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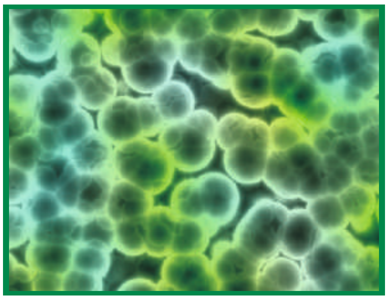
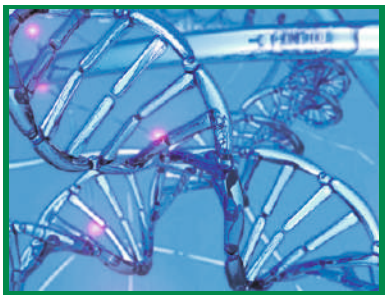


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CONTENTS

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Sl. No.	Title	Page No.
1.	**TEACHERS ENGAGEMENT IN ACADEMIC MOTIVATION OF SCHOOL STUDENTS** Rituaparna Basak and Saikat Kumar Basu	1-10
2.	**SOCIAL FORESTRY ENCOURAGE ECO-CONSERVATION, CULTURAL IMPORTANCE AND TRADITION FOR TRIBAL UPSHOT** Suparna Sanyal Mukherjee and Saikat Kumar Basu	11-17
3.	**TRITROPHIC ASSOCIATION AND DISTRIBUTION OF APHIDOPHAGOUS COCCINELLID CHEILOMENES SPP. (COCCINELLIDAE: COLEOPTERA: INSECTA) IN INDIA** Rajendra Singh, Ajeet Kumar Tiwari and Krishna Mohan Tiwari	18-46
4.	**PHARMACOLOGICAL BENEFITS AND CONSERVATION STRATEGIES OF RHODODENDRON ARBORETUM SM.: A COMPREHENSIVE REVIEW** Choudhary Shilpa and Vadakkemuriyil Nair Divya	47-59
5.	**THE THERAPEUTIC EDGES OF MEDICINAL PLANT-DERIVED CUTLERY** Akansha Srivastava and Shahwar Siddiqui	60-66
6.	**COMPARATIVE LC-MS ANALYSIS OF PHYTOCONSTITUENTS IN RIPE AND UNRIPE PAPAYA FERMENTA** Rupali Dutt, Lalita Kushwah, G. Tejovathi and D.K. Sharma	67-72
7.	**FLAVORED GOAT CHEESE AS A VALUE ADDED PRODUCT** Saikat Kumar Basu	73-76

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TEACHERS ENGAGEMENT IN ACADEMIC MOTIVATION OF SCHOOL STUDENTS

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Review Paper

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ABSTRACT

Teachers in schools can boost students' academic motivation by providing them with support and encouragement. This study attempted to explore the factors teachers use to support students' autonomy, competencies, and interests to boost their motivation for learning. Interpretative phenomenological analysis of qualitative research methodology was used in this research. The study was conducted on 18 school teachers working in government and private schools in Kolkata, India from whom data were collected through semi-structured interviews. The results showed that teachers employed four key themes to raise students' motivation for academics in the classroom. Highlighting the significance of learning, inspiring learning environment, promoting unique activities and resolving other issues were the major affairs that were reported. A favourable learning atmosphere, the benefits of extracurricular activities, the necessity of specific classes, the significance of learning for professional and personal growth, and counselling were also highlighted as ways to motivate students.

No. of Pages: 10 **References: 33**

Keywords: Teacher engagement, academic motivation, school students.

INTRODUCTION

For students learning should be integrated into play to ensure that students learn every day in a playful environment. An individual gains the opportunity to explore new chances by taking on new difficulties through learning. The ability to learn is a crucial one that supports a person's overall development. Students' capacity for learning can increase due to their own desires to know something new or due to the encouragement and assistance they receive from their teachers (Schuitema et. al., 2016; Theobald, 2006; Thoonen, Sleegers, Peetsma, & Oort, 2011).

Children are naturally inquisitive, questioning, and enthusiastic towards learning. Entering the school, they are full of energy and eager to quickly explore and learn everything around them. Success in their exploration or discovery leads to great happiness, motivation, and a lifelong desire to learn more new things about the surroundings. Studies showed that a child's willingness to participate in school activities, which is correlated with motivation, determines how well the youngster adjusts overall (Hinshaw, 1992). Children who receive appropriate assistance and constructive criticism in school grow up to be imaginative, daring, and driven learners (Bain, 2004; Ferlazzo, 2015). According to a study, students' interest in learning will rise when they recognize the value of knowing a certain subject and how it will affect their daily lives (Theobald, 2006). Similarly, Martin et al. (2002) highlighted the connection between classroom

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exercises and their impact on students' lives. When education is connected to real-world experiences, students are more likely to be motivated to learn. According to Ming-Te Wang and Jacquelynne S. Eccles at the University of Michigan (2012), peer and teacher influence on students' motivation varies in addition to parental influence. Numerous studies revealed that social environments, such as the classroom, school, and family, as well as internal personality traits influence academic motivation in all students, even those with high intellectual capacity (Deci & Ryan, 2008; Wentzel, 2002).

Effective student engagement refers to the meaningful involvement and active participation of students in their own learning processes (Bain, 2004; Ferlazzo, 2015; Schuitema et. al., 2016). It encompasses various aspects, including:

Cognitive Engagement: This involves students' investment in learning, their willingness to exert effort, and their use of deep learning strategies such as critical thinking and problem-solving.

Behavioural Engagement: This includes students' participation in academic, social, and extracurricular activities. It involves attending classes, completing assignments, and participating in discussions.

Emotional Engagement: This aspect covers students' emotional responses in the classroom, their sense of belonging, and their relationships with peers and teachers. Positive emotions such as interest, enthusiasm, and motivation are crucial.

Social Engagement: This involves collaborative learning and the development of interpersonal skills through group work, peer interactions, and communication.

Active Learning: This includes hands-on activities, interactive lessons, and opportunities for students to apply what they learn in real-world scenarios.

Effective student engagement leads to better academic outcomes, higher levels of student satisfaction, and increased retention rates. It is often fostered by creating an inclusive and supportive learning environment, using varied teaching methods, providing timely feedback, and encouraging student autonomy and voice in the learning process.

Effective student engagement in the classroom can be challenging due to several factors:

Diverse Learning Styles: Students have different learning preferences (visual, auditory, kinesthetic, etc.). Catering to all these styles in a single lesson can be difficult.

Varied Academic Abilities: Classrooms often contain students with a wide range of academic abilities. Providing materials and activities that challenge advanced students without overwhelming those who struggle is a complex balancing act.

Lack of Interest or Motivation: Some students may not find the subject matter interesting or relevant, making it hard to engage them.

Class Size: Large class sizes can make it difficult for teachers to give individual attention to each student, recognize when someone is disengaged, and provide meaningful feedback.

External Distractions: Students can be distracted by factors outside the classroom, such as personal issues, social media, or noise.

Limited Resources: Schools may lack the necessary resources, such as updated technology, books, or materials, which can hinder the ability to create engaging lessons.

Teaching Methods: Traditional teaching methods may not always resonate with modern students. Innovative and interactive approaches require additional preparation and resources.

Cultural and Socioeconomic Differences: Diverse cultural backgrounds and socioeconomic statuses can affect how students engage with the material and participate in class.

Behavioural Issues: Classroom management challenges, such as disruptive behaviour, can detract from the learning environment and reduce engagement for other students.

Assessment Pressure: High-stakes testing and an emphasis on grades can lead to a focus on rote learning rather than genuine engagement with the material.

Teacher Burnout: Overworked and under-supported teachers may find it difficult to maintain the energy and creativity needed to keep students engaged.

Addressing these challenges requires a multifaceted approach, including differentiated instruction, active learning strategies, incorporating technology, fostering a positive classroom environment, and ongoing professional development for teachers. This study concentrates on how teacher participation can improve students' academic motivation.

LITERATURE REVIEW

It is widely acknowledged that one of the most important factors influencing the effectiveness and quality of any learning outcome is students' willingness to learn (Mitchell, 1992). According to the study, national intervention is crucial to raising the academic standards' rigour and inspiring all students, even the most disengaged and demotivated ones (Brewster & Fager, 2000). Investigating the components of school-age academic motivation is crucial because academic intrinsic motivation in the formative years of education significantly impacts future achievement in life. Teachers' encouragement and involvement in the classroom have a distinct impact on children's motivation for academics.

Numerous studies on school children's motivation for academics have been carried out. Some examined the relationship with academic achievement, while others concentrated on the roles of peers, teachers, and parents. Research on intrinsic motivation has demonstrated its correlation with a series of positive results, including interest, performance, persistence, and positive emotions (Bouffard et al., 2001; Hardre & Reeve, 2003; Coutts, 2004; Valle et al., 2016). Most studies have indicated that higher learning achievement is correlated with students' increased approach to learning (Nunez et al. 2019).

In addition to assisting a child in succeeding in school, academic motivation also helps the youngster realize the value and satisfaction of learning in other spheres of life, including the workplace, community, and school. Gottfried (1990) defines academic motivation as “enjoyment of school learning characterized by a mastery orientation; curiosity; persistence; task-endogeny; and the learning of challenging, difficult, and novel tasks” (p. 525). According to Pintrich and Zusho (2002), academic motivation refers to internal processes that initiate and maintain actions intended to meet particular academic objectives. A cheerful, academically motivated child feels that education is vital, is eager to learn, and enjoys engaging in learning-related activities.

Researchers found that middle and high school pupils who successfully finished their assignments and applied the principles their teachers had taught in class had higher levels of motivation (Trautwein and Lüdtke, 2007; Dettmers et al., 2010). Teachers' feedback is also very important to students because it shows how the student is doing academically (Trautwein et al., 2009; Núñez et al., 2015a). Giving feedback enables students to learn from their successes and failures as well as opportunities for future improvement. Students' motivation to learn increases with the amount of positive feedback they receive. A study by Wang and Eccles (2013) found that those who perceived teachers as warm, caring, friendly, and approachable are more likely to attach themselves to their learning in school.

King (2015) reported that students who felt care and belonging in an academic environment showed high academic achievement while those who thought others were unfriendly expressed discontent with their learning According to Jang et al. (2016), Korean students who studied in circumstances that supported their autonomy showed more psychological need satisfaction and increased learning engagement, whereas students who learnt in environments that suppressed their autonomy demonstrated a disinterest in learning. Guvenc (2015) reported that academic engagement is influenced by motivation, and the degree of assistance provided is based on the teacher-student connection.

Wentzel and Wigfield (1998) discovered that students' academic motivation is positively impacted by their good and healthy interactions with teachers during regular classroom activities. Students who exhibit good behaviour and receive encouragement and motivation from their teachers are more likely to be motivated and enthusiastic about learning. Therefore, it is crucial to comprehend how teacher engagement affects students' academic motivation in the classroom. This study focused on how teacher engagement strategies can affect students' academic motivation in the classroom.

RESEARCH QUESTIONS

Effective student engagement is a multifaceted concept that involves various parameters or criteria, which can be broadly categorized into behavioural, emotional, cognitive, and social dimensions (Bouffard et al., 2001; Pintrich & Zusho, 2002; Hardre & Reeve, 2003; Coutts, 2004; Trautwein & Lüdtke, 2007; Dettmers et al., 2010; Jang et al. 2016;). Here are some key parameters for each category:

1. **Behavioural Engagement**

   A. Active Participation: Students are actively involved in classroom activities, discussions, and collaborative work.

   B. Attendance and Punctuality: Regular and timely attendance is a basic indicator of engagement.

   C. On-task Behaviour: Students remain focused and attentive during lessons and activities.

   D. Completion of Assignments: Consistent and timely submission of homework and projects.

2. **Emotional Engagement**
   A. Interest and Enthusiasm: Students show genuine interest and enthusiasm for the subject matter.
   B. Positive Attitude: A positive attitude towards learning, teachers, and classmates.
   C. Sense of Belonging: Students feel connected to the school community and classroom environment.

D. **Motivation: Intrinsic motivation to learn and achieve.**

3. **Cognitive Engagement**
   A. Critical Thinking: Engagement in higher-order thinking skills, such as analysis, synthesis, and evaluation.

   B. Self-regulation: Ability to set goals, monitor progress, and reflect on learning.

   C. Effort and Persistence: Willingness to put in the effort and persist through challenges.

   D. Curiosity and Inquiry: Active questioning and exploration of topics beyond the surface level.

4. **Social Engagement**
   A. Collaboration: Effective participation in group work and collaborative projects.

   B. Communication Skills: Ability to communicate ideas clearly and listen to others.

   C. Supportive Interactions: Positive interactions with peers and teachers, providing and receiving support.

   D. Respect and Inclusivity: Demonstrating respect for diverse perspectives and fostering an inclusive environment.

5. **Environmental Factors**
   A. Classroom Environment: A supportive and well-structured classroom that promotes engagement.

   B. Relevance of Content: Curriculum that is relevant and connected to students' lives and interests.

   C. Teacher Support: Availability and approachability of teachers, along with their ability to provide constructive feedback.

   D. Use of Technology: Effective use of technology to enhance learning and engagement.

6. **Institutional Support**

   A. Extracurricular Activities: Opportunities for students to engage in activities outside the classroom that interest them.

   B. Parental Involvement: Encouragement and support from parents or guardians.

   C. School Policies: Policies that promote student well-being and engagement, such as anti-bullying measures and mental health support.

7. **Personal Factors**

   A. Self-efficacy: Students' belief in their own ability to succeed.

   B. Goal Orientation: Clarity and alignment of personal and academic goals.

   C. Time Management: Effective management of time to balance academic and personal responsibilities.

Each of these parameters contributes to a holistic understanding of student engagement. Effective engagement strategies should address these various dimensions to create a comprehensive and supportive learning environment.

Finally, we wish to investigate: *How does teacher engagement influence the academic motivation of school students?*

Objectives of the study

- To explore the engagement of the teachers in the academic motivation of the schools at the primary level

- To know about the ways teachers morally support the students to motivate them to their better academic achievements

METHODS

Sample

The study was conducted on the teachers working in government and private schools in Kolkata, India. In this study, purposeful random sampling was employed. To obtain a variety of data from various locations in Kolkata, 24 primary school teachers were contacted by phone. Finally, eight teachers from private schools and ten teachers from government schools expressed interest in participating in the study. Of these, eleven are female teachers and seven are male teachers in the 28–41 age range. Among the 18 teachers, 8 had B.Ed., 7 were postgraduates, 3 had PhD degrees, and all had a minimum of 4 years of teaching experience.

Procedure

Semi-structured interviews were used to gather data from the primary school teachers in different schools in Kolkata on their engagement in enhancing the student's academic motivation at the primary level. The open-ended questions were used without any predetermined limit. Three experts verified these questions, and their recommendations were followed in the revisions. To ensure authenticity, the updated draft was sent to three teachers who were not involved in the study. Questions were asked both in Bengali and English depending on the comfort of the interviewees. Every interview was conducted over the phone, and the audio clip contains the responses that were captured. Every teacher had a brief personal profile taken. However, following the ethics of qualitative research, the respondent's identity was kept private. During the interview, a few valid questions were asked to the teachers firstly, how do you motivate students in the class? Secondly, how do you give feedback to the students in the class?

Instrument

Interpretative Phenomenological Analysis (IPA) of qualitative research methodology was used in this research. Research states that an individual's experience of a specific affair can be understood in detail with the help of IPA (Alase, 2017; Smith, 2011). Through IPA interviews, interviewers can gain insight into interviewees' subjective experiences and engagement with a specific issue (Joshi, Vinay & Bhaskar, 2020). IPA offers descriptive viewpoints in addition to interpretative assessments and experiences of the respondents (Smith, Osborn & Samara, 2008). In circumstances where a larger sample size is needed for in-depth analysis, IPA is typically employed (Smith, 1996). Here, teachers utilize IPA to investigate various teaching strategies that they employ in the classroom to encourage students' academic progress.

Data Analysis

Each interview was analysed following the steps proposed by Smith and Osborn (2003) mentioned in the research by Joshi, Vinay and Bhaskar (2020). In order to determine the main themes of academic motivation, every recording interview was carefully examined, and all pertinent material was recorded. Based on the verbatim transcripts, emerging themes were identified, recorded independently, and compared and contrasted before being grouped together based on commonalities. Every interview that was done for the study went through this procedure.

RESULTS

The teachers' responses collected through semi-structured interviews were then analysed and revealed the following aspects of their involvement in students' academic motivation. The findings are expressed in four major themes which were obtained by grouping the responses taken from the analysis.

1. **Highlighting the significance of learning** - Teachers are crucial in helping children understand the significance of learning. They do this by guiding their students through a variety of methods that communicate the goals, benefits, and ramifications of learning.

    i) *Personal development* - Learning is an indication of mental and brain activity. The brain is kept occupied by curiosity as it looks for original information about the surroundings. These students' growth curves and confidence are boosted by this knowledge, which is a measure of their level of contentment.

    "Students who are good in academics always ask questions and try to analyse with rationality." (Participant 3)

    ii) *Professional development* - Professional development is facilitated by learning, which offers a verified route to improve one's performance in one's sector.

"It is observed that students, who worked hard, improve a lot for getting better chances like school captain, sports captain." (Participant 12)

iii) *Changed the perspectives* – Learning always helps one see things differently and keeps the mind open to new possibilities. For a deeper comprehension of everything, it helps to alter one's values, behaviour, and attitude.

"The knowledgeable students are more understanding and open-mindedness compared to others." (Participant 16)

2. **Inspiring learning environment** - By fostering a positive, upbeat environment with lots of light, fresh air, and friends' support, teachers can increase their students' passion and drive for studying. Teachers can act as a catalyst for students to look forward to learning.

i) *Positive classroom* - A positive environment encourages students to investigate novel concepts by making them feel safe, secure, and at ease during their education. Their sense of respect and acceptance in the educational environment is made possible by the teachers' assistance.

"In a positive environment children work as a team and celebrate the achievement together." (Participant 6)

"In a supportive environment children show their real curiosity and unique ideas." (Participant 17)

ii) *Colourful classroom* – classroom painted with bright colour, full of needed supplies (books, school dress, pen, pencil, table, chair etc.) as much as necessary encouraged students to study more.

"Students are more likely to study in a colourful classroom full of famous quotes, and motivating posters." (Participants 2, 7, 13)

iii) *Natural learning environment* – Students enjoy studying more intently and with a clearer mind in an open environment. When exposed to outside environments such as gardens, ponds, and rooftops, they pay closer attention to what they are learning.

"Students are more excited in classes taken in open space". (Participants1, 4)

3. **Promoting unique activities** – In addition to the academic curriculum, extracurricular activities help students acquire skills outside subject-specific knowledge. These exercises help pupils develop their moral principles, intellectual prowess, social skills, personality, and character.

i) *Adequate learning* - Co-curricular activities merged with academics ensure students get to learn effectively. Science lab, computer lab, projects, and experiments in different fields all are part of co-curricular activities.

"Students who are more active in computer class tend to be good in other subjects also". (Participant 18)

ii) *Cultural values* - Students get to study about a range of cultural activities that are based on diverse faiths, beliefs, and values, ranging from traditional to national levels. Students learn about these events through books along with extracurricular activities based on different cultures organized by schools.

"Those students are more knowledgeable who take an active part in different cultural programmes because taking part in the event enables them to know in detail about the background of the event" (Participants 10, 11)

iii) *Personality development* - Students who actively participate in extracurricular activities improve their leadership, coordination, and communication abilities. Students gain a sense of community and sharing through a variety of activities such as debate, recitation, creative competitions, and group discussions. These experiences also help to positively form students' personalities.

"Students, who always take part in co-curricular activities besides study, are generally smart, cooperative, friendly, good speakers and good coordinators". (Participants 8, 12)

4. **Resolving other issues** – Even though students have access to all the amenities, it can occasionally be challenging to figure out why they lack motivation. Teachers then make an effort to learn about the issues that students are concentrating on.

i) *Nurturing special skills* - Sometimes students endure criticism from society for their academic performance. Then, teachers provide students the chance to recognize the unique abilities they possess such as by assigning creative writing assignments to develop writing abilities or arts and crafts projects to explore creativity in athletics, painting, or creating, among other areas.

"I have one student in my class who is wonderful at painting but not very good in study. I asked her to paint whenever she loves to do it because I observed that after painting she gives attention to her study." (Participant 5)

ii) *Special class* - Arranging separate classes for kids who struggle with learning encourages them to pay closer attention in class, take their studies more seriously, and find solutions to challenges outside of the classroom.

"In special class, few students talk about family problems." (Participant 4)

iii) *Counselling* - If teachers are unable to identify the cause of a student's low academic motivation, they will recommend them to the school counsellor, who will ultimately assist the student in increasing their academic drive.

"We have few students who improved much in study after having few counselling sessions." (Participant 14)

To draw a graph representing successful student engagement, we need to consider several key factors that influence engagement, such as:

1. Attendance: Consistent presence in class.
2. Participation: Active involvement in discussions and activities.
3. Assignments: Completion and quality of homework and projects.
4. Motivation: Students' enthusiasm and interest in the subject matter.
5. Feedback: Constructive feedback from teachers and peers.
6. Support: Availability of academic and emotional support.

A suitable graph for this purpose could be a radar chart (also known as a spider chart), as it can display multiple variables on a single plot, making it easy to visualize the level of engagement across different dimensions. The average rounded score of ten random students from our survey had the following scores (out of 10): Attendance: 8, Participation: 7, Assignments: 9, Motivation: 6, Feedback: 8 and Support: 7

Here is a radar chart (Fig. 1) representing successful student engagement across various factors. Each axis represents a different dimension of engagement, with higher values indicating better performance in that area. This graph allows for an easy comparison of strengths and areas needing improvement for a student's engagement.

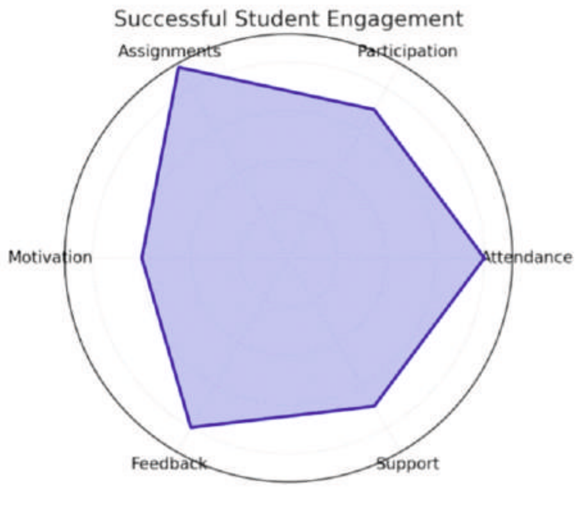

Fig. 1: Radar chart representing successful student engagement across various factors.

