).

## 2. Materials and methods

### 2.1. Essential oils

Six different essential oils were selected based on a literature survey, as well as their availability and use in traditional medicine.

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