DISCUSSION

Learning is an inevitable tool that nourishes the student's minds and calms the soul. It is a continuous process that encourages acquiring knowledge, competencies and skills to develop future opportunities and to deal with the continuous changes in life. Teachers encouraged the students for reading habits, building a learning network, asking questions, conducting research and exploring new facts so that every moment can be enjoyable for the students and they learn something new in each moment. This finding is supported by other studies which stated that students' motivation to learn can be increased by the support of teachers (Ferlazzo, 2015; Schiefele & Schaffner, 2015; Schuitema et al., 2016).

The classroom is the second home for the students and teachers make efforts to make the students feel comfortable as much as possible. They tried to create an environment that is more conducive to engagement and learning as a positive learning environment allows the students to develop a sense of belonging, and trust and feel encouraged to tackle challenges, take risks and ask questions. Schuitema et al. (2016) in their study reported teachers play an important role in creating a supportive environment for student's autonomy.

Teachers involve students in co-curricular activities at schools as these are part of academics and make the learning experience exciting for the students. Through different activities, students learn much better because participation in an activity brings out their natural skills. Fostering a positive environment, teachers help students acquire higher motivation that leads to wonderful learning outcomes. In the studies, it is found that teachers by supporting students' likings and interests help them develop personal interest and engagement in work which leads to motivation (Schuitema et al., 2016; Stearns, 2013). Teachers encountered many issues with students while teaching in schools. Sometimes they had to solve some other issues outside of academics. They refer counsellors sometimes if they become unable to solve those special issues which decreases the motivation of the students in learning. This finding is in accordance with the study of Thoonen et al. (2011) which stated that teachers support their student's learning by connecting to the personal world of the students.

CONCLUSION

Student motivation has an impact on learning, which is an essential tool. It equips students with the abilities that motivate them to take on life's problems. In addition to innate learning abilities, teachers' engagement greatly influences students' drive to learn. Teachers may help students become more motivated to learn by helping them see the value of education, creating a welcoming and supportive learning atmosphere, and providing encouraging comments for their future success.

LIMITATIONS AND FUTURE SCOPES

This study used Interpretative Phenomenological Analysis (IPA), a qualitative research methodology, to highlight teachers' importance in students' academic motivation in schools. The study cannot be applied to other sectors because it is limited to primary school teachers in Kolkata. Similar large-scale research on different topic groups from different sectors of other states or nations can be carried out in the future.

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SOCIAL FORESTRY ENCOURAGE ECO-CONSERVATION, CULTURAL IMPORTANCE AND TRADITION FOR TRIBAL UPSHOT

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ABSTRACT

Indian forest and forestry was enhanced with various new steps. Community development, forest regenerations, forest management ushers a new way of live and livelihood sustenance. Forest was first priority for the socio-economic pursuit to maintain economic upliftment for the people at large. India is a multi-ethnic society where people practices their traditional wellbeing with eco-conservation which encourage cultural importance. Social forestry encourages the management of forests for the benefits of local people. It emphasises on various aspects of which very few are- forest management, forest protection, and afforestation of deforested lands with the objective of improving the rural, environmental, and social development along with community protection. Every species of the forest bears a traditional approach with cultural values. Human existence could have been impossible if the forest was denuded. Environmental conservation is need to overcome the battle of global warming, climate change, loss of medicinal value of the natural species. It's a practice that paves the way for protection, conservation, manage the natural resources to encourage personages in adherence with social sway.The present investigation was peered into the Khagra Beat, Hijli Range of Kharagpur Forest Division with the involvement of people surrounded by way of social forestry explorations, plantation of Sal Trees to protect environment with traditional engagement of the local people which enhance cultural value orientations, encourage involvement of personages to adhere social see-saw.

No. of Pages: 7 **References: 7**

Keywords: Community, Economic, Environment, Forest & Forestry, Protection.

INTRODUCTION

Indian forest and forestry was enhanced with various new steps. Community development, forest regenerations, forest management ushers a new way of live and livelihood sustenance. Forest was first priority for the socio-economic pursuit to maintain economic upliftment for the people at large. India is a multi-ethnic society where people practice their traditional wellbeing with eco-conservation which encourages cultural importance (Bhowmik, 1963 & 1994).

Philosophy of development is an integral part of philosophy of life form itself. The sina qua non of human being is value orientated, not need based motivation. An authentic development should focus on the enrichment of human being not unceasing expansion of what existing. Standard of living must be corollary to the standard of life, not vice versa. Similarly, humanism of life deserves a higher pedestal than mechanics of life. Social Forestry inculcates need based production systems on uncultivated barren land. Social

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Forestry is a new concept of Forest Management which enriches a flow of production benefit to the marginalized rural population. In Indian context social forestry is defined as "The Science and Art of growing trees on available land for the purpose, outside declared forest areas and managing the same with intricate involvement of the local people" (Bhowmik, 1963 & 1994).

Forestry in India is a significant rural industry and a major environmental resource. India is one of the ten most forest-rich countries of the world. Together, India and 9 other countries account for 67 percent of the total forest area of the world. India's forest cover grew at 0.20% annually over 1990–2000 and has grown at the rate of 0.7% per year over 2000–2010, after decades where forest degradation was a matter of serious concern (Danda, 1991).

As of 2010, the Food and Agriculture Organization of the United Nations estimates India's forest cover to be about 68 million hectares, or 22% of the country's area. The 2013 Forest Survey of India states its forest cover increased to 69.8 million hectares by 2012, per satellite measurements; this represents an increase of 5,871 square kilometres of forest cover in 2 years. However, the gains were primarily in northern, central and southern Indian states, while north-eastern states witnessed a net loss in forest cover over 2010 to 2012. In 2018, the total forest and tree cover in India increased to 24.39% or 8, 02,088 km It increased further to 24.56 percent or 807,276 square kilometres in 2019 (Danda, 2002).

Unless India makes major, rapid and sustained effort to expand electricity generation and power plants, the rural and urban poor in India will continue to have to meet their energy needs through unsustainable destruction of forests and fuel wood consumption. India's dependence on fuel-wood and forestry products as a primary energy source is not only environmentally unsustainable; it is a primary cause of India's near-permanent haze and air pollution (Danda, 2002).

Forestry in India is more than just about wood and fuel. India has a thriving non-wood forest products industry, which produces latex, gums, resins, essential oils, flavours, fragrances and aroma chemicals, incense sticks, handicrafts, thatching materials and medicinal plants. About 60% of non-wood forest products production is consumed locally. About 50% of the total revenue from the forestry industry in India is in non-wood forest products category.

Every species of the forest bears a traditional approach with cultural values. Human existence could have been impossible if the forest was denuded. Environmental conservation is needed to overcome the battle of global warming, climate change, loss of medicinal value of the natural species. It's a practice that paves the way for protection, conservation, manage the natural resources to encourage personages in adherence with social sway (Raghaviah, 1956).

Forests and Tribes are the two sides of the same coin. They have a common history of suffering, neglect and exploitation so both are considered synonyms with backwardness. Forests and Tribe's are exploited for various reasons. Many species of flora and fauna are extinguishing, *The Forestry and Tribal Development* by R.S. Shukla (2000), tried to find out the reasons behind it, at the same time explained that some tribal groups are also becoming extinct. The entire ambit of forestry in India has been encompassed by S.S. Negi's *India's Forests, Forestry and Wildlife* (1994) and *Forest for Socio-economic and Rural Development in India*, (1996).

The present investigation was peered into the Khagra Beat, Hijli Range of Kharagpur Forest Division with the involvement of people surrounded by way of social forestry explorations, plantation of Sal Trees to protect environment with traditional engagement of the local people which enhance cultural value orientations, encourage involvement of personages to adhere social see-saw.

Objectives of the Study

1. To enhance forest& forestry
2. To encourage local people and develop people involvement
3. To protect environment
4. To restrict climate change
5. To save sustainable development

The Forest

Forest of all categories made a synergy in our planet earth. It has a definite role so far as Indian tradition and culture is concerned. The Forest plays a vital role among the forest dwellers especially the Tribes. Forest is the rich source of flora & fauna.

The Forest is a gripping first-person survival horror game where you find yourself as the sole survivor of a passenger jet crash, stranded in a mysterious forest**.** Your struggle for survival unfolds against a backdrop of cannibalistic mutants who inhabit the wilderness. Here are the key features of this intense experience:

Build and Explore**:** Chop down trees to construct a camp, create shelters, and even build ocean-side fortresses. The forest is your canvas for survival.

Terrifying Environment: As you explore, you'll encounter a living, breathing world where every tree and plant can be chopped down. The eerie atmosphere keeps you on edge.

Mutant Enemies: Defend yourself against a clan of genetic mutants who exhibit beliefs, families, and morals. Some appear almost human, making the encounters even more chilling.

Crafting and Survival: Craft weapons and tools from basic materials like sticks and stones. Scavenge for food to stave off hunger. Lay traps and defences to protect yourself.

Day and Night Cycle: During the day, explore and build. At night, hunker down and defend your base against the mutant threat.

Social Forestry

Social forestry (Fig 1) is the forest management designed to meet the forestry related basic needs of rural people. It enhances and involves people participation in the forestry activity for their benefit. It encourages main aspects of forest management, forest protection, afforestation of deforested lands with the objective of improving the rural, environmental and rural development. Dietrich Brandis considered as the father of Social Forestry.

Fig 1. Social forestry from southern West Bengal. Photo credit: Saikat Kumar Basu

Types of Social Forestry

There are various types of social forestry- Farm forestry, community forestry, rural forestry and agro forestry (Fig. 2). The present sequel is relied upon community forestry.

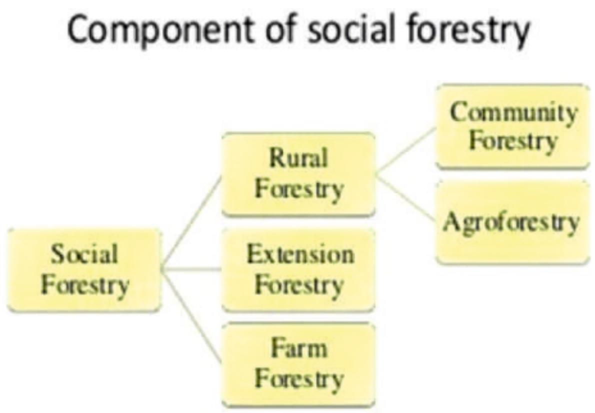

Fig 2: Present study is emphasized on community forestry.

Community forestry

1. Community forestry enhances people involvement in forest and its vicinity.
2. It encourages people participation in the forest based community programs like plantations, eco-conservation, eco-sustainability, eco-development, socio-economic, socio-cultural upliftment in connection with forest sustainability.
3. It restores the cultural activities among the people at large specially the forest dwellers.
4. It protects age old rights over the forest of the forest dwellers.

The Kharagpur social forestry division

Kharagpur Forest Division is primarily a social forestry division. Gram panchayats of Kharagpur II block/ panchayat samiti are: Chakmakrampur, Changual, Kaliara I, Kaliara II, Lachhmpur, Palsya, Paparara I, Paparara II and Sankoa-II. Area: 265.63 km^2 (102.56 sq mi) total forest cover area is 7 hectors, which is 70000.00 square meter. Rest portion is other land area covered. The Lengamara village covers 10 square meter forest cover of 50 square meter total villagecovered area.

Eco-Conservation

Ecological conservation refers to the preservation and management of biodiversity and natural resources. It aims to maintain the delicate balance of an ecosystem or set of wildlife. The goal is to ensure that population numbers of threatened or endangered species are not put at risk (Fig. 4).

Fig 3: The map of the Kharagpur Forest Division.

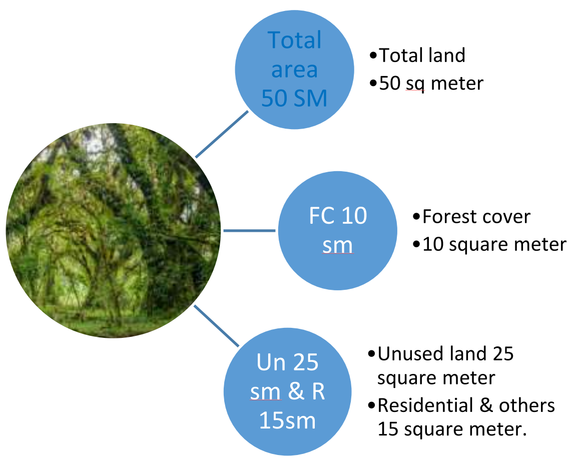

Fig. 4: Land orientation of Lengamara village.

The village Lengamara

The village Lengamara situated deep inside the forest, in Kharagpur Forest Division, Hijli Range and Beat, Khagra.Lengamara village of PaschimMedinipur District of West Bengal. A multi-ethnic village where different types of people are residing with sustainable community structure, different socio-economic and socio-cultural nomenclature. The total population of the village is 396 belonging to 68 households of which 28 are the Lodha and 40 households belong to the Caste Peasant. Among them are 156 Lodha and 240 other village people.

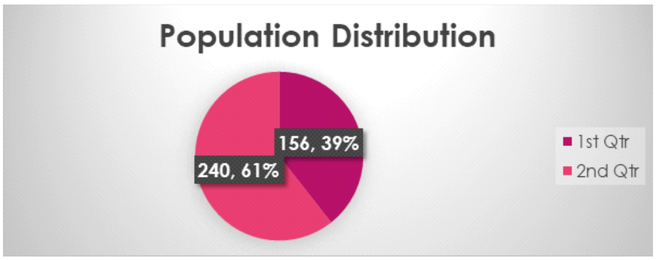

Fig 5: Population structure of the Lengamara village.

The above pie chart (Fig 5) is signifying the population distribution of the Lengamara village. The Lodha Male is showing 39% of the total village population and Lodha Female is depicting 61%. Hence the Lodha Female is higher than the male counterparts.

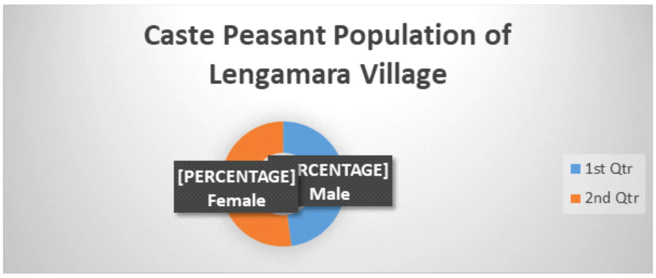

Fig 6: Population structure of the caste peasant of Lengamara village.

The above pie chart (Fig. 6) is depicting caste peasant population of the Lengamara village. The male value points 48% and female value is 52% the 1st and 2nd qtr respectively. The female is higher than the male counterpart. Hence it is proved that in both the cases Female are maintaining higher percentage than the male in the population distribution. The pie chart (Fig. 7) denotes 51% female population of Lodha and 49% of male. 1% frequency is enhancement is showing for the population distribution of the Lodhas of Lengamara village.

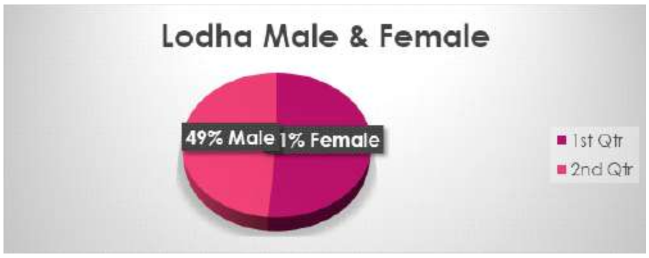

Fig. 7: Population structure of the Lodha of Lengamara village.

Lodha Male & Female Income outside and forest based before introduction of community forestry program. Lodhas Male female Income outside and forest based before implementation of community forestry program. Regular Forest based income those who visit forest every day in a month, Partially Forest based income is who are attending forest 15 days in a month and Non Forest based depicts who are absolutely not depended on the forest. Fig. 8 points out non dependence is high in male female both, partially dependence is high in female than the male and dependence on forest for income generation is high in male than the female.

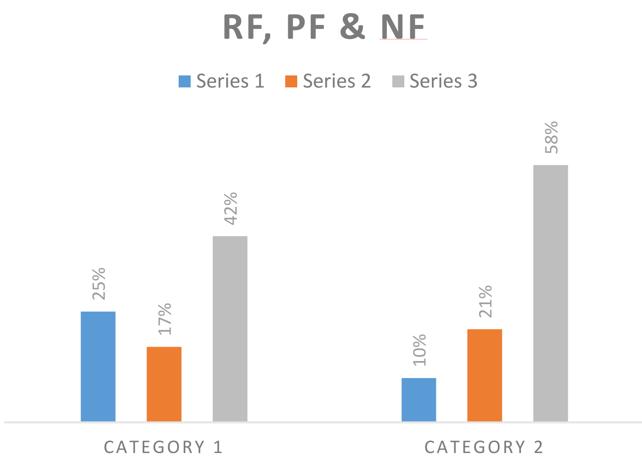

Fig. 8: Per capita income of non-forest and forest based household of Lodha & caste peasants before social forestry implementation.

Caste Peasants Male female Income outside and forest based before implementation of community forestry program. Regular Forest based income those who visit forest every day in a month, Partially Forest based income is who are attending forest 5 days in a month and Non Forest based depicts who are absolutely not depended upon the forest. Fig. 9 points out non dependence is high in male female both, partially dependence is same and dependence on forest for income generation is high in female than the male.

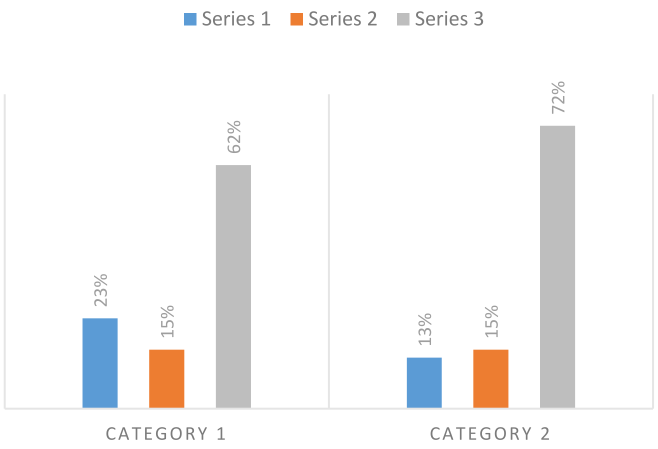

Fig 9: Per capita income of non-forest and forest based household of Lodha & caste peasants after social forestry implementation.

Lodha Male & Female Income outside and forest based after introduction of community forestry program. Regular Forest based income who always visit forest every day in a month, Partially Forest based income is who are attending forest 15days in a month and Non Forest based denotes who are absolutely not depended upon the forest. Fig. 10 points out non dependence is low in male female both, partially dependence is high in male than female and dependence on forest for income generation is high in female and the male both.

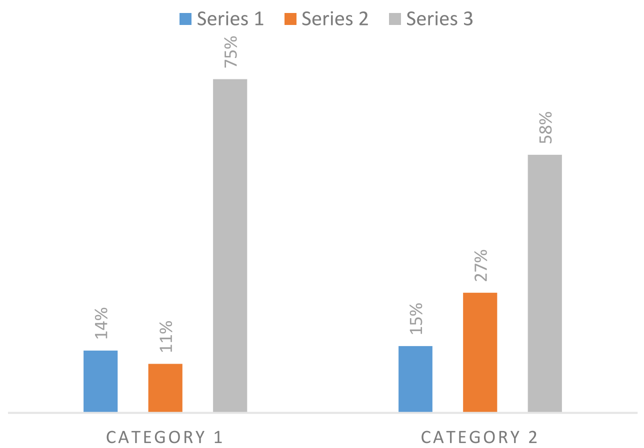

Fig. 10: Per capita income of non forest and forest based household of lodha& caste peasants before community forestry implementation.

Caste Peasant Income outside and forest based after implementation of community forestry program.Regular Forest based income those who move around forest every day in a month, Partially Forest based income denotes who are attending forest1 5 days in a month and Non Forest based depicts who are absolutely not depended upon the forest. Fig 11 points out non dependence is 28% in male and 12% in female, partially dependence is high in male and 11% in female and regular dependence on forest for income generation is high in female than the male.

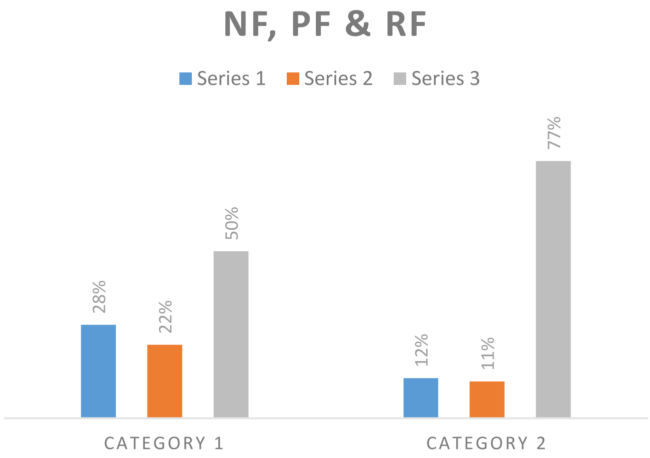

Fig 11: Per capita income of non forest and forest based household of lodha & caste peasants after community forestry implementation.

Hence it has been amply proved that lodha male, female and caste peasant male female are very much interested in the community forest management program. Regular dependence has been increased for income generation for daily livelihood sustenance. Lodha Non Dependence-30% which is showing in 1st qrt, Dependence denotes- 37%, and Total Forest Dependence denotes- 33% for the daily livelihood sustenance (Fig 12).

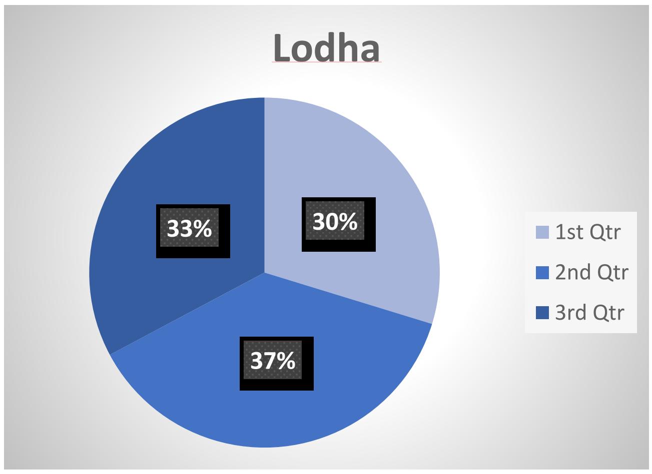

Fig 12. Resultant factor of the community forestry program of the Lodha.

Caste Peasant Non Dependence identifies – 35% which showing in1st qrt, Dependence- 16% denotes in 2nd qtr and Total Forest Dependence is points out – 49% for their daily livelihood sustenance. Hence non dependence in the forest produces specially the non timber minor forest produces is depicting higher ratio in the caste peasant than the tribes and caste peasant total forest dependence is 49% and Lodha 33%. Thereby 16% difference is showing in case of the Lengamara village population among the Lodha and Caste Peasant (Fig 13).

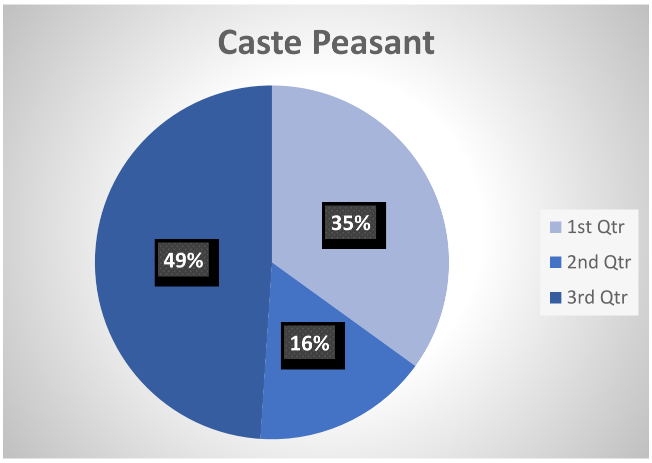

Fig 13: Resultant factor of the community forestry program of the Caste Peasant.

CONCLUSION

The present study amply proved that social forestry is a fruitful measures for development of the forest dwellers, the local people along with the Tribes. Forest dependence has been improved 37%+33%=70% among the Lodha Tribe and 49%+16%=65% among the Caste Peasants, which was 43% and 0% among the Lodha and The Caste Peasants respectively before implementation of the Social Forestry Program specially the Community Forestry Program. Social Forestry empowers people at large in the forestry program, sustainable forest uses and management, develop eco-balance, empower communities by raising awareness, and improve eco-balance, develop eco-sustainability. To encourage eco-conservation and cultural heritage to the personages to adhere the social sway.

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TRITROPHIC ASSOCIATION AND DISTRIBUTION OF APHIDOPHAGOUS COCCINELLID *CHEILOMENES* SPP. (COCCINELLIDAE: COLEOPTERA: INSECTA) IN INDIA

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Research Paper

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ABSTRACT

The paper deals with the prey records of *Cheilomenes* spp. in different states of India. In India, only two species of the genus *Cheilomenes* Chevrolat, 1837 - *Cheilomenes propinqua* (Mulsant, 1850) and *Cheilomenes sexmaculata* (Fabricius, 1781) are known to prey aphids. *Cheilomenes propinqua* is recorded in India on only one aphid species *Aphis (Aphis) gossypii* Glover, 1877 infesting brinjal in Assam and Meghalaya. The *Cheilomenes sexmaculata* (Fabricius, 1781), also known as six-spotted zigzag ladybird, preys on 76 species of aphids infesting 160 species of plants belonging to several families distributed throughout India except Jharkhand and Mizoram states. In union territories, it is recorded preying on aphids only in Jammu and Kashmir and Delhi. The most preferred prey is *Aphis (Aphis) gossypii* Glover which was found infesting 53 plant species distributed in 21 states/union territories followed by *Aphis (Aphis) craccivora* Koch infesting 35 plant species distributed in 24 states/union territories and *Myzus (Nectarosiphon) persicae* (Sulzer) infesting on 20 plant species distributed in 16 states/union territories. Total number of tritrophic relationship of *Cheilomenes sexmaculata* (Fabricius) (predator-prey-host plant) reported in India was 282; maximally being in Gujarat (72) followed by Uttar Pradesh (56), West Bengal (46), Bihar (43), Karnataka (41), Manipur (38), Maharashtra (25), and less than it in other states.

No. of Pages: 28 **References: 248**

Keywords: Aphid, ladybird beetle, aphidophagous coccinellids, biocontrol, checklist, Coccinellidae, prey-predator relationship.

INTRODUCTION

The ladybird beetles (Coccinellidae: Coleoptera) have attracted more attention for a long time because majority of them prey on several notorious insect pests of agricultural and horticultural crops, particularly, soft-bodied ones such as aphids, mealybugs, scale insects, thrips, leafhoppers, etc. keeping their population under check. The beetles belong to class Insecta, which is the largest class of Animals (Verma and Prakash, 2020). Long back, Hodek and Honek (1996) presented a comprehensive account of their natural history, biology and ecology. Later, Dixon (2000) presented a systematic account of their ecological relationships with their preys highlighting their importance as bioagents in biocontrol programmes of these insect pests, particularly aphids. *Cheilomenes* Chevrolat, 1837 is a very small genus of ladybirds. Only three species are ecologically

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important, e.g., *Cheilomenes lunata* (Fabricius, 1775), a predator of the citrus aphids (Scholtz and Holm, 1985) and wheat aphids (Picker et al., 2004) in Africa; *Cheilomenes propinqua* (Mulsant, 1850), used as a bioagent in greenhouses against several aphid pests and distributed widely in its native range in the Afrotropical and the Middle East region (Ofuya, 1986; Reznik et al., 2021); and *Cheilomenes sexmaculata* (Fabricius, 1781), a generalist predator of several aphid species (Agarwala and Yasuda, 2000) and is widely distributed across intermediate and equatorial latitudes (Sasaji, 1971) including Indian subcontinent (Agarwala and Ghosh, 1988), Far East (Kawakami et al., 2016), and South and South East Asia (Sugiura and Takada, 1998) and also introduced in North America (Cartwright et al., 1977; Romanowski et al., 2020) and South America (Ramírez et al., 2018). Among these species, *Cheilomenes sexmaculata* (Fabricius, 1781), commonly known as six-spotted zigzag ladybird, is one of the most significant species with high biocontrol potential against several aphid species of aphids, mealybugs, scale insects and other soft-bodied insects infesting agricultural and horticultural crops in India (Agarwala and Yasuda, 2000). It is polymorphic with variation in its elytral colour (Kawakami et al., 2013). Earlier, Agarwala and Yasuda (2000) reviewed its life history, reproductive physiology, prey range, prey consumption by larvae and adults both, feeding efficiency between sexes, etc.

The prey records of *Cheilomenes* spp. compiled by Agarwala and Ghosh (1988), Shantibala and Singh (1991), Agarwala and Yasuda (2000), Omkar and Pervez (2004) and Satpathi (2009) do not provide complete information regarding the association of predator - prey - host plant (triplet) and their distribution in different states and union territories of India. As predatory efficiency of *Cheilomenes sexmaculata* (Fabricius, 1781) varies with aphid species (Chaudhary et al., 1983; Pandi et al., 2012; Kumar et al., 2016; Aniyaliya et al., 2022), host plant species on which its prey feed (Murugan et al., 2000; Rakhshan and Ahmad, 2015a; Routray et al., 2016; Pervez and Chandra, 2018) and habitats (distribution in different ecological region) (Hodek and Honek, 1996; Agarwala and Yasuda, 2000), record of its prey along with their food plants and distribution is essential if they are to be assessed as bioagents against the said prey species in a particular area.

MATRIALS AND METHODS

This empirical checklist of aphidophagous *Cheilomenes* spp. is based on the literature published in recent past books, journals and few authentic theses, and websites, up to May 31, 2024. In most of the literature published earlier, several errors crept in the scientific names of the predators, aphids and host plants even in the recent ones. It happened because such contents become outdated quickly and, due to their perceived comprehensiveness, readers sometimes overlook newer sources of information. Additionally, the researches on prey-predator relationship are continued with the new records, their modified status, and the publication of other nomenclatural decisions. In the present checklist, attempts have been made to correct the errors in the scientific names of the aphid prey following the Aphid Species File (Favret, 2024) and food plants following World Flora Online (WFO, 2024) and Global Biodiversity Information Facility (GBIF, 2024). For synonymy of aphids Fevret (2024) may be consulted. Only those synonymies of plants are mentioned that are reported in India.

RESULTS AND DISCUSSION

In India, only two species of the genus *Cheilomenes* Chevrolat, 1837 - *Cheilomenes propinqua* (Mulsant, 1850) and *Cheilomenes sexmaculata* (Fabricius, 1781) are known to prey aphids. Following is the detail list of their prey records along with their food plants and distribution in Indian states and union territories.

A. *Cheilomenes propinqua* (Mulsant, 1850) (Type species: *Cydonia propinqua* Mulsant, 1850)

This species is mostly distributed in african countries (GBIF, 2024), it is recorded in India on only one aphid species infesting brinjal in Assam and Meghalaya as mentioned below.

1. *Aphis (Aphis) gossypii* Glover, 1877

- *Solanum melongena* L. - Assam (Borkakati et al., 2019); - Meghalaya (Boruah and Pathak, 2023); Uttar Pradesh (Singh, 2023)

B. *Cheilomenes sexmaculata* (Fabricius, 1781) (Type species: *Coccinella sexmaculata* Fabricius, 1781; Syn. *Cheilmenes sexmachlata* (Fabricius, 1781; *Chilomenes quadriplagiata* (Swartz, 1808); *Menochilus sexmaculatus* (Fabricius, 1781))

The six-spotted zigzag ladybird, *Cheilomenes sexmaculata* (Fabricius, 1781), is one of the highly significant aphidophagous coccinellid and has been used in biocontrol of several soft-bodied insect pests including aphids. It is widely distributed in the Oriental and Australasian regions, throughout India, Bangladesh, Pakistan, Sri Lanka, Bhutan, Myanmar, Malaysia, Indonesia, The Philippines, Vietnam, China, Japan, Australasia, introduced in the Caribbeans and spread to parts of North and South America. Data displayed in Table 1 and 2 demonstrated that the six-spotted zigzag ladybird preys on 77 species of aphids infesting 164 species of plants belonging to several families distributed throughout India except Jharkhand and Mizoram states. In union territories, it is recorded preying on aphids only in Jammu and Kashmir and Delhi. The most preferred prey is *Aphis gossypii* Glover which was found infesting 53 plant species distributed in 21 states/union territories followed by *Aphis (Aphis) craccivora* Koch infesting 35 plant species distributed in 25 states/union territories and *Myzus (Nectarosiphon) persicae* (Sulzer) infesting on 20 plant species distributed in 19 states/union territories (Table 1). Total number of tritrophic relationship of *Cheilomenes sexmaculata* (Fabricius) (predator-prey-host plant) reported in India was 270; maximally in Gujarat (72) followed by Uttar Pradesh (56), West Bengal (46), Bihar (43), Karnataka (40), Manipur (38), Maharashtra (25), and less than it in other states (Table 2, Figure 1).

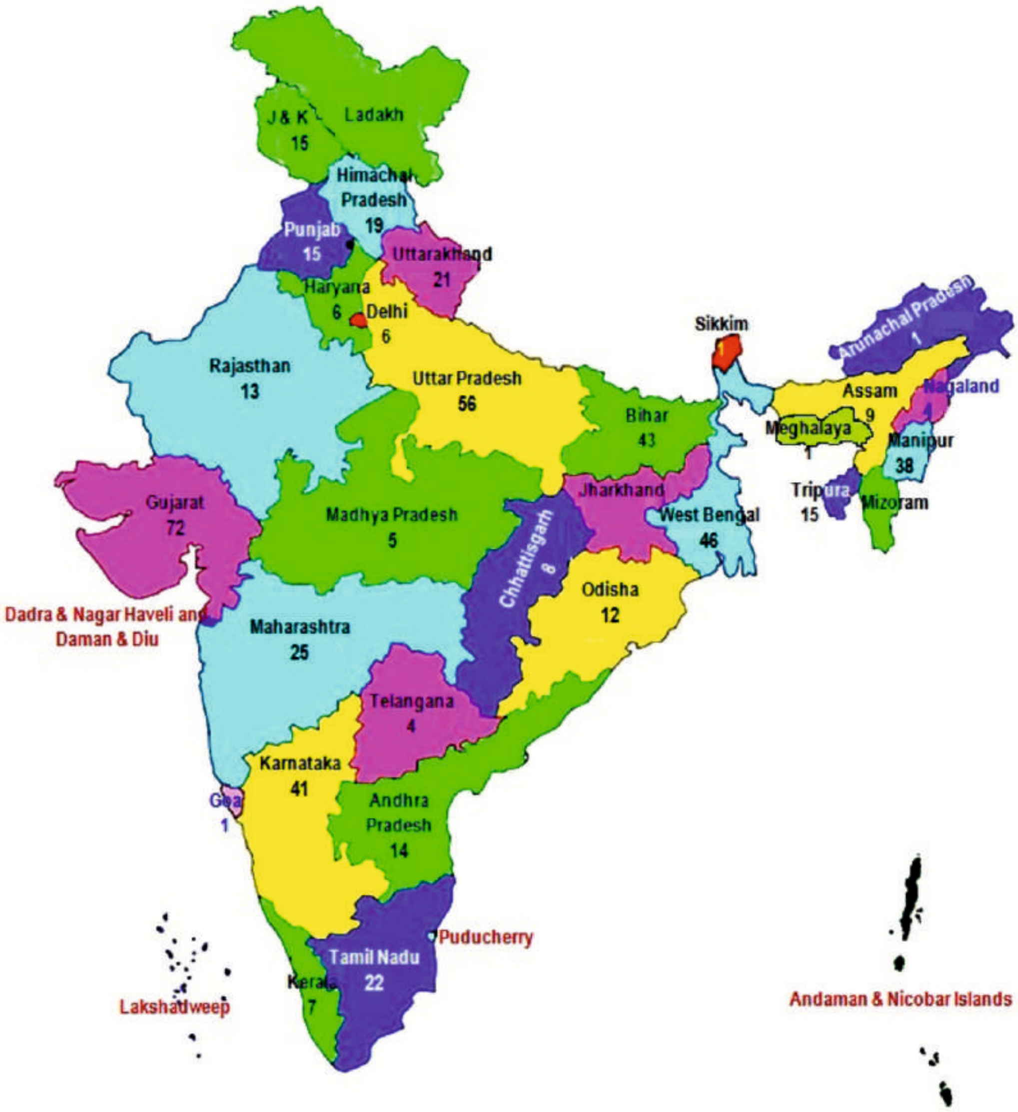

Fig. 1: Map showing the number of tritrophic association (predator-prey-food plant) and distribution of *aphidophagous coccinellid Cheilomenes* spp. in India.

Record of aphid preys and food plants in different states/union territories are given below.

***Acyrthosiphon (Acyrthosiphon) pisum* (Harris, 1776)**

- *Medicago sativa* L. - Karnataka (Megha et al., 2015)
- *Pisum sativum* L. - Manipur (Shantibala, 1989); - Nagaland (Shantibala, 1989); - Rajasthan (Sharma, 1973); - Uttar Pradesh (Mishra et al., 2011; Chaudhary and Singh, 2012); - West Bengal (Maji et al., 2023)
- *Vicia faba* L. - Uttar Pradesh (Tiwari et al., 2024)

***Acyrthosiphon* sp.**

- *Medicago sativa* L. - Gujarat (Chakraborty, 2012)

***Aphis (Aphis) affinis* del Guercio, 1911**

- *Mentha arvensis* L. - Himachal Pradesh (Singh and Bali, 1993); - Uttar Pradesh (Singh and Bali, 1993)
- *Hyoscyamus muticus* L. - Himachal Pradesh (Singh and Bali, 1993); - Uttar Pradesh (Singh and Bali, 1993)

Aphis (Aphis) asclepiadis Fitch, 1851

- Unknown plant - Uttar Pradesh (Agarwala, 1983)

***Aphis (Aphis) craccivora* Koch, 1854**

- *Aeschynomene indica* L. - Gujarat (Thamilvel, 2009)
- *Amaranthus tricolor* L. - Gujarat (Thamilvel, 2009)
- *Arachis hypogaea* L. - Andhra Pradesh (Routray et al., 2016); - Gujarat (Patel and Vyas, 1984; Parsana et al., 1997); - Karnataka (Megha et al., 2015); - Punjab (Bakhetia and Sidhu, 1977)
- *Cajanus cajan* (L.) Millsp. (syn. *Cajanus indicus* Spreng.) - Bihar (Ahmad et al., 2020); - Karnataka (Chinnu et al., 2023); - Tamil Nadu (Rekha et al., 2009)
- *Canavalia gladiata* (Jack) DC. - Gujarat (Thamilvel, 2009)
- *Crotolaria pallida* Aiton - Gujarat (Thamilvel, 2009)
- *Cyamopsis tetragonoloba* (L.) Taub. - Gujarat (Thamilvel, 2009); - Karnataka (Chinnu et al., 2023)
- *Gliricidia maculata* (Kunth) Steud. - Karnataka (Megha et al., 2015); - Tamil Nadu (Basheer, 1958; Chelliah, 1971)
- *Glycine max* L. - Karnataka (Megha et al., 2015)
- *Gossypium hirsutum* L. - Andhra Pradesh (Routray et al., 2016)
- *Helianthus annuus* L. - Andhra Pradesh (Routray et al., 2016)
- *Indigofera tinctoria* L. - Gujarat (Thamilvel, 2009)
- *Lablab purpureus (*L.) Sweet ssp. *purpureus* (syn. *Dolichos lablab* L.) - Bihar (Prabhakar and Roy, 2010; Rakhshan and Ahmad, 2015b; Ahmad et al., 2020); - Gujarat (Patel, 2015; Ashwini and Shukla, 2022); - Karnataka (Joshi et al., 1997; Chinnu et al., 2023); - Kerala (Jose, 2003); - Madhya Pradesh (Verma et al., 1983); - Maharashtra (Kale et al., 2020); - Manipur (Shantibala, 1989; Lokeshwari et al., 2006); - Nagaland (Shantibala, 1989); - Rajasthan (Sharma, 1973); - Tamil Nadu (Rekha et al., 2009); - Tripura (Agarwala et al., 1987a); - Uttar Pradesh (Omkar and Bind, 1998; Omkar and Bind, 2004; Chaudhary and Singh, 2012); - Uttarakhand (Pervez and Chandra, 2018); - West Bengal (Ghosh et al., 1981; Gurung et al., 2019)
- *Lathyrus aphaca* L. - West Bengal (Poddar, 1982)
- *Lathyrus* sp. - Bihar (Sharma and Yadav, 1994)
- *Macroptilium atropurpureum* (DC.) Urb. - Telangana (Shanker et al., 2018)
- *Medicago sativa* L. - Karnataka (Megha et al., 2015)
- *Mussaenda acuminata* Blume - West Bengal (Maji et al., 2023)
- *Phaseolus vulgaris* L. (syn. *Phaseolus sinensis* Schur) - Bihar (Prabhakar and Roy, 2010; Rakhshan and Ahmad, 2015b; Ahmad et al., 2020)
- *Pisum sativum* L. - Kerala (Mathew et al., 1971); - West Bengal (Pal et al., 2023)
- *Psophocarpus tetragonolobus* (L.) DC. - Gujarat (Thamilvel, 2009)
- *Ranunculus sceleratus* L. - Uttarakhand (Pervez and Chandra, 2018)
- *Rumex nepalensis* Spreng. - Sikkim (Poddar, 1982)
- *Senna sophera* (L.) Roxb. (syn. *Cassia sophera* L.) - West Bengal (Poddar, 1982)
- *Senna tora* (L.) Roxb. (syn. *Cassia tora* L.) - West Bengal (Poddar, 1982)

- *Solanum melongena* L. - Jammu and Kashmir (Bhat, 2017); - West Bengal (Satpathi and Mandal, 2006)
- *Tephrosia purpurea* (L.) Pers. - Gujarat (Thamilvel, 2009)
- *Trigonella foenum-graecum* L. - Himachal Pradesh (Poddar, 1982); - West Bengal (Poddar, 1982)
- *Vicia faba* L. - Andhra Pradesh (Rao et al., 1997); - Bihar (Sharma and Yadav, 1994; Ahmad et al., 2020); - Himachal Pradesh (Poddar, 1982); - Manipur (Shantibala, 1989); - West Bengal (Poddar, 1982)
- *Vicia lens* (L.) Coss. and Germ. (syn. *Lens esculenta* Moench) - Bihar (Sharma and Yadav, 1994)
- *Vigna mungo* (L.) Hepper (syn. *Phaseolus roxburghii* Wight and Arn.; *Phaseolus mungo* L.) - Andhra Pradesh (Routray et al., 2016); - Bihar (Rakhshan and Ahmad, 2015b; Rakhshan et al., 2018); - Gujarat (Chakraborty, 2012); - Karnataka (Megha et al., 2015); - Rajasthan (Jat and Rana, 2018); - Tamil Nadu (Rekha et al., 2009); - West Bengal (Poddar, 1982)
- *Vigna radiata* (L.) R. Wiczek (syn. *Phaseolus radiatus* L.) (syn. *Phaseolus aureus* Roxb.) - Andhra Pradesh (Routray et al., 2016); - Assam (Sorokhaibam and Dutta, 2011); - Bihar (Rakhshan and Ahmad, 2015b; Rakhshan et al., 2018); - Karnataka (Megha et al., 2015)
- *Vigna trilobata* (L.) Verdc. - Telangana (Shanker et al., 2018)
- *Vigna unguiculata* (L.) Walp. (syn. *Vigna catjang* (Burm.f.) Walp.) - Andhra Pradesh (Routray et al., 2016; Vasista et al., 2021);- Chhattisgarh (Nagdev et al., 2022); - Delhi (Rai et al., 2003; Pandi et al., 2012); - Gujarat (Aniyaliya et al., 2022; Singh et al., 2024); - Karnataka (Srikanth and Lakkundi, 1990; Joshi et al., 1997; Megha et al., 2015); - Kerala (Nandakumar and Sheela, 1996; Jagdish et al., 2011); - Odisha (Mishra et al., 2022); - Rajasthan (Chhangani et al., 2022); - Tripura (Agarwala and Bardhanroy, 1997); - West Bengal (Poddar, 1982)
- *Vigna unguiculata* ssp. *unguiculata* (L.) Walp. (syn. *Vigna sinensis* (L.) Savi ex Hassk.) - Tamil Nadu (Rajamohan and Jayaraj, 1973; Walawalkar et al., 2019); - West Bengal (Poddar, 1982)

***Aphis (Aphis) cytisorum* Hartig, 1841**

- *Laburnum anagyroides* Medik., 1787 (syn. *Cytisus laburnum* L.) - Punjab (Modawal, 1941)

***Aphis (Aphis) fabae* Scopoli, 1763**

- *Vicia faba* L. Odisha (Behura and Parida, 1979); - Tamil Nadu (Babu and Ananthakrishnan, 1993)

***Aphis (Aphis) glycines* Matsumura, 1917**

- *Glycine max* L. - Manipur (Singh and Singh, 2000)

***Aphis (Aphis) gossypii* Glover, 1877**

- *Abelmoschus esculentus* (L.) Moench (syn. *Hibiscus esculentus* L.) - Assam (Das et al., 2021); - Bihar (Prabhakar and Roy, 2010; Ahmad et al., 2020); - Gujarat (Chakraborty, 2012); - Maharashtra (Kale et al., 2020); - Tamil Nadu (Rajamohan and Jayaraj, 1973; Rekha et al., 2009); - Uttarakhand (Bhatt et al., 2018); - West Bengal (Gurung et al., 2019)
- *Acalypha indica* L. - Gujarat (Thamilvel, 2009)
- *Ageratum conyzoides* L. - Gujarat (Thamilvel, 2009); - Tripura (Ghosh et al., 2017)
- *Amaranthus tricolor* L. - Gujarat (Thamilvel, 2009)
- *Anethum graveolens* L. - Jammu and Kashmir (Butani and Kapadia, 2000a)
- *Arachis hypogaea* L. - Andhra Pradesh (Vasista et al., 2021)
- *Artocarpus integer* (Thunb.) Merr. (syn. *Artocarpus integrifolia* L.f.) - Manipur (Devi and Singh, 1987)
- *Barleria prionitis* L. - Gujarat (Thamilvel, 2009)
- *Benincasa hispida* Cogn. - Chhattisgarh (Bisen et al., 2017)
- *Boerhavia repens* L. - Gujarat (Thamilvel, 2009)
- *Brassica oleracea* L. - Bihar (Prakash and Rani, 2015); - Manipur (Devjani and Singh, 1998; Singh et al., 2002)
- *Cajanus cajan* (L.) Millsp. (syn. *Cajanus indicus* Spreng.) - Bihar (Ahmad et al., 2020)
- *Capsicum annuum* L. - Chhattisgarh (Kumar et al., 2020b); - Gujarat (Thamilvel, 2009); Uttar Pradesh (Tiwari et al., 2024); - West Bengal (Maji et al., 2023)
- *Capsicum chinense* Jacq. - Assam (Begam et al., 2016; Thangjam et al., 2020)

- *Capsicum frutescens* L. - Bihar (Ahmad et al., 2020); - Gujarat (Thamilvel, 2009); - Tamil Nadu (Rekha et al., 2009); Uttar Pradesh (Tiwari et al., 2024); - West Bengal (Gurung et al., 2019)
- *Cardiospermum halicacabum* L. - Gujarat (Thamilvel, 2009)
- *Catharanthus pusillus* (Murray) G.Don - Gujarat (Thamilvel, 2009)
- *Catharanthus roseus* (L.) G.Don - Bihar (Ahmad et al., 2020); - Gujarat (Thamilvel, 2009)
- *Centella asiatica* (L.) Urb. - Gujarat (Thamilvel, 2009)
- *Chromolaena odorata* (L.) R.M.King and H.Rob. (syn. *Eupatorium odoratum* L.) - Manipur (Shantibala, 1989)\
- *Coccinia grandis* (L.) Voigt (syn. *Coccinia indica* Wight and Arn.) - Gujarat (Thamilvel, 2009)
- *Commelina benghalensis* L. - Gujarat (Thamilvel, 2009)
- *Coriandrum sativum* L. - Gujarat (Butani and Kapadia, 2000a)
- *Cucumis sativus* L. - Gujarat (Thamilvel, 2009); - Manipur (Shantibala, 1989)
- *Cucurbita maxima* Duchesne - Tripura (Ghosh et al., 2017); Uttar Pradesh (Tiwari et al., 2024)
- *Cyanthillium cinereum* (L.) H.Rob. (syn. *Vernonia cinerea* (L.) Less.) - Gujarat (Thamilvel, 2009)
- *Foeniculum vulgare* Mill. - Bihar (Ahmad et al., 2020)
- *Gloriosa superba* L. - Gujarat (Thamilvel, 2009)
- *Gossypium arboreum* L. (syn. *Gossypium indicum* Medik.) - West Bengal (Agarwala and Saha, 1986)
- *Gossypium herbaceum* L. - Gujarat (Butani and Kapadia, 2000b)
- *Gossypium hirsutum* L. - Andhra Pradesh (Gunneswara Rao, 2013); - Delhi (Pandi et al., 2012; Venkanna et al., 2020); - Gujarat (Chakraborty, 2012; Patel, 2015; Aniyaliya et al., 2022); - Karnataka (Jalali and Singh, 1994; Joshi et al., 1999; Megha et al., 2015); - Maharashtra (Vennila, 1998; Vennila et al., 2007; Kale et al., 2020); - Odisha (Bhattacharyya et al., 2019); - Rajasthan (Dhaka, 2013); - Tamil Nadu (Veeravel and Jeganathan, 2002); - Uttarakhand (Joshi and Sharma, 2008); - West Bengal (Maji et al., 2023)
- *Helianthus annuus* L. - Maharashtra (Kale et al., 2020)
- *Hibiscus rosasinensis* L. - Bihar (Ahmad et al., 2020)
- *Lagenaria siceraria* (Molino) Standl. (syn. *Lagenaria leucantha* Rusby; *Lagenaria vulgaris* Ser.) - Bihar (Kumar et al., 2016; Ahmad et al., 2020); - Jammu and Kashmir (Bhat, 2017); - Uttar Pradesh (Omkar and Bind, 1998; Omkar and Bind, 2004); - West Bengal (Saha et al., 2016)
- *Luffa aegyptiaca* Mill. (syn. *Luffa cylindrica* M. Roem.) - Bihar (Ahmad et al., 2020)
- *Luffa acutangula* (L.) Roxb. - Uttar Pradesh (Tiwari et al., 2024)
- *Magnolia champaka* (L.) Baill. ex Pierre (syn. *Michelia champaka* L.) - Manipur (Shantibala, 1989)
- *Malus domestica* (Suckow) Borkh. (syn. *Pyrus malus* L.) - Manipur (Devi and Singh, 1987); - West Bengal (Chakrabarti et al., 2012)
- *Momordica charantia* L. - Bihar (Ahmad et al., 2020); - Gujarat (Thamilvel, 2009); - Kerala (Jose, 2003)
- *Ocimum tenuiflorum* L. (syn. *Ocimum sanctum* L.) - West Bengal (Maji et al., 2023)
- *Plantago ovata* Forssk. - Rajasthan (Ola et al., 2024)
- *Psidium guajava* L. - Karnataka (Mani and Krishnamoorthy, 1989); - Manipur (Devi and Singh, 1987)
- *Cleome rutidosperma* DC. var. *burmanni* (Wight and Arn.) Siddiqui and S.N.Dixit (syn. *Cleome burmanni* Wight and Arn.) - Gujarat (Thamilvel, 2009)
- *Solanum lycopersicum* L. (syn. *Lycoperiscon esculentum* Mill.) - Haryana (Khokhar and Rolania, 2021); - Gujarat (Thamilvel, 2009); - Kerala (Jose, 2003); - Tamil Nadu (Rekha et al., 2009)
- *Solanum melongena* L. - Andhra Pradesh (Rao et al., 1997); - Assam (Kalita et al., 1998; Borah and Saikia, 2017); - Bihar (Ahmad et al., 2020); - Delhi (Anand, 1984); - Gujarat (Thamilvel, 2009); - Jammu and Kashmir (Bhat, 2017); - Karnataka (Prashanth et al., 2024); - Madhya Pradesh (Verma et al., 1983); - Manipur (Lokeshwari et al., 2006); - Meghalaya (Boruah

and Pathak, 2023); - Rajasthan (Sharma, 1973); - Tamil Nadu (Veeravel and Baskaran, 1995; Rekha et al., 2009); - Uttar Pradesh (Afroze, 2001; Chaudhary and Singh, 2012); - West Bengal (Chaudhuri et al., 1983; Satpathi, 1999; Satpathi and Mandal, 2006; Gurung et al., 2019)

- *Solanum nigrum* L. - Manipur (Shantibala, 1989)
- *Solanum tuberosum* L. - Manipur (Nonita et al., 2002); - Uttar Pradesh (Raj, 1989)
- *Solanum* sp. - Manipur (Shantibala, 1989)
- *Stachytarpheta jamaicensis* (L.) Vahl - Gujarat (Thamilvel, 2009)
- *Trachyspermum ammi* Sprague (syn. *Carum copticum* (L.) Benth. and Hook.f. ex Hiern - Gujarat (Butani and Kapadia, 2000a)
- *Trichosanthes cucumerina* L. (syn. *Trichosanthes anguina* L.) - Gujarat (Thamilvel, 2009)
- *Tridax procumbens* L. - Telangana (Shanker et al., 2018)

Aphis (Aphis) kurosawai **Takahashi, 1921**

- *Artemisia vulgaris* L. - Manipur (Shantibala, 1989); - Uttarakhand (Ghosh et al., 1991)

Aphis (Aphis) longisetosa **Basu, 1970**

- *Abelmoschus esculentus* Moench (syn. *Hibiscus esculentus* L.) - Himachal Pradesh (Agarwala et al., 1981)

Aphis (Aphis) nasturtii **Kaltenbach, 1843**

- *Capsicum frutescens* L. - Uttar Pradesh (Chaudhary and Singh, 2012)
- *Solanum melongena* L. - Bihar (Ahmad et al., 2020)

Aphis (Aphis) nerii **Boyer de Fonsc., 1841**

- *Calotropis gigantea* (L.) W.T. Aiton - Bihar (Ahmad et al., 2020); - Gujarat (Thamilvel, 2009); - Karnataka (Joshi et al., 1999); - Tamil Nadu (Babu and Ananthakrishnan, 1993; Pugalenthi and Livingstone, 1997; Murugan et al., 2000)
- *Calotropis procera* (Aiton) Dryand. - Gujarat (Patel, 2015); Odisha (Behura and Parida, 1979); - Tripura (Agarwala et al., 1987b); - Uttar Pradesh (Omkar and Bind, 1998; Chaudhary and Singh, 2012); - West Bengal (Chaudhary et al., 1983)
- *Calotropis* sp. - Karnataka (Puttarudriah and Channa Basavanna, 1956)
- *Capsicum annuum* L. - Gujarat (Thamilvel, 2009)
- *Gymnema sylvestre* (Retz.) R.Br. ex Sm. - Gujarat (Tiwari et al., 2014; Shivakumara et al., 2022)
- *Leptadenia reticulata* (Retz.) Wight and Arn. - Gujarat (Chakraborty, 2012)

Aphis (Aphis) odinae **(van der Goot, 1917)**

- *Anacardium occidentale* L. - Goa (Maruthadurai and Singh, 2017; Maruthadurai, 2019); - Karnataka (Mulimani and Rajanna, 2014; Chinnu et al., 2023)
- *Mangifera indica* L. - Uttar Pradesh (Chaudhary and Singh, 2012); - West Bengal (Maji et al., 2023)

Aphis (Aphis) pomi **de Geer, 1773**

- *Malus domestica* (Suckow) Borkh. (syn. *Pyrus malus* L.) - Himachal Pradesh (Kumari et al., 2006; Kumari, 2019); - Jammu and Kashmir (Bhagat et al., 1988; Khan and Shah, 2018)

Aphis (Aphis) punicae **Passerini, 1863**

- *Punica granatum* L. - Jammu and Kashmir (Mohi-ud-din et al., 2019); - Karnataka (Mani and Krishnamoorthy, 1995; Sreedevi, 2003; Sreedevi and Verghese, 2007)

Aphis (Aphis) rumicis **Linnaeus, 1758**

- *Vigna unguiculata* (L.) Walp. (syn. *Vigna catjang* (Burm.f.) Walp.) - Karnataka (Puttarudriah and Channa Basavanna, 1956)

Aphis (Aphis) solanella **Theobald, 1854**

- *Capsicum frutescens* L.-Uttar Pradesh (Chaudhary and Singh, 2012; Tiwari et al., 2024)

Aphis (Aphis) spiraecola **Patch, 1914**

- *Ageratum conyzoides* L. - Tripura (Ghosh et al., 2017)
- *Cestrum diurnum* L. - Uttar Pradesh (Chaudhary and Singh, 2012)
- *Cestrum nocturnum* L. - Uttar Pradesh (Tiwari et al., 2024)
- *Citrus jambhiri* Lush. - Maharashtra (Rao and Shivanhar, 2012)
- *Citrus reticulata* Blanco - Maharashtra (Rao and Shivanhar, 2012)
- *Coriandrum sativum* L. - Bihar (Ahmad et al., 2020); - Uttar Pradesh (Tiwari et al., 2024)

- *Cosmos bipinnatus* Cav. - Uttar Pradesh (Dubey and Singh, 2011)
- *Cosmos* sp. - Bihar (Ahmad et al., 2020)
- *Solanum melongena* L. - Bihar (Ahmad et al., 2020); Uttar Pradesh (Tiwari et al., 2024)
- *Vicia faba* L. - Uttar Pradesh (Tiwari et al., 2024)
- Unknown - Tripura (Agarwala et al., 1987b)

Aphis (Aphis) umbrella **(Börner, 1950)**

- *Cucurbita moschata* Duchesne - Tamil Nadu (Rajamohan and Jayaraj, 1973)

Aphis **(*Toxoptera*)** ***aurantii*** **Boyer de Fonsc., 1841**

- *Camellia sinensis* (L.) Kuntze (syn. *Camellia thea* Link) - Assam (Das and Rava, 1968; Das and Kakoty, 1992; Roy and Rahman, 2014); - Karnataka (Muraleedharan et al., 1988; Radhakrishnan and Muraaledharan, 1991); - Kerala (Muraleedharan et al., 1988; Radhakrishnan and Muraaledharan, 1995); - Tamil Nadu (Radhakrishnan and Muraaledharan, 1995)
- *Chrysanthemum indicum* L. – Bihar (Ahmad et al., 2012)
- *Citrus* ^{x}*aurantium* L. - Manipur (Devi and Singh, 1987; Chakrabarti et al., 2012); - Uttar Pradesh (Chaudhary and Singh, 2012)
- *Citrus* sp. - Karnataka (Mani and Krishnamoorthy, 2005)
- *Mangifera indica* L. - Manipur (Devi and Singh, 1987)
- *Phlogacanthus thyrsiformis* (Roxb. ex Hardw.) Mabb. (syn. *Phlogacanthus thyrsiflorus* (Roxb.) Nees) - West Bengal (Maji et al., 2023)
- *Schima wallichii* (DC.) Korth. – West Bengal (Raychaudhuri et al., 1998)
- Unknown - Tripura (Agarwala et al., 1987b)

Aphis (Toxoptera) citricidus **(Kirkaldy, 1907)**

- *Citrus maxima* (Burm.) Merr. (syn. *Citrus decumana* L., *Citrus grandis* (L.) Osbeck) - Manipur (Devi and Singh, 1987; Shantibala, 1989)
- *Citrus* sp. - Maharashtra (Kale et al., 2020)

Brachycaudus (Brachycaudus) helichrysi **(Kaltenbach, 1843)**

- *Artemisia vulgaris* L. - Nagaland (Shantibala, 1989)
- *Chromolaena odorata* (L.) R.M.King and H.Rob. (syn. *Eupatorium odoratum* L.) - Nagaland (Raychaudhuri et al., 1978; Chakrabarti et al., 2012)
- *Clerodendron* sp. - Uttar Pradesh (Chaudhary and Singh, 2012)

Brevicoryne brassicae **(Linnaeus, 1758)**

- *Brassica juncea* (L.) Czern - Himachal Pradesh (Soni et al., 2021); - Uttarakhand (Verma et al., 2023)
- *Brassica napus* L. - Uttar Pradesh (Tiwari et al., 2024)
- *Brassica oleracea* L. - Assam (Sarma et al., 2021); - Bihar (Prakash and Rani, 2015); Delhi (Anand, 1984); - Gujarat (Chakraborty, 2012; Patel, 2015); - Himachal Pradesh (Sharma and Verma, 1993); - Jammu and Kashmir (Mir, 2013; Bhat, 2017); - Karnataka (Bhaskar and Viraktamath, 2002; Chinnu et al., 2023); - Manipur (Debraj et al., 1997; Devjani and Singh, 1998; Singh et al., 2002); - Odisha (Mandal and Patnaik, 2006a, 2008); - Rajasthan (Sharma, 1973; Jat et al., 2017); - Uttar Pradesh (Omkar and Bind, 1998; Afroze, 2001; Chaudhary and Singh, 2012)
- *Brassica oleracea* L. var. *capitata* - Chhattisgarh (Singh, 2014); - Uttar Pradesh (Pal and Singh, 2012)
- *Brssica rapa* L. - Uttar Pradesh (Tiwari et al., 2024); - Uttarakhand (Sharma and Joshi, 2012)
- *Brassica* sp. - Jammu and Kashmir (Khan et al., 2009)
- *Raphanus sativus* L. - Uttar Pradesh (Tiwari et al., 2024)

Capitophorus himalayensis **Ghosh, Ghosh and Raychaudhuri, 1971**

- Unidentified plant of Polygonaceae ? - West Bengal (Agarwala, 1983)

Cavariella (Cavariella) aegopodii **(Scopoli, 1763)**

- *Salix tetrasperma* Roxb. - Uttarakhand (Ghosh et al., 1986)

Cavariella (Cavariella) indica **Maity and Chakrabarti, 1982**

- *Salix babylonica* L. - Uttarakhand (Ghosh et al., 1991)

Cavariella (Cavariella) simlaensis **Chowdhuri, Basu and Raychaudhuri, 1969**

- Indet - Himachal Pradesh (Das and Raychaudhuri, 1983)

***Ceratovacuna lanigera* Zehntner, 1897**

- *Saccharum officinarum* L. - Karnataka (Patil et al., 2006; Kiran et al., 2019); - Maharashtra (Rabindra et al., 2002); - Manipur (Shantibala, 1989); - West Bengal (Maji et al., 2023)

***Cervaphis rappardi indica* Basu, 1961**

- *Cajanus cajan* (L.) Millsp. (syn. *Cajanus indicus* Spreng.) - Manipur (Shantibala et al., 1994; Shantibala et al., 1997); - West Bengal (Maji et al., 2023)
- *Cannabis sativa* L. - Manipur (Shantibala, 1989)

***Cervaphis schouteniae* van der Goot, 1917**

- Unknown - Tripura (Agarwala et al., 1987b)

***Chaitophorus himalayensis* (Das, 1918)**

- *Salix* sp. - Himachal Pradesh (Das, 1918; Das and Raychaudhuri, 1983)

***Coloradoa rufomaculata* (Wilson, 1908)**

- *Chrysanthemum* sp. - Himachal Pradesh (Das and Raychaudhuri, 1983)

***Eriosoma lanigerum* (Hausmann, 1802)**

- *Malus domestica* (Suckow) Borkh– Uttarakhand (Maurya, 2011)

***Epipemphigus imaicus* (Cholodkovsky, 1912)**

- *Populus ciliata* Wall. ex Royle - Uttarakhand (Ghosh et al., 1991)

***Greenidea (Trichosiphum) psidii* van der Goot, 1917**

- *Psidium guajava* L. – Bihar (Ahmad et al., 2012); - Manipur (Devjani and Singh, 2007); - Uttar Pradesh (Tiwari et al., 2024); - West Bengal (Ghosh and Raychaudhuri. 1982; Chakrabarti et al., 2012)
- *Syzygium cumini* (L.) Skeels (syn. *Eugenia jambolana* Lam.) - Manipur (Devi and Singh, 1987)

***Greenideoida (Greenideoida) ceyloniae* van der Goot, 1917**

- *Mesua ferrea* L. - Chhattisgarh (Rawat and Modi, 1969)
- Unknown - Tripura (Agarwala et al., 1987b)

***Hyadaphis coriandri* (Das, 1918)**

- *Anethum graveolens* L. - Jammu and Kashmir (Butani and Kapadia, 2000a); - Karnataka (Chinnu et al., 2023)
- *Coriandrum sativum* L. - Haryana (Purti et al., 2017); - Jammu and Kashmir (Butani and Kapadia, 2000a); - Punjab (Sagar and Kumar, 1996); - Rajasthan (Lekha and Jat, 2002; Meena et al., 2009); - Uttar Pradesh (Chaudhary and Singh, 2012; Tiwari et al., 2024); - West Bengal (Maji et al., 2023)
- *Foeniculum vulgare* Mill. - Gujarat (Patel, 2015; Kanjiya et al., 2018)
- *Trachyspermum ammi* Sprague (syn. *Carum copticum* (L.) Benth. and Hook.f. ex Hiern - Gujarat (Butani and Kapadia, 2000a)
- Unknown - Tripura (Agarwala et al., 1987b)

***Hyalopterus pruni* (Geoffroy, 1762)**

- *Phragmites karka* (Retz.) Trin. ex Steud. - Uttar Pradesh (Chaudhary and Singh, 2012)
- *Prunus amygdalus* Batsch - Manipur (Devi and Singh, 1987)
- *Prunus persica* (L.) Batsch - Manipur (Devi and Singh, 1987; Varatharajan et al., 1991)

***Hysteroneura setariae* (Thomas, 1878)**

- *Amaranthus tricolor* L. - Gujarat (Thamilvel, 2009)
- *Andropogon* sp. – Bihar (Ahmad *et al*., 2012)
- *Chloris barbata* Sw. - Gujarat (Thamilvel, 2009)
- *Cynodon dactylon* (L.) Pers. - Uttar Pradesh (Omkar and Bind, 1993, 1995)
- *Cyperus rotundus* L. - Uttar Pradesh (Chaudhary and Singh, 2012)
- *Dactyloctenium aegyptium* (L.) Willd. - Gujarat (Thamilvel, 2009)
- *Digitaria ciliaris* (Retz.) Koeler - Gujarat (Thamilvel, 2009)
- *Elaeis guineensis* Jacq. - Karnataka (Dhileepan, 1996)
- *Melinis repens* (Willd.) Zizka - Karnataka (Chinnu et al., 2023)
- *Triticum aestivum* L. (syn. *Triticum sativum* Lam., *Triticum vulgare* Vill.) - Maharashtra (Kale et al., 2020)

***Liosomaphis atra* Hille Ris Lambers, 1966**

- *Berberis* sp. - Himachal Pradesh (Das and Raychaudhuri, 1983)

***Lipaphis (Lipaphis) erysimi* (Kaltenbach, 1843)**

- *Arivela viscosa* (L.) Raf. (syn. *Cleome viscosa* L.) - Gujarat (Thamilvel, 2009)

- *Brassica carinata* A. Braun - Punjab (Kumar, 2015)
- *Brassica juncea* (L.) Czern - Assam (Das, 2020); - Chhattisgarh (Kolhekar et al., 2019); - Delhi (Pandi et al., 2012); - Gujarat (Patel, 2015); - Haryana (Kalra, 1988); - Himachal Pradesh (Soni et al., 2021); - Karnataka (Joshi et al., 1999); - Madhya Pradesh (Mishra and Kanwat, 2017); - Manipur (Rajeshwari and Singh, 2022); - Punjab (Sharma et al., 1997; Soni et al., 2004; Kumar, 2015); - Uttar Pradesh (Shukla and Kumar, 2024; Tiwari et al., 2024); - Uttarakhand (Verma et al., 2023); - West Bengal (Ghosh, 1983)
- *Brassica napus* L. - Manipur (Shantibala, 1989); - Punjab (Kumar, 2015); - Uttar Pradesh (Tiwari et al., 2024)
- *Brassica nigra* L. - West Bengal (Ghosh et al., 1981)
- *Brassica oleracea* L. - Andhra Pradesh (Rao et al., 1997); - Bihar (Prakash and Rani, 2015); - Gujarat (Chakraborty, 2012); - Maharashtra (Shaikh et al., 2020); - Manipur (Devjani and Singh, 1998); - Odisha (Mandal and Patnaik, 2006b)
- *Brassica oleracea* L. var. *capitata* - Chhattisgarh (Singh, 2014); - Uttar Pradesh (Tiwari et al., 2024)
- *Brassica rapa* L. (syn. *Brassica campestris* L.) - Bihar (Prabhakar and Roy, 2010; Kumar et al., 2016); Delhi (Anand, 1984); - Gujarat (Chakraborty, 2012; Singh et al., 2024); - Haryana (Rana, 2006); - Jammu and Kashmir (Mir, 2013; Bhat, 2017); - Madhya Pradesh (Verma et al., 1983); - Maharashtra (Kale et al., 2020; Shaikh et al., 2020); - Punjab (Kumar, 2015; Shenhmar and Brar, 1995); - Rajasthan (Sharma, 1973; Singh et al., 2008); - Uttar Pradesh (Omkar and Bind, 1998; Hugar et al., 2008; Chaudhary and Singh, 2012); - Uttarakhand (Joshi and Sharma, 2008; Pervez and Chandra, 2018); - West Bengal (Chaudhuri et al., 1983)
- *Brassica* sp. - Jammu and Kashmir (Khan et al., 2009); - Punjab (Modawal, 1941)
- *Eruca vesicaria* (L.) Cav. (syn. *Eruca sativa* Miller) - Punjab (Kumar, 2015)
- *Raphanus sativus* L. - Gujarat (Thamilvel, 2009); - Maharashtra (Shaikh et al., 2020); - Uttarakhand (Pervez and Chandra, 2018)
- *Vigna unguiculata* (L.) Walp. (syn. *Vigna catjang* (Burm.f.) Walp.) - Andhra Pradesh (Rao et al., 1997)
- Unknown - Tripura (Agarwala et al., 1987b)

***Lipaphis (Lipaphis) pseudobrassicae* (Davis, 1914)**
- *Brassica juncea* (L.) Czern - Gujarat (Aniyaliya et al., 2022); - Jammu and Kashmir (Khan and Shah, 2017)
- *Brassica oleracea* L. - Jammu and Kashmir (Khan and Shah, 2017)

***Macrosiphoniella (Macrosiphoniella) kalimpongensis* Basu and Raychaudhuri, 1976**
- Unknown - Tripura (Agarwala et al., 1987b)

***Macrosiphoniella (Macrosiphoniella) pseudoartemisiae* Shinji, 1933**
- *Artemisia vulgaris* L. - Uttarakhand (Ghosh et al., 1991)

***Macrosiphoniella (Macrosiphoniella) sanborni* (Gillette, 1908)**
- *Chrysanthemum indicum* L. – Bihar (Ahmad et al., 2012); - Uttar Pradesh (Chaudhary and Singh, 2012); - West Bengal (Maji et al., 2023)
- *Chrysanthemum* sp. - Odisha (Nayak and Behura, 1969); - Uttarakhand (Ghosh et al., 1991)
- *Tanacetum cinerariifolium* Sch. Bip. (syn. *Chrysanthemum cinerariifolium* Vis.) - Uttar Pradesh (Afroze, 2001)

***Macrosiphum (Macrosiphum) rosae* (Linnaeus, 1758)**
- *Brassica juncea* (L.) Czern - Uttarakhand (Verma et al., 2023)
- *Rosa indica* L. - Uttar Pradesh (Chaudhary and Singh, 2012; Tiwari et al., 2024)
- *Rosa* sp. - Himachal Pradesh (Agarwala et al., 1981); - Karnataka (Raj, 1989; Chinnu et al., 2023)

***Melanaphis bambusae* (Fullaway, 1910)**
- *Bambusa* sp. - Manipur (Shantibala, 1989)

***Melanaphis donacis* (Passerini, 1862)**
- *Arundo donax* L. - Manipur (Shantibala, 1989)

***Melanaphis sacchari* (Zehntner, 1897)**
- *Sorghum bicolor* (L.) Moench (syn. *Sorghum vulgare* Pers.) - Andhra Pradesh (Sharma and Dhillon, 2005); - Odisha (Patnaik et al., 1977); - Tamil Nadu (Rekha et al., 2009); - Uttar Pradesh (Tiwari et al., 2024)

- *Zea mays* L. - Odisha (Patnaik et al., 1977)
- Unknown - Tripura (Agarwala et al., 1987b)

Melanaphis sacchari indosacchari **(David, 1956)**
- *Saccharum officinarum* L. - Tamil Nadu (Easwaramoorthy et al., 1998)

Myzus (Nectarosiphon) persicae **(Sulzer, 1776)**
- *Abelmoschus esculentus* Moench - Karnataka (Megha et al., 2015); - West Bengal (Gurung et al., 2019)
- *Ageratum conyzoides* L. - Telangana (Shanker et al., 2018)
- *Brassica juncea* (L.) Czern - Bihar (Prabhakar and Roy, 2010); - Himachal Pradesh (Soni et al., 2021); - Karnataka (Chinnu et al., 2023)
- *Brassica oleracea* L. - Bihar (Prakash and Rani, 2015); - Gujarat (Chakraborty, 2012); - Karnataka (Bhaskar and Viraktamath, 2002; Megha et al., 2015); - Manipur (Devjani and Singh, 1998; Singh et al., 2002; Bijaya et al., 2006); - Odisha (Mandal and Patnaik, 2006a; 2008)
- *Brassica rapa* L. (syn. *Brassica pekinensis* Skeels; *Brassica campestris* L.; *Brassica rapa* subsp. *oleifera* (DC.) Metzg.) - Gujarat Chakraborty, 2012); - Manipur (Bijaya et al., 2001); Uttarakhand (Sharma and Joshi, 2012); - West Bengal (Chaudhuri et al., 1983)
- *Capsicum annuum* L. - Punjab (Kaur and Sangha, 2016)
- *Capsicum chinense* Jacq. - Assam (Thangjam et al., 2020)
- *Capsicum frutescens* L. - Karnataka (Megha et al., 2015); - Tamil Nadu (Rajagopal and Karim, 1979)
- *Cuminum cyminum* L. (syn. *Cuminum sativum* L.) - Rajasthan (Gupta and Yadav, 1989a)
- *Hyoscyamus muticus* L. - Himachal Pradesh (Singh and Bali, 1993); - Uttar Pradesh (Singh and Bali, 1993)
- *Linum usitatissimum* L. - West Bengal (Gurung et al., 2019)
- *Raphanus sativus* L. - Uttar Pradesh (Tiwari et al., 2024)
- *Sesamum indicum* L. (syn. *Sesamum orientale* L.) - Manipur (Shantibala, 1989)
- *Solanum lycopersicum* L. (syn. *Lycoperiscon esculentum* Mill.) - Gujarat (Thamilvel, 2009); - Haryana (Khokhar and Rolania, 2021); - Jammu and Kashmir (Bhat, 2017); - Tamil Nadu (Rekha et al., 2009); - Uttar Pradesh (Chaudhary and Singh, 2012)
- *Solanum melongena* L. - Assam (Borah and Saikia, 2017); – Bihar (Ahmad et al., 2012); - Gujarat (Thamilvel, 2009); - Uttar Pradesh (Omkar and Bind, 2004; Tiwari et al., 2024); - West Bengal (Satpathi and Mandal, 2006; Gurung et al., 2019)
- *Solanum nigrum* L. - Gujarat (Thamilvel, 2009); - Uttar Pradesh (Omkar and Bind, 1998; Tiwari et al., 2024)
- *Solanum tuberosum* L. - Bihar (Parween et al., 2023); - Manipur (Shantibala, 1989; Nonita et al., 2002); - Uttar Pradesh (Raj, 1989)
- *Spinacia oleracea* L. - Bihar (Parween et al., 2023)
- *Tagetes erecta* L. - Chhattisgarh (Bhagat et al., 2018)
- *Urtica dioica* L. - Manipur (Shantibala, 1989)

Myzus (Nectarosiphon) persicae nicotianae **Blackman, 1987**
- *Nicotiana tabacum* L. - Andhra Pradesh (Joshi et al., 1979; Rao et al., 2007); - Bihar (Parween et al., 2023); - Karnataka (Venkatesan et al., 2002; Jagadish et al., 2010)

Pemphigus (Pemphigus) napaeus **Buckton, 1896**
- *Populus* sp. - Himachal Pradesh (Agarwala et al., 1981)

Pentalonia nigronervosa **Coquerel, 1859**
- *Musa acuminata* Colla (syn. *Musa cavendishii* Lamb.) - Kerala (Padmalatha and Singh, 1998); - Tamil Nadu (Poorani et al., 2023)

Phorodon (Diphorodon) cannabis **Passerini, 1860**
- *Cannabis sativa* L. – Bihar (Ahmad et al., 2012); - Uttarakhand (Ghosh et al., 1991)

Prociphilus **sp.**
- *Lonicera quinquelocularis* Hardw. - Uttarakhand (Ghosh et al., 1991)

Rhopalosiphum maidis **(Fitch, 1856)**
- *Cenchrus americanus* (L.) Morrone (syn. *Pennisetum glaucum* R. Br.; *Pennisetum typhoides* (Burm.f.) Stapf and C.E.Hubb.) - Gujarat (Chakraborty, 2012); - Karnataka (Savithri and Prakash, 2023); - Rajasthan (Sharma, 1973); - Tamil Nadu (Rekha et al., 2009)

- *Pennisetum purpureum* Schumach. - Gujarat (Chakraborty, 2012)
- *Sorghum bicolor* (L.) Moench (syn. *Sorghum vulgare* Pers.) - Delhi (Gautam, 1989); - Gujarat (Chakraborty, 2012); - Karnataka (Megha et al., 2015); - Maharashtra (Kale et al., 2020); Odisha (Nayak et al., 1981); - Punjab (Modawal, 1941); - Tamil Nadu (Rajamohan. and Jayaraj, 1973; Rekha et al., 2009)
- *Triticum aestivum* L. (syn. *Triticum sativum* Lam., *Triticum vulgare* Vill.) - Karnataka (Megha et al., 2015); - West Bengal (Gurung et al., 2019)
- *Zea mays* L. - Bihar (Kumar and Ahmad, 2017); - Delhi (Pandi et al., 2012); - Gujarat (Patel, 1998; Chakraborty, 2012; Singh et al., 2024); - Karnataka (Joshi et al., 1999; Chinnu et al., 2023); - Karnataka (Megha et al., 2015); - Rajasthan (Swaminathan et al., 2015; Swami and Bajpai, 2009); - Tamil Nadu (Rekha et al., 2009); - Uttar Pradesh (Omkar and Bind, 2004; Chaudhary and Singh, 2012); - West Bengal (Gurung et al., 2019; Maji et al., 2023)

Rhopalosiphum nymphaeae **(Linnaeus, 1761)**
- *Euryale ferox* Salisb. - Bihar (Saraswati and Ghosh, 1996)

Rhopalosiphum padi **(Linnaeus, 1758)**
- *Avena sativa* L. - Punjab (Singh and Dhaliwal, 2004)
- *Oryza sativa* L. - Uttar Pradesh (Chaudhary and Singh, 2012)
- *Triticum aestivum* L. (syn. *Triticum sativum* Lam., *Triticum vulgare* Vill.) - Uttar Pradesh (Omkar and Bind, 1993)

Sarucallis kahawaluokalani **(Kirkaldy, 1907)**
- Unknown - Tripura (Agarwala et al., 1987b)

Schizaphis (Schizaphis) graminum **(Rondani, 1852)**
- *Cenchrus americanus* (L.) Morrone (syn. *Pennisetum glaucum* R. Br.; *Pennisetum typhoides* (Burm.f.) Stapf and C.E.Hubb.) - Uttar Pradesh (Chaudhary and Singh, 2012)

Schizaphis rotundiventris **(Signoret, 1860)**
- *Elaeis guineensis* Jacq. - Karnataka (Dhileepan, 1996)

Schizoneuraphis himalayensis **(Ghosh and Raychaudhuri, 1973)**
- *Machilus gamblei* King ex Hook.fil. (syn. *Persea bombycina* (King ex Hook.fil.) Kosterm.) - West Bengal (Ponnusamy et al., 2019)

Schoutedenia emblica **(Patel and Kulkarni, 1952)**
- *Phyllanthus emblica* L. (syn. *Emblica officinalis* Gaertn.) - Gujarat (Bharpoda et al., 2009); - Karnataka (Chinnu et al., 2023); - Uttar Pradesh (Singh et al., 2018)

Shivaphis (Shivaphis) celti **Das, 1918**
- *Celtis tetrandra* Roxb. – Himachal Pradesh (Das and Raychaudhuri, 1983)

Sinomegoura citricola **(van der Goot, 1917)**
- *Schima wallichii* (DC.) Korth. – West Bengal (Raychaudhuri et al., 1998)

Sitobion (Sitobion) alopecuri **(Takahashi, 1921)**
- *Hordeum vulgare* L. - Gujarat (Chakraborty, 2012)
- *Triticum aestivum* L. (syn. *Triticum sativum* Lam., *Triticum vulgare* Vill.) - Gujarat (Chakraborty, 2012)

Sitobion (Sitobion) avenae **(Fabricius, 1775)**
- *Triticum aestivum* L. (syn. *Triticum sativum* Lam., *Triticum vulgare* Vill.) - Punjab (Modawal, 1941); - West Bengal (Maji et al., 2023)

Sitobion (Sitobion) graminis **Takahashi, 1950**
- *Triticum aestivum* L. (syn. *Triticum sativum* Lam., *Triticum vulgare* Vill.) - Punjab (Modawal, 1941)

Sitobion (Sitobion) miscanthi **(Takahashi, 1921)**
- *Triticum aestivum* L. (syn. *Triticum sativum* Lam., *Triticum vulgare* Vill.) – Bihar (Ahmad et al., 2012); - Gujarat (Tank et al., 2008); - Haryana (Ranjith et al., 2018); - Uttar Pradesh (Chaudhary and Singh, 2012; Tiwari et al., 2024); - Uttarakhand (Ghosh et al., 1991); - West Bengal (Gurung et al., 2019)
- *Zea mays* L. – Bihar (Ahmad et al., 2012)

Sitobion (Sitobion) rosaeiformis **(Das, 1918)**
- *Rosa bourboniana* L. - Himachal Pradesh (Kakkar and Sood, 1989)
- *Rosa indica* L. - Uttar Pradesh (Chaudhary and Singh, 2012; Tiwari et al., 2024)
- *Rosa* sp. - West Bengal (Agarwala, 1983)

***Sitobion* sp.**

- *Zea mays* L. - West Bengal (Maji et al., 2023)

***Therioaphis (Pterocallidium) trifolii* (Monell, 1882)**

- *Medicago sativa* L. - Gujarat (Patel, 2015) ; - Karnataka (Megha et al., 2015); - Uttar Pradesh (Chaudhary and Singh, 2012)

***Tuberculatus (Orientuberculoides) nervatus* Chakrabarti and Raychaudhuri, 1976**

- *Quercus serrata* Murray - Manipur (Somen Singh et al., 1995)

***Tuberculatus (Orientuberculoides) paiki* Hille Ris Lambers, 1974**

- *Quercus serrata* Murray - Manipur (Singh et al., 1985; Shantibala, 1989)

***Uroleucon (Uroleucon) sonchi* (Linnaeus, 1767)**

- Unknown - Tripura (Agarwala et al., 1987b)

***Uroleucon (Uromelan) cartham i* (Hille Ris Lambers, 1948)**

- *Carthamus tinctorius* L. - Madhya Pradesh (Verma et al., 1983); - West Bengal (Chaudhuri et al., 1983)

***Uroleucon (Uromelan) compositae* (Theobald, 1915)**

- *Cannabis sativa* L. – Bihar (Ahmad et al., 2012)
- *Carthamus tinctorius* L. - Chhattisgarh (Khandekar et al., 2023); - Karnataka (Joshi et al., 1999; Megha et al., 2015); - Maharashtra (Kale et al., 2020); - Uttar Pradesh (Omkar and Bind, 1998, 2004)
- *Gaillardia pulchella* Foug. - Gujarat (Bhatt et al., 2007)

***Uroleucon (Uromelan) solidaginis* (Fabricius, 1779)**

- *Solidago virgaurea* L. - Punjab (Modawal, 1941)

Unknown

- *Brassica oleracea* L. var. *capitata* - Maharashtra (Bagal and Trehan, 1945)
- *Brassica oleracea* L. var. *gongylodes* - Maharashtra (Bagal and Trehan, 1945)
- *Brassica rapa* L. - Maharashtra (Bagal and Trehan, 1945)
- *Capsicum annuum* L. - Maharashtra (Bagal and Trehan, 1945)
- *Carthamus tinctorius* L. - Maharashtra (Bagal and Trehan, 1945)
- *Coccinia grandis* (L.) Voigt (syn. *Coccinia indica* Wight and Arn.) - Maharashtra (Bagal and Trehan, 1945)
- *Cyamopsis psoralioides* DC. - Maharashtra (Bagal and Trehan, 1945)
- *Lens culinaris* Medik. (syn. Lens esculenta Moench) - Maharashtra (Bagal and Trehan, 1945)
- *Linum usitatissimum* L. - Maharashtra (Bagal and Trehan, 1945)
- *Moringa oleifera* Lam. - Karnataka (Math et al., 2013)
- *Medicago sativa* L. - Maharashtra (Bagal and Trehan, 1945)
- *Nicotiana tabacum* L. - Maharashtra (Bagal and Trehan, 1945)
- *Pisum sativum* L. - Maharashtra (Bagal and Trehan, 1945)
- *Solanum melongena* L. - Maharashtra (Bagal and Trehan, 1945)
- *Raphanus sativus* L. - Maharashtra (Baghal and Trehan, 1945)
- *Solanum tuberosum* L. - Maharashtra (Bagal and Trehan, 1945)
- *Vicia lens* (L.) Coss. and Germ. (syn. *Lens esculenta* Moench) - Maharashtra (Bagal and Trehan, 1945)
- *Sorghum bicolor* (L.) Moench (syn. *Andropogon sorghum* Roxb. - Maharashtra (Bagal and Trehan, 1945)
- Unknown - Arunachal Pradesh (Hemchandra et al., 2010)

Table 1. The number of species of food plants of aphid preys of *Cheilomenes sexmaculata* and its distribution different states/union territories of India.

Sl. No.	Species of aphid prey	No. of food plant species	No. of states recorded
1.	*Acyrthosiphon (Acyrthosiphon) pisum*	3	6
2.	*Acyrthosiphon sp.*	1	1
3.	*Aphis (Aphis) affinis*	2	2
4.	*Aphis (Aphis) craccivora*	35	24
5.	*Aphis (Aphis) cytisorum*	1	1
6.	*Aphis (Aphis) fabae*	1	1
7.	*Aphis (Aphis) glycines*	1	1
8.	*Aphis (Aphis) gossypii*	53	21
9.	*Aphis (Aphis) kurosawai*	1	2
10.	*Aphis (Aphis) longisetosa*	1	1
11.	*Aphis (Aphis) nasturtii*	2	2
12.	*Aphis (Aphis) nerii*	4	7
13.	*Aphis (Aphis) odinae*	2	4
14.	*Aphis (Aphis) pomi*	1	2
15.	*Aphis (Aphis) punicae*	1	2
16.	*Aphis (Aphis) rumicis*	1	1
17.	*Aphis (Aphis) solanella*	1	1
18.	*Aphis (Aphis) spiraecola*	9	4
19.	*Aphis (Aphis) umbrella*	1	1
20.	*Aphis (Toxoptera) aurantii*	5	8
21.	*Aphis (Toxoptera) citricidus*	2	2
22.	*Brachycaudus (Brachycaudus) helichrysi*	3	2
23.	*Brevicoryne brassicae*	6	12
24.	*Capitophorus himalayensis*	1	1
25.	*Cavariella (Cavariella) aegopodii*	1	1
26.	*Cavariella (Cavariella) indica*	1	1
27.	*Cavariella (Cavariella) simlaensis*	1	1
28.	*Ceratovacuna lanigera*	1	4
29.	*Cervaphis rappardi indica*	2	2
30.	*Cervaphis schouteniae*	1	1
31.	*Chaitophorus himalayensis*	1	1
32.	*Coloradoa rufomaculata*	1	1
33.	*Epipemphigus imaicus*	1	1
34.	*Eriosoma lanigerum*	1	1

34.	*Greenidea (Trichosiphum) psidii*	2	3
35.	*Greenideoida (Greenideoida) ceyloniae*	2	2
36.	*Hyadaphis coriandri*	4	10
37.	*Hyalopterus pruni*	3	2
38.	*Hysteroneura setariae*	10	5
39.	*Liosomaphis atra*	1	1
40.	*Lipaphis (Lipaphis) erysimi*	10	20
41.	*Lipaphis (Lipaphis) pseudobrassicae*	2	2
42.	*Macrosiphoniella (Macrosiphoniella) kalimpongensis*	1	1
43.	*Macrosiphoniella (Macrosiphoniella) pseudoartemisiae*	1	1
44.	*Macrosiphoniella (Macrosiphoniella) sanborni*	3	5
45.	*Macrosiphum (Macrosiphum) rosae*	3	4
46.	*Melanaphis bambusae*	1	1
47.	*Melanaphis donacis*	1	1
48.	*Melanaphis sacchari*	2	5
49.	*Melanaphis sacchari indosacchari*	1	1
50.	*Myzus (Nectarosiphon) persicae*	20	19
51.	*Myzus (Nectarosiphon) persicae nicotianae*	1	3
52.	*Pemphigus (Pemphigus) napaeus*	1	1
53.	*Pentalonia nigronervosa*	1	2
54.	*Phorodon (Diphorodon) cannabis*	1	1
55.	*Prociphilus sp.*	1	1
56.	*Rhopalosiphum maidis*	5	10
57.	*Sarucallis kahawaluokalani*	1	1
58.	*Schizaphis (Schizaphis) graminum*	1	1
59.	*Schizaphis rotundiventris*	1	1
60.	*Schizoneuraphis himalayensis*	1	1
61.	*Schoutedenia emblica*	1	2
62.	*Shivaphis (Shivaphis) celti*	1	1
63.	*Sinomegoura citricola*	2	1
64.	*Sitobion (Sitobion) alopecuri*	2	1
65.	*Sitobion (Sitobion) alopecuri*	1	3
66.	*Sitobion (Sitobion) graminis*	1	1
67.	*Sitobion (Sitobion) miscanthi*	2	7
68.	*Sitobion (Sitobion) rosaeiformis*	3	3
69.	*Sitobion sp.*	1	1
70.	*Therioaphis (Pterocallidium) trifolii*	1	3
71.	*Tuberculatus (Orientuberculoides) nervatus*	1	1

72.	*Tuberculatus (Orientuberculoides) paiki*	1	1
73.	*Uroleucon (Uroleucon) sonchi*	1	1
74.	*Uroleucon (Uromelan) carthami*	1	2
75.	*Uroleucon (Uromelan) compositae*	2	6
76.	*Uroleucon (Uromelan) solidaginis*	1	1
77.	*Unidentified aphid*	13	3
	Total	**164**	**28**

Table 2: Distribution of prey species, host plant species and aphid-host plant associations of *Cheilomenes sexmaculata* in different states/union territories of India.

Sl. No.	States/Union territories	Number of species of aphid preys	Number of host plant species	Number of Aphid-host plant associations
1.	Andhra Pradesh	5	12	14
2.	Arunachal Pradesh	1	1	1
3.	Assam	6	7	9
4.	Bihar	18	32	43
5.	Chhattisgarh	6	7	8
6.	Delhi	4	5	6
7.	Goa	1	1	1
8.	Gujarat	15	60	72
9.	Haryana	5	5	6
10.	Himachal Pradesh	15	16	19
11.	Jammu and Kashmir	9	11	15
12.	Karnataka	21	34	41
13.	Kerala	4	7	7
14.	Madhya Pradesh	4	5	5
15.	Maharashtra	10	25	25
16.	Manipur	18	32	38
17.	Meghalaya	1	1	1
18.	Nagaland	3	4	4
19.	Odisha	10	9	12
20.	Punjab	10	14	15
21.	Rajasthan	21	13	41
22.	Sikkim	1	1	1
23.	Tamil Nadu	11	19	22
24.	Telangana	3	4	4
25.	Tripura	13	6	15
26.	Uttar Pradesh	28	41	56
27.	Uttarakhand	16	15	21
28.	West Bengal	20	38	46
	Total	**77**	**164**	**282**

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PHARMACOLOGICAL BENEFITS AND CONSERVATION STRATEGIES OF *RHODODENDRON ARBORETUM* SM.: A COMPREHENSIVE REVIEW

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ABSTRACT

Rhododendron arboreum, an evergreen shrub native to the Himalayan region, is renowned for its vibrant red flowers and significant medicinal properties. This review explores the diverse pharmacological benefits of R. arboreum, which is integral to traditional medicine in the Himalayas. The plant contains bioactive compounds likeflavonoids, tannins, saponins, and phenolic acids, contributing to its therapeutic potential. Extensive research indicates that R. arboreum exhibits hepatoprotective, antimicrobial, anti-inflammatory, antioxidant, anti-diabetic, and anti-diarrheal properties. The hepatoprotective effects are evident from studies showing its ability to mitigate carbon tetrachloride-induced liver damage and normalize liver enzymes. Its antimicrobial efficacy, particularly against Gram-positive bacteria, is attributed to the bioactive compounds identified in the methanolic extracts of leaves and flowers. Anti-inflammatory and analgesic properties are prominent in the bark extracts, providing potential treatments for chronic inflammation and pain. Additionally, antioxidant studies reveal that R. arboreum extracts reduce oxidative stress and free radical production. Anti-diabetic activities have been demonstrated in streptozotocin-induced diabetic models, showing improved blood glucose levels and lipid profiles. The plant's anti-diarrheal efficacy is supported by animal models indicating reduced gastrointestinal motility and enhanced absorption of water and electrolytes. R. arboreum faces threats from climate change, habitat destruction, and overexploitation, necessitating effective conservation strategies. Genetic studies reveal significant diversity within the species, essential for its adaptation and long-term survival, and offer opportunities for breeding programs. Comprehensive conservation efforts, including habitat protection, sustainable use practices, and the integration of traditional knowledge with scientific research, are imperative. This review highlights the need for sustainable conservation strategies and further research to fully harness the medicinal potential of R. arboreum, ensuring its availability for future therapeutic applications.

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Keywords: *Rhododendron arboreum*, medicinal properties, hepatoprotective, antimicrobial, anti-inflammatory, antioxidant, anti-diabetic, anti-diarrheal, biotechnological approaches, tissue culture, genetic studies.

INTRODUCTION

Plants present in the Himalayan region provide food and therapeutic benefits to both urban and tribal inhabitants. Traditional medicine makes considerable use of therapeutic herbs. In underdeveloped countries, the conventional medical system serves more than 80% of the population (Ahmad et al., 2020). The importance of medicinal plants in traditional healthcare can help guide future research and biodiversity conservation initiatives. The Himalayan region supports half of the country's vegetation, including approximately 4,000 indigenous species

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(Anpin et al., 2010). The growing usage of medicinal plants for therapeutic research puts a pressure on their communities. Plants produce a vast range of bioactive compounds, making them an excellent source of various treatments. Studies on medicinal plants have proven the existence of valuable pharmacologically active compounds with anti-inflammatory, anticancer, antiparasitic, antifungal, and antibacterial activities, based on traditional applications (Bhandary and Kawabata, 2008).

Native to the Himalayas and other mountainous regions of Asia, *Rhododendron arboreum*, also referred to as the tree rhododendron, is an evergreen shrub or small tree.It is the national flower of Nepal and is well-known for its spectacular display of vibrant red flowers. The tree can grow to be as tall as 20 meters, but it is usually 12 meters tall and wide. Trusses of 15-20 bell-shaped flowers, measuring 5 cm in width and 3-5 cm in length, emerge in red, pink, or white in the early to mid-spring. The nectar pouches and markings on the flowers are both black. *R. arboreum* favors green, humus-rich, acidic soil that is well-drained and has dappled shade. The leaves are large, 7–19 cm long, dark green, and have a hairy covering underneath that is silvery, fawn, or brown. Shelter is necessary to avoid wind damage to the leaves. Flowers are modified reproductive shoots of plants. Edible flowers are a traditional food source across a large portion of the globe (Ramaseshan et al., 2015). They can be consumed directly or used to make various products. Many flowers are ingested today, including burans, pumpkins, roses, artichokes, hibiscus, agave, marigold, marshmallow, pansies, and moringa. Flowers are believed to offer medical, traditional, and aesthetic benefits. Buran, often known as *Rhododendron*, is a naturally occurring plant that offers numerous health and economic benefits. *Rhododendron* can prevent and treat problems related to diarrhea, heart, inflammation, dysentery, detoxification, bronchitis, asthma, and fever. There are many food products that use *Rhododendron*, such as wine, chutney, preserves, jam, and jelly (Paul et al. 2005).

Rhododendron is a compound word made up of the Greek terms "rhodo," which means "rose," and "dendron," which means "tree." The term "bioactive compound" comes from the words "bio" (life) and "active," which refer to energy and dynamic activity. A bioactive compound is a material that exhibits biological activity (Abdelkarim et al., 2014). Rhododendron may be found in India's Himalayan area at elevations ranging from 1500 to 5500 meters, with approximately 80 species and 14 subspecies (Bhattacharya, 2011). Rhododendron extracts are commonly used in traditional medicine in regions where they grow naturally (Rehman et al., 2010).*Rhododendron arboreum* leaves have been shown to have strong antioxidant properties (Anpin et al., 2010), and the ethanolic extract of the flowers has potent anti-diabetic activity (Bhandary and Kawabata, 2008). Flowers have religious significance and are often used to decorate temples. This plant is well-known for its therapeutic and commercial uses, and it currently holds the Guinness World Record for being the largest *Rhododendron*. To commemorate this flower, the Indian Postal Department released a stamp.

Systematic classification of *Rhododendron arboretum* Sm.

Rhododendron arboreum belongs to the Ericaceae family of flowering plants. It belongs to the class Magnoliopsida, order Ericales, phylum Tracheophyta, kingdom Plantae, and genus *Rhododendron*. "having a tendency to be woody or forming like a tree" is the meaning of the species name "*arboreum*." It is a tiny tree or evergreen shrub with vivid red blossoms that grows to an altitude of 1200–3600 meters. The plant produces cluster of up to 20 red, pink, or white blooms along with oblong-lanceolate leaves. Anti-inflammatory and antioxidant substances such taraxerol, ursolic acid, quercetin, and rutin are found in its bark, leaves, and flowers. Parts of *R. arboreum* are used by the locals to treat liver problems, headaches, and diarrhea (Madhvi et al., 2019).

Native to the Himalayan region, which includes portions of Tibet, Bhutan, India, and Nepal, *Rhododendron arboreum* grows there. Between 1.5K and 4K meters above sea level are the high altitudes at which it grows. The species can be found throughout a broad range of environments, such as rocky slopes, shrublands, and forests. It can withstand temperatures below freezing and is suited to cool, moist environments and acidic soil(Pradhan and Lachungpa, 1990).

Distribution

Most *Rhododendrons* are grown in Western Europe, North America, South East Asia, and North East Asia. The kinds of *Rhododendrons* are found all throughout the world, with China having the largest population of this species. In India, there are about eighty species (Chaudhary et al., 2021).

Rhododendron arboreum is found across north-eastern India's woods, especially in the milder areas. *Rhododendron arboreum* is distributed in Thailand, Sri Lanka, Nepal, Bhutan, China, India, Myanmar, and Pakistan (Cullen and Chamberlain, 1978). It is a keystone species between subalpine and lower altitude environments because it is also found in the southern portion of its range (Barua and Das, 2018). The species is typically 39 feet tall and broad, but records show that it can reach heights of 66 feet. This plant currently holds the record for the largest *Rhododendron* in the world according to Guinness (Bhattacharya and Mukherjee, 2011). There are numerous subspecies and variations of *Rhododendron arboreum*, such as subspecies of *Cinnamomeum, Zeylanicum, Album, Delavayi*, and *Nilagiricum*. These subspecies and variations have distinct traits and are found in various geographical areas (Tiwari and Chauhan, 2005).Vegetative shoot and flowersof the*Rhododendron arboretum* are shown in(figure 1)

Fig. 1: Vegetative shoot and flowers of the *Rhododendron arboreum.*

Subspecies of *Rhododendron arboreum*

Rhododendron arboreum is known to have multiple subspecies, which can be identified by differences in flower size, color, and distribution. Among the noteworthy subspecies are:

The most common subspecies, *R. arboreum ssp. arboreum*, is found in the Himalayan region, extending via Pakistan to Arunachal Pradesh. It features 4-5 cm diameter bright red flowers with a white or pale yellow throat.

The eastern Himalayas, spanning from Nepal to Bhutan, are home to *R. arboreum ssp. cinnamomeum*. It features deep red throats and flowers that are pink or rose in color, measuring 4-6 cm in diameter.

Northern Myanmar and China's Yunnan province are home to *R. arboreum ssp. delavayi*. It features 5–6 cm in diameter, bright red flowers with a dark red neck.

The Indian state of Tamil Nadu is home to *R. arboreum ssp. nilagiricum*. The leaves have hairs that are brown and cinnamon underneath(Cox et al., 1997).

Traditional Uses

R. arboreum has been utilized for centuries in traditional medicine and local folklore across its native range in the Himalayas. In traditional Ayurvedic and folk medicine, several sections of the plant, including leaves, flowers, and bark, have been used to treat a variety of ailments (Chauhan, 1999).The flowers and leaves have been traditionally used to treat dysentery, diarrhea, headaches, and inflammation. The plant is also known for its anti-inflammatory and analgesic properties (Kala, 2005). These traditional uses have been passed down through generations, indicating a deep-rooted understanding of the plant's therapeutic benefits.

Cultural Significance: In many Himalayan regions, the flowers are used in religious rituals and festivals. The vibrant red blossoms are often considered symbols of beauty and are integral to local traditions. The flowers are also used to make a traditional wine called "Buransh," which is believed to have health benefits (Shrestha et al., 2010).

Intra-and Interspecific Diversity Studies in Rhododendrons

Genetic Studies

Molecular techniques are being used to study the genetic diversity and population structure of *Rhododendron arboreum.* These studies are crucial for developing effective conservation strategies (Mehta et al., 2013). The genetic diversity of *R. arboreum* populations is essential for their adaptation to changing environmental conditions.

Random Amplified Polymorphic DNA, or RAPD, markers: These are used to evaluate genetic diversity and connections between *R. arboreum* populations. These markers are useful because they can amplify random portions of DNA to reveal polymorphisms and don't need prior knowledge of the genome. Significant genetic variety has been found in populations of *R. arboreum*, according to RAPD studies (Bandali, 2008). A study by Sharma et al. (2003) examined genetic variance across several groups in the Himalayas using RAPD markers, and the results showed significant genetic differentiation and diversity as a result of geographic isolation.

Amplified Fragment Length Polymorphism, or AFLP, is a more sophisticated method that offers more accuracy for identifying genetic variations. It entails using restriction enzymes to break down DNA, then amplifying certain bits. *R. arboreum* variation in genome has been studied using AFLP markers, which clearly demonstrate genetic diversity between groups (Hata, 2010). sharma et al. (2018) examined the genetic makeup of *R. arboreum* populations throughout Nepal using AFLP markers. Their findings demonstrated notable genetic divergence and the influence of geographical restrictions on gene flow.

DNA Sequencing: Chloroplast DNA (cpDNA) and nuclear DNA sequencing are two examples of DNA sequencing techniques that have yielded extensive insights into the genetic composition and ancestral connections of R. arboreum. These strategies have aided in studying the phylogeography and historical biogeography of this species. Different phylogeographic patterns have been observed in studies utilizing cpDNA sequences, indicating historical isolation and subsequent population diversification (Bandali, 2008).

Phylogenetic Studies

The genetic diversity of divergent communities of *R. arboreum* from the temperate and tropical forests of the Indian subcontinent was examined by Kuttapetty et al. (2014). By using UPGMA cluster analysis and PCA scatter plots, they were able to validate their findings of considerable genetic divergence among areas and relatively high genetic diversity in temperate populations.

Based on chloroplast DNA data, a study conducted in Taiwan on the Rhododendron pseudochrysanthum species complex suggested that the complex had a single origin and had originally been widely distributed. The findings indicated that the complex's present disjunct distribution is the result of a once continuous range breaking apart (Chung et al., 2007).

A different study examined the evolutionary connections between two potential Kalmia × Rhododendron hybrids using cpDNA trnL-F sequences. The hybrids had a Rhododendron seed parent, as evidenced by the results, which also demonstrated that they were nested within the genus Rhododendron. The female parent's identification down to the species group level was made possible by the cpDNA data (Grant, 2004).

Chloroplast DNA markers were employed in a recent phylogenomic study of the Rhododendron subgenus Hymenanthes, that includes numerous Himalayan species. Evidence of between-lineage hybridization during this subgenus' adaptive radiation was discovered by the study (Ma et al., 2022).

Impact of Climate Change on *R. arboreum*

Early Flowering: *R. arboreum* has been shown in studies to exhibit early flowering, which is linked to temperature increases. This variation in the phenology of flowering can be a reaction to climate change, showing that the species is adjusting to warmer temperatures (Chung et al., 2007).

Upward Shift: In response to climate change, a study projects that *R. arboreum* will probably relocate to higher altitudes in the western Himalayas. Changes in rainfall patterns and rising temperatures could be the cause of this upward shift (Ghosh, 2020).

Threats to Biodiversity: The *R. arboreum's* upward movement may put it in danger of becoming geographically isolated due to difficult terrain, which could jeopardize its survival. In addition, the revival of *R. arboreum* populations is already being impacted by human activities including habitat fragmentation and deforestation (Ghosh, 2020).

Phylogenetic Signals: Studies have shown that the distribution responses of species of rhododendron to changes in the environment have modest phylogenetic signals, meaning that the species' reactions to climate change are not significantly impacted by how they evolved (li et al., 2023).

Existing Threats to Biodiversity of *R. arboreum*

Human Interference: The development and advancement of *R. arboreum*are being hampered by an increase in human activities such as fragmentation of habitats, deforestation, and overexploitation of the species for its flowers and lumber (Shing et al., 2022).

Habitat Loss and Fragmentation: *R. arboreum* habitats are becoming less and more fragmented as a result of habitat degradation brought on by human activities such as building infrastructure, growing urbanization, and cultivation.

Over-Utilization: The long-term viability of the species is being threatened by the over-harvesting of Rhododendron flowers and wood for commercial purposes (Shing et al., 2022).

Ecological Importance

Keystone Species: In the Indian Himalayas, *R. arboreum* is regarded as a keystone species because of its critical role in the management of forests, sequence, and ecological processes (Ahmad et al., 2021).

Food supply: A variety of birds and insects, especially pollinators like bees and flies, depend on the nectar and flowers of *R. arboreum* as a food supply (Basnett and Ganesan, 2022).

Habitat: Himalayan black bears, red pandas, musk deer, tragopans, blood pheasants, and monals, among other creatures, find the ideal home among rhododendron dense vegetation.

Ecosystem Connectivity: Because rhododendron forests are highly interconnected species in the dietary web, their disappearance could have a significant negative impact on the ecosystem by causing a large number of secondary extinctions (Basnett and Ganesan, 2022).

Economic Importance

Local Economy: By harvesting and selling its blossoms, which are used to manufacture a variety of goods like juice, jams, and chutneys, *R. arboreum* contributes to the local economy(Ahmad et al.,2021).

Travel: The Garhwal mountains' tourist sector heavily relies on the tree, with walking trails that allow visitors to get up close and personal with Rhododendron species being particularly well-liked.

Livelihood Enhancement: By supplying non-timber forest products (NTFPs) and encouraging local entrepreneurship, bioprospecting *R. arboreum* can improve livelihoods in the area (Negi et al., 2013).

Conservation Efforts

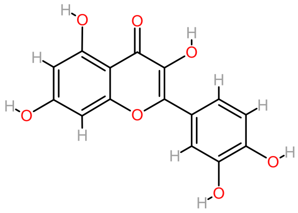
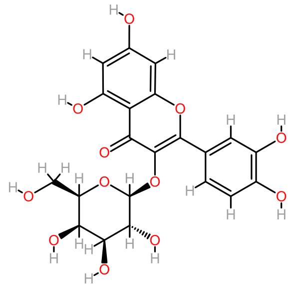
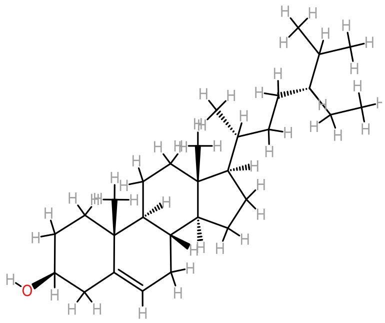
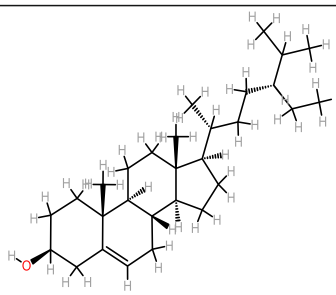
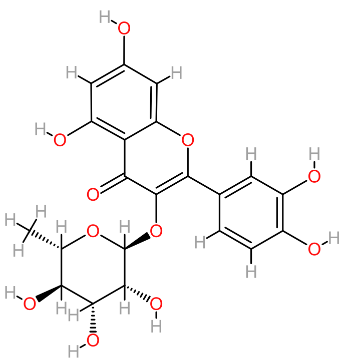
Due to habitat loss and overharvesting, some populations of *R. arboreum* are under threat. Conservation strategies, including habitat protection and sustainable harvesting practices, have been proposed to preserve this species (Pant &Samant, 2012). The implementation of these conservation measures is crucial for the long-term survival of *R. arboreum* in its native habitats.

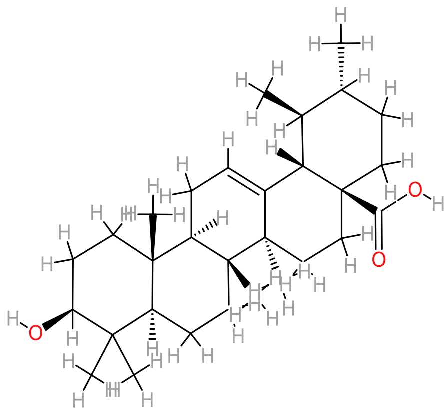
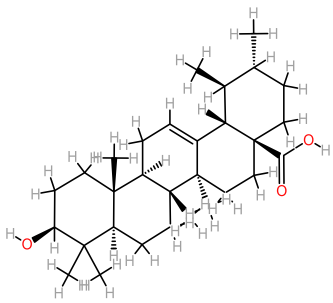
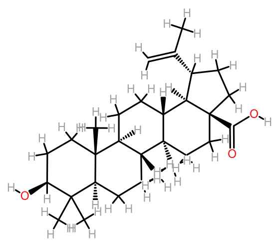
Chemical constituents

Researchers extracted secondary metabolites liketannins, phenols, and saponin from *R. arboreum* leaf extracts. Four physiologically active compounds were identified in the methanolic extract of *R. arboreum* leaves by another study: quercitine-3-Ogalactoside, quercitrine, synergic acid, and epicatechin (Kiruba et al. 2012). The methanolic extract of *R. arboreum* flowers using the HPTLC method shows the presence of phenolic compounds, including rutin, coumaric acid, and quercitine(Kiruba et al. 2012; Sharma et al. 2010; Swaroop et al. 2005).Using standard natural product identification tests, the methanolic extract of *R. arboreum* verified the existence of secondary metabolites from stem, roots, flowers,leaves,and bark,including tannins, steroids,anthraquinones, terpenoids, saponins,phlobatanins, flavonoids,as shown in (table 1)glycosides, and reducing sugars (Rawat et al., 2017).

Rhododendron blossoms provide a variety of vital elements. Due to the existence of pigments (Cartinoids, Anthocyanins, Flavanoids) that are soluble in fat and water, flowers have been shown to have substantial antioxidant properties. Flowers contain 2685 μg of carotenoids per 100 milliliters and 154.8 mg of anthocyanins per liter, respectively. They are also a considerable source of total flavonoids (1276.5 mg/ml and 288.7 mg/100 ml, respectively) and flavanols, which makes them very valuable in pharmacology (Kumar et al., 2019).According to reports, the calcium and iron concentrations of rhododendron blooms from two distinct regions of Himachal Pradesh are 16.64-27.29 mg/100g and 5.62-6.25 mg/100g, respectively. Comparable outcomes have been documented in research on its phytochemistry and pharmacology using the methanol extraction technique (Devi and vats, 2017: Madhavi et al., 2019). The found small variations in flower protein content range from 4.85 to 5.59 percent, which can be attributed to the geographical region in which the flowers are grown (Agarwal and Awasthi, 2021).

Table 1: Chemical Compounds Found in Plants: IUPAC Names, Structures and Plant Parts.

Compound Name	IUPAC Name	Chemical structure	Plant Parts	References
Flavanoids Quercetine	3,3 ,4 ,5,7-pentahydroxy flavone		Flower, Leaves	(Verma et al., 2010; Verma et al., 2012)
Quercetin-3 -O-galactoside	2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R, 4S,5R,6R)-3,4,5-trihydroxy-6-(hydroxymethyl)oxan-2 -yl]oxychromen-4-one		Flower, Leaves	(Sonar et al., 2012; Sonar et al., 2012; Bhandari et al., 2014)
Sterol β-Sitosterol	(3S,8S,9S,10R,13R,14S, 17R)-17-[(2R,5R)-5-ethyl -6-methylheptan-2-yl]-10, 13-dimethyl-2,3,4,7,8,9, 11,12,14,15,16, 17-dodecahydro-1H-cyclopenta[a] phenanthren-3-ol		Leaves	(Sonar et al., 2012)
Flavonol glycoside Rutin	2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R, 4S,5S,6R)-3,4,5-trihydroxy-6-[[(2R,3R, 4R,5R,6S)-3,4, 5-trihydroxy-6-methyloxan-2-yl]oxymethyl]oxan-2-yl]oxychromen-4-one		Leaves	(Sonar et al., 2012; Sonar et al.,
Quercitrin	2-(3,4-dihydroxyphenyl)-5,7-dihydroxy-3-[(2S,3R, 4R,5R,6S)-3,4,5-trihydroxy-6-methyloxan-2-yl]oxychromen-4-one		Flower	(Rangaswami, and Sambamurthy, 1960)

Pentacyclic triterpenoid Ursolic acid	(1S,2R,4aS,6aR,6aS,6bR, 8aR,10S,12aR,14bS)-10-hydroxy-1,2,6a,6b,9,9, 12a-heptamethyl-2,3,4, 5,6,6a,7,8,8a,10,11,12, 13,14b-tetradecahydro-1H-picene-4a-carboxylic acid		Flower, Bark, Leaves	(Raza et al., 2015;Rangaswami, and Sambamurthy, 1960; Sonar et al., 2012)
Triterpenoid Betulin	(1R,3aS,5aR,5bR,7aR,9S, 11aR,11bR,13aR,13bR)-3a-(hydroxymethyl)-5a, 5b,8,8,11a-pentamethyl-1-prop-1-en-2-yl-1,2,3, 4,5,6,7,7a,9,10,11,11b, 12,13,13a,13b-hexadecahydrocyc-lopenta[a]chrysen-9-ol		Bark	(Nisar et al., 2013; Raza et al., 2015)
Betulinic acid	(1R,3aS,5aR,5bR,7aR,9S, 11aR,11bR,13aR,13bR)-9-hydroxy-5a,5b,8,8, 11a-pentamethyl-1-prop-1-en-2-yl-1,2,3,4,5,6,7, 7a,9,10,11,11b,12,13, 13a,13b-hexade-cahydrocyclopenta[a] chrysene-3a-carboxylic acid		Bark	(Nisar et al., 2013; Hariharan, and Rangaswami, 1966)

Major pharmacological activities

Antimicrobial activity

It was discovered that R. arboreum's methanolic leaf extract was very effective against the Gram-positive bacterium Listeria monocytogenes. Strong antibacterial activity was demonstrated by *R. arboreum* leaf extracts against Yersinia pestis, Bacillus cereus, and Staphylococcus aureus, among other Gram-positive bacteria (prakash et al., 2017).

Furthermore, the *R. arboreum* flower methanol extract demonstrated positive antibacterial activity against the Gram-positive Bacterium*Staphylococcus aureus*(prakash et al., 2017).

A thorough investigation revealed that 17 different species of Rhododendron, including *R. arboreum*, had leaf extracts that significantly inhibited the growth of Gram-positive bacteria. The extracts' effect on Gram-negative bacteria was, nevertheless, minimal (Saranaya and Rana, 2016).

According to phytochemical study, the antibacterial effects of *R. arboreum* are probably caused by its bioactive components, which include tannins, alkaloids, flavonoids, and terpenoids (Rezk et al., 2015). According to in silico research, the two most effective phytocompounds and potential antibacterial agents from *R. arboreum* are epifriedelanol and campanulin (Mehta et al., 2023).

Anti-nociceptive and anti-inflammatory properties

The bark of *R. arboreum* showed strong antinociceptiveand anti-inflammatory effects in both

the crude methanolic extract and fractions.A study was created to assess the methanolic extract of *R. arboreum* bark's possible anti-inflammatory properties. The outcomes showed that thea extract had strong anti-inflammatory and analgesic properties.
Regarding pharmacological significance, rhododendron has been shown to be useful as a treatment for chronic bronchitis, choleretic, antioxidant, diuretic, and antispasmodic.Significant antioxidant and anti-inflammatory qualities are also present in the methanolic extract of *R. arboreum* flowers (Nisar et al., 2016).

The potential therapeutic benefits of the plant's polysaccharides have been studied using an animal model of systemic inflammation generated by lipopolysaccharide (LPS). *R. arboreum*poly saccharides (RAP) were found to have a protective effect against multi-organ damage, as evidenced by the considerable restoration of biochemical parameters, antioxidant indicators, and plasma pro-inflammatory cytokines (Ahmad et al., 2020). An opioid-independent central impact is shown to enhance the analgesic profile of Polygonatum verticillatum's aerial portions, which primarily exhibit peripheral activity (Nisar et al., 2014).

Antioxidant Activity
Research has indicated that *R. arboreum* extracts have antioxidant activity when studied in vitro. For instance, it has been discovered that the plant's ethanol extract contains antioxidant qualities. These qualities were assessed in rats and mice utilizing models of immobilization stress, swimming endurance, and anoxia stress tolerance (Agarwal and Awasthi, 2021).

Studies have demonstrated the noteworthy antioxidant qualities of R. arboreum, which are ascribed to its bioactive constituents, including tannins, flavonoids, and saponins. These substances have been demonstrated to lessen the oxidation process in the body, which lowers the production of free radicals and protects against oxidative stress and associated illnesses (Gautam et al., 2020).When exposed to chromium (VI) stress, Vigna radiata (mung bean) plants' antioxidant defense system was found to be strengthened by the methanol extract of *R. arboreum* leaves (MEL). MEL raised the concentrations of pigments including xanthophylls and anthocyanins, antioxidant enzymes, & non-enzymatic antioxidants like ascorbic acid, glutathioneand tocopherol (Gautam et al., 2020).

FRAP (Ferric Reducing Antioxidant Power) &DPPH (1,1-diphenyl-2-picrylhydrazyl) tests revealed that the ethanolic extract of *R. arboreum* flowers had strong antioxidant activity. The FRAP value was 140.6±2.76 mM TE/g, and the DPPH radical scavenging activity was 134.1±2.34 mM TE/g (Piyush et et al., 2018).

In a different study, DPPH, FRAP, and ABTS techniques were used to assess the antioxidant activity of several solvent extracts like chloroform, petroleum ether, ethyl acetate, acetone,water, and methanol from different sections of *R. arboreum* (leaves, flowers, and stem bark). The maximum potential for antioxidants was demonstrated by the leaf methanol extract (Sharma et al., 2021).

In addition to demonstrating the potent antimutagenic and cancer cell growth suppression properties of *R. arboreum* leaves and flowers, this study also detailed the plant parts' *in vitro* antioxidant activity (Gautam et al., 2020).

Anti-diabetic activity
Under chromium stress, the methanol extract of *R. arboreum* leaves improved antioxidant defenses in mung bean plants, indicating possible anti-diabetic benefits.

In streptozotocin-induced diabetic mice, the ethyl acetate fraction of *R. arboreum* flower extract dramatically lowered blood glucose levels (73.6% at 200 mg/kg dose). Additionally, it enhanced these animals' lipid profiles, glycolysis, and insulin secretion. In streptozotocin-induced diabetic rats, *R. arboreum* floral extract demonstrated antihyperglycemic and antihyperlipidemic effects. After 30 days of administration, the active fraction (200–400 mg/kg) increased insulin levels and decreased blood urea, creatinine, and hemoglobin A1C (Verma et al., 2020). Rats with diabetes caused by streptozotocin showed anti-diabetic and anti-hyperlipidemic benefits from the bark extract of R. arboretum (Gautam and Chaudhary, 2020).

The bloom of the *R. arboreum* Sm was tested for anti-diabetic efficacy, and active chemicals were extracted. Rat intestinal β-glucosidase was reported to be inhibited by an aqueous methanolic extract of Laligurans flower. In the β-glucosidase-soluble and ethyl acetate-soluble sections, the aqueous methanolic extract demonstrated inhibitory effects, with the ethyl acetate-soluble component showing higher activity. From the ethyl acetate-soluble portion, the β-glucosidase inhibitor quercetin-3-O- -D-galactopyranoside, also referred to as hyperin, was separated using enzyme-assay guided separation. The extracted substance exhibited a dose-dependent inhibitory effect on β-glucosidase, with IC50 values for maltase and sucrase being 0.76 mM and 1.66 mM, respectively. According to this study, flowers may have anti-diabetic properties that might be used to create functional foods, nutraceuticals, or pharmaceutical treatments for diabetes and its consequences (Bhandary, and Kawabata, 2009).

Hepatoprotective activity

Studies have shown that *R. arboreum* leaves exhibit strong hepatoprotective effects against carbon tetrachloride (CCl_4)-induced liver damage in rats. The ethanolic extract of *R. arboreum* leaves significantly reduced elevated blood marker enzymes (SGPT, SGOT, ALP, bilirubin) and prevented liver necrosis, lipid alterations, and inflammation in CCl_4-intoxicated rats, attributed to the antioxidant properties of the leaves that scavenge free radicals and reduce oxidative stress (Parakash et al., 2008).

Additionally, the ethyl acetate fraction of *R. arboreum*, administered at doses of 100, 200, and 400 mg/kg over 14 days, normalized serum levels of SGOT, SGPT, ALP, -GT, and bilirubin, and restored the activities of GST and glutathione reductase. This fraction further demonstrated its hepatoprotective potential by preventing the dose-dependent rise in hepatic malondialdehyde as well as the depletion of reduced glutathione. These findings suggest that *R. arboreum* leaves may serve as a promising natural agent for protecting the liver from chemical-induced damage (Verma et al., 2011).

Anti-diarrhoeal activity

It has been demonstrated in experimental animals such as the standardized ethyl acetate fraction of *R. arboreum* flowers (EFRA) has strong antidiarrheal properties (Verma et al., 2011). FRA has been used traditionally to treat diarrhea and dysentery because it decreases gastrointestinal motility, improves the absorption of water and electrolytes, and strengthens the mucus barrier function in the gut (Verma et al., 2011). In rats with castor oil-induced diarrhea models, it has been discovered that the methanolic extract of *R. arboreum* leaves exhibits strong antidiarrheal efficacy. The amount of feces produced as well as the frequency and duration of diarrhea are decreased by the extract. The capacity of *R. arboreum* leaves to decrease gastrointestinal motility, increase the absorption of water and electrolytes, and improve the function of the gut's mucus barrier may be the cause of their antidiarrheal properties (Semwal, and Goyal, 2014)..

Material and methods

Literature Search and Data Collection

To conduct a comprehensive review of *R. arboreum* and its various pharmacological properties, an extensive literature search was performed using multiple databases including Web of Science , PubMed, ScienceDirect, and Google Scholar. The search terms used included "R. arboreum," "hepatoprotective," "antimicrobial," "anti-inflammatory," "antioxidant," "anti-diabetic," and "anti-diarrhoeal." Articles were selected based on their relevance, publication date, and the presence of experimental data related to the pharmacological properties of *R. arboreum*.

Selection Criteria

- **Inclusion Criteria:**
    - o Peer-reviewed journal articles, reviews, and conference papers.
    - o Studies that specifically focus on the pharmacological properties of *R. arboreum*.
    - o Articles published in English.
- **Exclusion Criteria:**
    - o Studies lacking experimental data.
    - o Articles not available in full text.
    - o Non-peer-reviewed sources.

Data Extraction

Data extraction was performed independently by multiple reviewers to minimize bias. The following information was extracted from each selected study:

- **Pharmacological properties**: Hepatoprotective, antimicrobial, anti-inflammatory, antioxidant, anti-diabetic, and anti-diarrhoeal activities.
- **Plant parts used**: Leaves, flowers, bark.
- **Extraction methods**: Types of solvents used for extraction (ethanol, methanol, ethyl acetate, etc.).
- **Bioactive compounds identified**: Tannins, flavonoids, saponins, phenols, quercitrin, epicatechin, and others.

- **Experimental models**: In vivo (animal models) and in vitro studies.
- **Dosage and administration**: Concentration and duration of extract administration.

Data Synthesis and Analysis

An extensive synopsis of *R. arboreum's* pharmacological characteristics was produced by synthesizing the extracted data. The findings from different studies were compared and analyzed to identify consistent patterns and discrepancies. The potential mechanisms of action of the bioactive compounds were discussed based on the experimental evidence.

CONCLUSION

R. arboreum, with its rich history and diverse applications, continues to be a subject of extensive research. The plant's traditional uses in medicine and culture have been validated by modern scientific studies, highlighting its therapeutic potential. *R. arboreum*, native to the Himalayan region, is a valuable medicinal plant with a diverse range of therapeutic benefits, owing to its rich bioactive compounds likeflavonoids, tannins, saponins, and phenolic acids. The plant's extracts exhibit significant anti-inflammatory, hepatoprotective, antimicrobial, antioxidant, anti-diabetic, and anti-diarrheal properties. Research studies have shown that the ethanolic and ethyl acetate extracts of its leaves protect against carbon tetrachloride-induced liver damage, normalize elevated liver enzymes, and prevent hepatic necrosis and inflammation due to their antioxidant activity. Additionally, methanolic extracts of the leaves and flowers demonstrate potent antimicrobial effects against Gram-positive bacteria, while the bark exhibits strong anti-inflammatory and analgesic activities. The plant's extracts also reduce oxidative stress, improve insulin secretion, lower blood glucose levels, and enhance lipid profiles, making them promising natural treatments for diabetes. Furthermore, *R. arboreum* extracts effectively treat diarrhea by reducing gastrointestinal motility and improving water and electrolyte absorption. Research on *R. arboreum's* genetic makeup reveals a great deal of diversity across the species, which is essential for its long-term survival and ability to adapt to shifting environmental conditions. Additionally, breeding programs aiming at enhancing desirable traits like resistance to disease and environmental tolerance can benefit from this genetic diversity. However, to ensure the sustainability of *R. arboreum*, there is an urgent need for comprehensive conservation efforts. These should include habitat protection, promotion of sustainable use practices, and the integration of traditional knowledge with modern scientific research. Future research should focus on elucidating the mechanisms of these bioactive compounds, optimizing extraction methods, and conducting clinical trials to confirm the efficacy and safety of *R. arboreum*-based treatments, alongside conservation efforts to protect this valuable species.

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THE THERAPEUTIC EDGES OF MEDICINAL PLANT-DERIVED CUTLERY

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ABSTRACT

This study explores the potential of utilizing medicinal plants in the development of edible cutlery, which offers a sustainable alternative to conventional single-use plastic cutlery. Medicinal plants are known for their diverse bioactive compounds, making them a promising source for producing environmentally friendly and biodegradable edible utensils. The investigation focuses on evaluating the nutritional value, safety, and sensory attributes of the edible cutlery. The results indicate that edible cutlery made from medicinal plants demonstrates promising potential as a viable and eco-friendly alternative to reduce plastic waste, while also offering potential health benefits through the ingestion of beneficial phytochemicals. This research contributes to the broader efforts towards sustainable food packaging and consumption practices, promoting a greener and healthier future.

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Keywords: Medicinal plants, Edible cutlery, Sustainable alternative, Biodegradable, Nutritional value.

INTRODUCTION

The growing worldwide concern about environmental degradation caused by plastic waste has created an urgent need for sustainable alternatives in various industries, including food packaging and utensils. Single-use plastic cutlery, which contributes significantly to the plastic pollution crisis, has become a prime target for innovative and eco-friendly solutions. In 2014, J. Gasperi, R. Dris, T. Bonin, and V. Rocher conducted research on the "Assessment of floating plastic debris in surface water along the Seine River." They found that a significant portion of the debris consisted of food wrappers, containers, and plastic cutlery, likely resulting from intentional or unintentional dumping. Plastic tables, which were found in the river, accounted for between 0 and 0.8% and 5.1% of the total debris by weight during discharge and surface runoff. Environmental pollution, as defined by Dana Gopal et al. (2014) in their research paper "Impact Of Plastic Leading Environmental Pollution," refers to the unfavorable changes in the physical, chemical, and biological characteristics of our air, land, and water caused by overpopulation, rapid industrialization, and other human activities such as agriculture and deforestation, which introduce various pollutants. Plastic is a commonly used material in the construction sector, disposable cutlery industry, and storage industry. The increasing use of plastic in developing and growing nations is particularly concerning due to inadequate waste management systems. The accumulation of plastic materials on land and in bodies of water is known as plastic pollution. The exact degradation time of plastic is not known, as it is a synthetic polymer made from petrochemicals that takes 500 to 1000 years to

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degrade. Manufacturing processes release many harmful chemicals that can contaminate humans and animals. Plastic cutlery takes hundreds of years to decompose, releasing harmful chemicals during the process. Additionally, the production of plastic utensils involves the extraction and processing of fossil fuels, contributing to carbon emissions and exacerbating climate change. The negative effects of plastic cutlery on the environment and human health have led to a search for sustainable alternatives that reduce waste generation and minimize ecological damage. In recent years, the concept of edible cutlery has emerged as a promising approach to tackling this environmental challenge while also harnessing the potential health benefits of medicinal plants. Medicinal plants have been valued for centuries in traditional medicine systems for their therapeutic properties, containing a wide range of bioactive compounds with various health-promoting effects. As we confront the adverse impacts of plastic pollution on our ecosystems and health, exploring the integration of medicinal plants into edible cutlery offers a unique opportunity to address both environmental and nutritional concerns simultaneously. This paper aims to explore the potential of medicinal plants in the development of edible cutlery. We will examine the reasons behind the growing interest in edible cutlery, discuss the advantages of using medicinal plants in its production, and explore the potential nutritional benefits that such utensils could offer.

EDIBLE CUTLERY: AN ECO-FRIENDLY ALTERNATIVE

The global awareness of plastic pollution has sparked a shift in consumer behavior and industry practices. Edible cutlery has emerged as a promising eco-friendly option to address environmental concerns. Its biodegradability and potential to mitigate plastic waste make it a sustainable choice. In a study by Thagunna et al. (2023), a long-lasting substitute for plastic cutlery was developed by combining water, salt, wheat flour, finger millet, rice flour, jaggery, and oil. The resulting cutlery was not only tasty and healthy but also advantageous for the environment. Using less plastic reduces the discharge of harmful compounds as it breaks down. In a study by Sorna Prema Rajendran et al. in 2020, nutrient-rich edible cutlery was created using a composite flour made of wheat flour, pearl millet, and barnyard millet. The composition was optimized based on water absorption characteristics at different temperatures using the Box Behnken design under the Response Surface Methodology (RSM). The nutritional value of the optimized sample was determined to be 5.67 g/100g of protein, 2.36 g/100g of total fat, and 83.68 g/100g of carbohydrates. This biodegradable cutlery replaced plastic in just five days.Another study by Sayani Hazra and Manmath Sontakke in 2023 explored the use of ashwagandha root powder, finger millet flour, and sorghum flour as functional ingredients in edible cutlery for nutrient enrichment. The biodegradability of the product was investigated and found to enhance soil health without adverse effects on the environment. Additionally, the availability of raw materials makes it a potentially more economical technology. The addition of grape seed flour improved the antioxidant capabilities of the spoons, as stated by Dordevic in 2021. Xanthan gum was used to increase the hardness and texture of the spoons. While these biodegradable spoons may not be suitable for all food items and are not reusable, future research aims to enhance this aspect.

Vyshali et al. (2022) researched the use of natural, biodegradable polymer made from fruit waste as blends with natural binders to improve the performance of edible cutlery. The pineapple variant had the most appeal overall, with high protein content and the least moisture. The pomegranate version scored well in terms of ash and crude fiber content. Future research can focus on improving the durability of fruit waste-based products by combining them with inexpensive binders like jackfruit seed powder and flax seed powder. Using composite millet flour, Shabaana et al. (2021) created edible cutlery that is naturally nourishing without preservatives. By incorporating Moringa oleifera into the cutlery, it may help reduce the risk of childhood anemia, which is a prevalent dietary deficiency worldwide.

In conclusion, edible cutlery offers an environmentally friendly alternative to plastic utensils. With its sustainable production, biodegradability, customization potential, and nutritional benefits, edible cutlery aligns with the growing demand for eco-conscious practices. By embracing this innovative solution, we can contribute to a cleaner, greener future while still enjoying the convenience and functionality of traditional utensils.

MEDICINAL PLANTS: A RESOURCE FOR SUSTAINABLE EDIBLE CUTLERY

Medicinal plants and animals have long been revered for their diverse bioactive compounds and therapeutic properties in traditional medicine systems (Sharma and Pareek, 2021; Prakash and Verma, 2021; Jafri and Mishra, 2022). Utilizing medicinal plants as a sustainable source for edible cutlery production is an attractive option due to their renewability, abundant availability, and potential to replace conventional plastics. Various medicinal plant species exhibit promising attributes for creating eco-friendly utensils. According to Dasgupta et al. (2004), Azadirachta indica stands out among other plants with its wide range of uses. The leaves, bark, fruit, flowers, oil, and gum of the neem tree have all been linked to medicinal benefits, making it a versatile herb. Neem's first known application dates back to the 'Harrappa Culture' of ancient East India, where it was included in hundreds of medicines and cosmetics 4500 years ago. These time-tested Neem formulations have been a staple of Ayurvedic pharmacy for ages, thanks to the ancient healing technique known as Ayurvedic medicine. Azadirachta indica parts are used in the treatment of bacterial, fungal, and viral illnesses, as well as for immune system stimulation (Arya, 2019). Among its remarkable qualities, neem's usefulness as a natural, non-toxic pesticide boosts its wide range of applications (Wealth of India, 2000). Neem is a well-known medicinal plant that contains various bioactive compounds, such as nimbin, nimbidin, and azadirachtin, known for their antimicrobial and insecticidal properties. Edible cutlery made from neem leaves or extracts could potentially inhibit the growth of harmful microorganisms, ensuring food safety, and reducing the need for chemical preservatives in packaging.

Pattanayak et al. (2010) stated that Ocimum sanctum L., commonly known as tulsi or Ocimum tenuiflorum, has been used in Ayurveda for thousands of years for various therapeutic purposes. Tulsi, known as the Queen of plants and the fabled "Incomparable One" of India, is among the most revered and sacred oriental plants that promote health and healing. Tulsi is recognized as an adaptogen because it helps people adapt to stress and balances various biological systems. It is considered a type of "elixir of life" in Ayurveda and is believed to promote longevity. Tulsi stands out for its strong scent and pungent flavor. Tulsi extracts are used in Ayurvedic therapies for colds, headaches, stomachaches, inflammation, malaria, and various poisonings. Traditional preparations of O. sanctum L. include fresh leaves, dried powder, and herbal tea. Edible cutlery infused with holy basil extracts could offer additional nutritional value while imparting a pleasant aroma and potential health benefits to the user.

Aloe barbadensis Miller (Aloe vera) is well-known for its calming and restorative qualities. Its usage in nutrition and medicine has expanded due to its anti-inflammatory, antioxidant, antibacterial, antiviral, antiparasitic, and antifungal properties. These biologically active components, such as minerals, vitamins, carbohydrates, enzymes, anthraquinones or phenolic compounds, saponins, amino acids, lignin, and sterols, are responsible for these actions according to Ebrahim et al. (2020).

Akram et al. (2010) reviewed the use of the rhizomes of Curcuma longa, a plant in the ginger family (Zingiberaceae), in the production of turmeric. Rhizomes are horizontal underground stems that produce both roots and shoots. Turmeric gets its vivid yellow color from curcuminoids, which are fat-soluble, polyphenolic pigments. Curcumin is the main curcuminoid found in turmeric and is considered its most active component. Turmeric also contains demethoxycurcumin and bisdemethoxycurcumin. In addition to being used as a spice and a colorant, turmeric has a long history of medicinal use in India. Recent research has shown that curcumin may have anti-inflammatory and anticancer properties, sparking renewed interest in its potential as a disease preventative and treatment. By infusing edible cutlery with turmeric, it may be possible to reduce oxidative stress and inflammation when consumed, promoting overall well-being.

Ginger, the rhizome of Zingiber officinale, another member of the ginger family (Zingiberaceae), is a highly versatile medicinal plant with a wide range of biological activities. It has been used for over 2000 years for medicinal purposes and is also a popular condiment in various cuisines and beverages. Ginger contains compounds such as gingerol, paradol, and shogaols, which contribute to its therapeutic effects. There is currently a growing interest in ginger, and numerous scientific studies are being conducted to explore its active ingredients and pharmacological effects for treating various illnesses and ailments (Dhanik, J., Arya, N., & Nand, V., 2017). Ginger is well-known for its digestive properties and immune-boosting effects. Infusing edible cutlery with ginger could add a subtle ginger flavor to food and potentially provide digestive benefits to the consumer.

Trevisan et al. (2017) researched Mentha piperita, which is one of the most commonly used herbs worldwide and has a long history of safe use in therapeutic preparations. It is known for its effectiveness in treating various conditions such as the common cold, liver inflammation, inflammation of the mouth, throat, and pharynx, as well as gastrointestinal problems including cramps, nausea, vomiting, diarrhea, and dyspepsia. This plant contains polyphenols, which are powerful antioxidants that are less harmful than synthetic ones. The food industry finds this characteristic very interesting as phenolic chemicals can prevent the degradation of lipids through oxidation, thereby improving food quality and nutritional content. Mentha piperita is highly valued for its refreshing taste and high menthol content, which has a soothing effect on the digestive system.

Nieto et al. (2018) have investigated the biological properties of rosemary extracts, including their hepatoprotective, antifungal, insecticide, antioxidant, and antibacterial properties. It is widely acknowledged that phenolic chemicals play a significant role in the biological activity of rosemary. However, due to their smell, color, and flavor, they are only occasionally used in recipes. To address this, commercial techniques have been developed to create odorless, colorless antioxidant chemicals derived from rosemary. The consumption of antioxidant-rich rosemary has been associated with improved cognitive performance. Edible cutlery infused with rosemary extracts may therefore offer a distinctive flavor profile and potentially possess neuroprotective properties.

According to a review by Manvitha & Bidya (2014), lemongrass, scientifically known as Cymbopogon citratus, is a herb belonging to the Gramineae family. It is characterized by its distinct lemon-like aroma, mainly due to the presence of citral, a cyclic monoterpene. This aromatic grass is a fast-growing perennial that is indigenous to South India and Sri Lanka, but is now widely cultivated in tropical regions of America and Asia. The essential oil is obtained from freshly cut and partially dried leaves, which are also utilized for medicinal purposes. In Ayurvedic medicine, lemongrass is commonly used. Various studies have connected Cymbopogon citratus to a range of pharmacological activities, including anti-amoebic, anti-bacterial, anti-diarrheal, anti-filarial, anti-fungal, and anti-inflammatory effects. Additional research has explored its potential for anti-malarial, anti-mutagenicity, anti-mycobacterial, antioxidant, hypoglycemic, and neurobehavioral benefits. Lemongrass is renowned for its citrusy aroma and antimicrobial essential oils. The use of edible cutlery made from lemongrass extracts could not only add a delightful aroma to food, but possibly also inhibit the growth of harmful bacteria. These examples highlight the potential of medicinal plants in creating edible cutlery as sustainable alternatives to conventional plastics, with the added benefits of nutrition and health. The diverse array of bioactive compounds found in medicinal plants offers exciting possibilities for developing eco-friendly utensils that promote well-being while reducing the environmental impact of plastic waste.

NUTRITIONAL IMPLICATIONS OF EDIBLE CUTLERY:

Edible cutlery refers to utensils that can be consumed after use, as opposed to traditional utensils made from materials like plastic, metal, or wood that are typically discarded. These edible utensils are often made from various ingredients such as rice, wheat, millets, corn, and other grains. While edible cutlery offers some potential benefits, it also presents certain nutritional implications:

- Nutritional Value: The nutritional value of edible cutlery depends on the ingredients used. Manufacturers generally try to make them nutritious by incorporating whole grains and other healthy ingredients. However, the specific nutritional content can vary, so it's essential to check the product's label or packaging for detailed information.
- Calories and Energy Content: Edible cutlery may contribute to calorie intake depending on the quantity consumed. Since they are made from grains, they are likely to contain carbohydrates, which are a significant source of energy.
- Dietary Fiber: Whole grains used in edible cutlery can provide dietary fiber, which is beneficial for digestion and can help maintain a healthy gut.
- Micronutrients: Depending on the ingredients and processing methods, edible cutlery may contain certain vitamins and minerals from the grains. However, the amounts may be relatively small compared to other whole food sources.

- Gluten Concerns: Some edible cutlery might contain gluten if they are made from wheat or other gluten-containing grains. People with celiac disease or gluten sensitivity should be cautious and look for gluten-free options.
- High in Carbohydrates: Edible cutlery is typically made from grains, so it can be high in carbohydrates. While carbohydrates are an essential energy source, excessive consumption may not be suitable for people on low-carb diets or those with diabetes.
- Salt and Additives: Manufacturers might use certain additives or flavorings to enhance the taste and preserve the cutlery. High sodium content should be a concern for individuals with hypertension or those who need to limit their salt intake.
- Limited Protein and Fats: Edible cutlery primarily consists of carbohydrates and may not be a significant source of protein or healthy fats.
- Environmental Impact: While not directly a nutritional implication, the environmental impact of edible cutlery is an important factor to consider. If these products lead to reduced plastic waste and pollution, they can indirectly contribute to a healthier environment.

Overall, edible cutlery can be a novel and eco-friendly alternative to traditional single-use plastic cutlery. From a nutritional standpoint, they can be a better choice than disposable plastic cutlery since they are made from edible and potentially more nutritious ingredients. However, like any food product, moderation and a balanced diet are essential to ensure that the nutritional benefits are not outweighed by potential drawbacks.

CHALLENGES AND FUTURE DIRECTIONS:

- While there is potential for medicinal plants to be used in edible cutlery, there are also certain challenges and limitations that need to be addressed. This section will discuss these obstacles, including scaling up production, standardizing formulations, and ensuring regulatory compliance. Additionally, the review will emphasize the importance of ongoing research to optimize the nutritional and functional aspects of these edible utensils.
- One of the main challenges in utilizing medicinal plants for edible cutlery is the reliable sourcing of raw materials. Some medicinal plants may have limited availability or only grow in specific regions, which makes it difficult to maintain a consistent supply chain. It is crucial to establish a sustainable and ethical sourcing process to avoid overharvesting and biodiversity loss. Developing edible cutlery with medicinal plants requires finding the right balance between incorporating the plant material and maintaining the structural integrity and functionality of the utensils. Achieving the desired texture, taste, and durability without compromising safety is a complex task. Some medicinal plants may contain compounds that could trigger allergies or adverse reactions in certain individuals. It is important to ensure that the edible cutlery is safe for widespread consumption and free from harmful contaminants. Establishing standardized manufacturing processes and quality control measures is essential to ensure consistency in the final product. Achieving uniformity in the nutritional content and sensory attributes of the edible cutlery is necessary for consumer acceptance. The cost of producing edible cutlery from medicinal plants can be higher than traditional plastic alternatives. Making these eco-friendly utensils cost-effective and affordable for consumers is a significant challenge.

FUTURE DIRECTIONS:

- **Research and Development:** Investing in research and development is crucial to optimize the utilization of medicinal plants in edible cutlery. Advancements in extraction techniques, processing methods, and formulation will lead to improved functionality and nutritional value.
- **Collaboration and Partnerships:** Collaborative efforts among researchers, industries, and governments can accelerate progress in this field. Partnerships can facilitate knowledge exchange, funding opportunities, and the sharing of best practices.
- **Consumer Education and Awareness:** Educating consumers about the environmental and health benefits of using

edible cutlery made from medicinal plants can drive demand and promote sustainable consumption habits.

- **Regulatory Support:** Establishing clear regulatory frameworks and standards for the production, labelling, and safety of edible cutlery will build consumer trust and ensure compliance with quality measures.
- **Waste Management Solutions:** Exploring innovative waste management solutions for used edible cutlery, such as composting or bioconversion, will enhance the overall sustainability of this alternative.
- **Diversification of Plant Sources:** Identifying and exploring new medicinal plant species with suitable properties for edible cutlery can enhance diversity and resilience in the production process.
- **Market Expansion:** Encouraging the use of medicinal plant-based edible cutlery in various settings, including restaurants, events, and airlines, can foster market growth and promote wider adoption.

In conclusion, the potential of medicinal plants in edible cutlery offers a promising pathway towards sustainability and healthier consumption practices. However, addressing the challenges and pursuing future directions outlined above will be critical to fully harnessing the benefits of this innovative approach and making a positive impact on both the environment and human well-being.

CONCLUSION

In conclusion, the integration of medicinal plants into edible cutlery offers an exciting avenue to address both environmental and nutritional concerns. Edible cutlery made from medicinal plants not only presents a sustainable solution to combat plastic pollution but also has the potential to contribute beneficial bioactive compounds to our diet. Further research and innovation in this field are crucial to fully unlock the potential of medicinal plants in edible cutlery, paving the way for a more sustainable and healthier future.

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COMPARATIVE LC-MS ANALYSIS OF PHYTOCONSTITUENTS IN RIPE AND UNRIPE PAPAYA FERMENTA

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Research Paper

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ABSTRACT

Around the world, papayas (*Carica papaya Linn*.) are well-known for their culinary and nutritional benefits. In conventional medicine, papaya fruit and other plant parts are very well known for their therapeutic qualities. Papaya is grown commercially because every component of the tree has a marketable value. The biological activity and therapeutic uses of papaya have advanced significantly over the past few decades, and it is today regarded as a valuable fruit plant with nutraceutical properties. In addition to being tasty and nutritious, the ripe fruit and unripe fruit pulp have been shown to offer therapeutic benefits. The study reveals that ripe and unripe papaya fermenta have various phytoconstituents including: spirohexane-5-one (linolenic acid),1(+)-lactic acid, tert-butyldimethylsilylester (Propanoic acid), Caffeic acid (CA), myristic acid, myristin and linolelaidic acid. These compounds have various biological activities and are responsible for papaya's numerous health advantages.

No. of Pages: 6 **References: 28**

Keywords: *Carica papaya*, medicinal plant, phytoconstituents, LCMS, Biological activity.

INTRODUCTION

Carica papaya is herbaceous plant belongs to Caricaceae family. It is found in tropical region of the world. The papaya tree is a tiny tree with few branches that typically has a single stem that grows between 6- 10 meters (16 and 33 feet) tall and has spirally arranged leaves. According to Yogiraj *et al*., (2014) large, long-stemmed, weak, and usually unbranched terminal cluster of leaves produces an abundance of white latex, growing up to 10 meters tall. It is an herbaceous perennial with copious amounts of milky latex (Fayziyeva *et al*., 2021; Carvalho *et al*., 2012). The enormous, strongly palmately lobed leaves have seven lobes. Latex is present in all plant parts with articulated laticifers (Ogunlakin *et al*., 2023). Papayas reproduce sexually. The male flowers have their stamens fused to their petals, whereas the female blooms have five parts and are very dimorphic. The female flowers feature five twisted petals that are loosely attached at the base, along with a superior ovary (Ashish *et al*., 2021).

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The goal of phytochemical analysis is to define phytochemical standards for medicinal plant material for quality control purposes as well as to screen, identify, extract, and isolate phytoconstituents in order to assess the therapeutic potential of the plant. Nutraceuticals, food supplements, traditional medicine, pharmaceutical intermediates, bioactive products, and traditional medical systems all contain new pharmaceuticals derived from medicinal plants.

It also offers the plant extract's chemical fingerprint. This fingerprinting is carried out through qualitative examination, and quantitative assay can also be used to confirm it. Biological samples containing pharmaceuticals and plant metabolites have also been analyzed and quantified using LCMS.

MATERIALS AND METHODS

Plant materials

The fresh ripe and unripe papaya fruits were purchased from market of Gwalior, India. The authentication of fruit is done by Jiwaji University Institute of Ethnobiology.

Preparation of ripe and unripe papaya fermenta

After purchasing ripe and unripe papaya from the market, the skin (peel) and seeds were carefully removed and the pulp was salvaged. After being mechanically crushed, the pulp was diluted 1:1 (w/v) with purified water for both ripe and unripe papaya. The Panda et al., (2014) modified method is used for fermentation. After fermentation the product was filtered and kept in cold store for further analysis.

LC-MS (Liquid chromatography- mass spectrometry)

The analytical chemistry technique known as liquid chromatography–mass spectrometry (LC-MS) blends the mass analysis powers of mass spectrometry (MS) with the physical separation capabilities of liquid chromatography (or HPLC). Coupled chromatography - mass spectrometry systems are widely used in chemical analysis due to their ability to increase the specific capabilities of each technique while working in concert. Mass spectrometry offers the structural identification of the individual components with high molecular specificity and detection sensitivity, whereas liquid chromatography separates mixtures with many components. Organic, inorganic, and biochemical substances that are frequently present in complex samples with biological and environmental origins can all be analyzed using this tandem approach. Thus, LC-MS can be used in many different fields, such as biotechnology, food processing, environmental monitoring, pharmaceutical, agrochemical, and cosmetic industries (Jaspreet *et al*., 2022).

An LC-MS system includes instruments for mass spectrometry and liquid chromatography in addition to an interface that effectively moves the separated components from the LC column into the MS ion source (Mukherjee, 2002; Kamboj, 2000). The LC and MS devices are essentially incompatible, necessitating the interface. Although the mobile phase in an LC system is a pressurized liquid, high vacuum (about 10−6 torr / 10−7 "Hg) is typically used by MS analyzers. Consequently, the eluate from the LC column cannot be pumped straight into the MS source. In general, the interface is a mechanically straightforward component of the LC-MS system that transfers the most analyte possible, eliminates a sizable percentage of the LC mobile phase, and maintains the chemical identity of the chromatography products (which are chemically inert). The interface must not impede the MS system's ionizing efficiency or vacuum conditions (Dr. Mukherjee, 2002). These days, atmospheric pressure ionization (API) techniques such as electrospray ionization (ESI), atmospheric pressure chemical ionization (APCI), and atmospheric pressure photo-ionization (APPI) represent the foundation of the majority of widely used LC-MS interfaces. Following a two-decade research and development process, these interfaces were made available in the 1990s (Verma & Singh, 2006).

Analysis of fermented papaya products by LCMS

For LC-MS analysis, Liquid Chromatography-Mass Spectroscopy Shimadzu model no. 8030 was used. LC-MS analysis of fermented Papaya products was carried out using a mobile phases A (water/acetonitrile 90:10 (v/v) 0.1% HCOOH) and B (acetonitrile 0.1 % HCOOH) at a flow rate of 0.6ml/min. The following gradient was applied linear increases from solution 30% B to 100% B in 17 min, hold at 100% solution B for 20 min. The various details of LC-MS were that the m/z scanning range was 50-500 [Q3 scan (+) (-)] with a run time of 15 min. along with the event speed of 0.005sec. The scan speed is 1857 with nebulizing crus flow of 2L/min. The heat block temperature of the instrument is 400˚C with drying crus flow of 15 l/min. The total flow rate is 0.9ml/min and the pump concentration of B: A is 65:35%. The maximum and the minimum pressure limit of both the pumps A & B re 300 kg f/cm^3 & 0 kg f/ cm^3 resp. The detector used in UV detector along with the wavelength of 254nm with auxillary range 1.04 Au/m and recercler range of 1.0000. The intensity unit is calculated in Volt & the temp. of the column oven is 40˚C. The mobile phases of pump A are 0.1 formic acid and the mobile phase of pump B is 100% methanol. Analytical HPLC analysis (Shimadzu LC20 AD) was carried out on a C reversed phase analytical column (150mm_4.6mm, particle size 5mm) at 37˚C using mobile phase A (water/acetonitrile, 90:10 (v/v) 0.1 TFA and B (acetonitrile, 0.1TFA) at a flow rate of 1.5ml/min. The following gradient was applied linear increase from solution 30% B to 100% B in 10 min. Their condition of columns as well as the flow rates etc. where same as LCMS.

RESULT AND DISCUSSION

The LC-MS investigation of fermented Papaya products reveals the presence of three compounds in ripe papaya fermenta and ten compounds in unripe papaya fermenta. Detailed information about the identified components including molecular weight, molecular formula are shown in fig 1,2 and table 1,2.

In the ripe papaya fermenta, the LC-MS analysis indicated the presence of 2-butanone, 4-hydroxy-3-methyl, myristic acidand spirohexane-5-one(linolenic acid).

The unripe papaya fermenta contained (+)-3,4 dihydroproline amide; N, N-Dimethyl-o-(1-methylbutyl)-hydroxylamine; 5-fluoro-6-methyl-5-heptene-2-one; pyrimidine-2,4 (1H, 3H)-dione, 5 amino, 6 nitroso; DL-glyceraldehyde dimer; 2-butanone, 4-hydroxy-3-methyl and 1(+)-lactic acid, tert-butyldimethylsilylester.

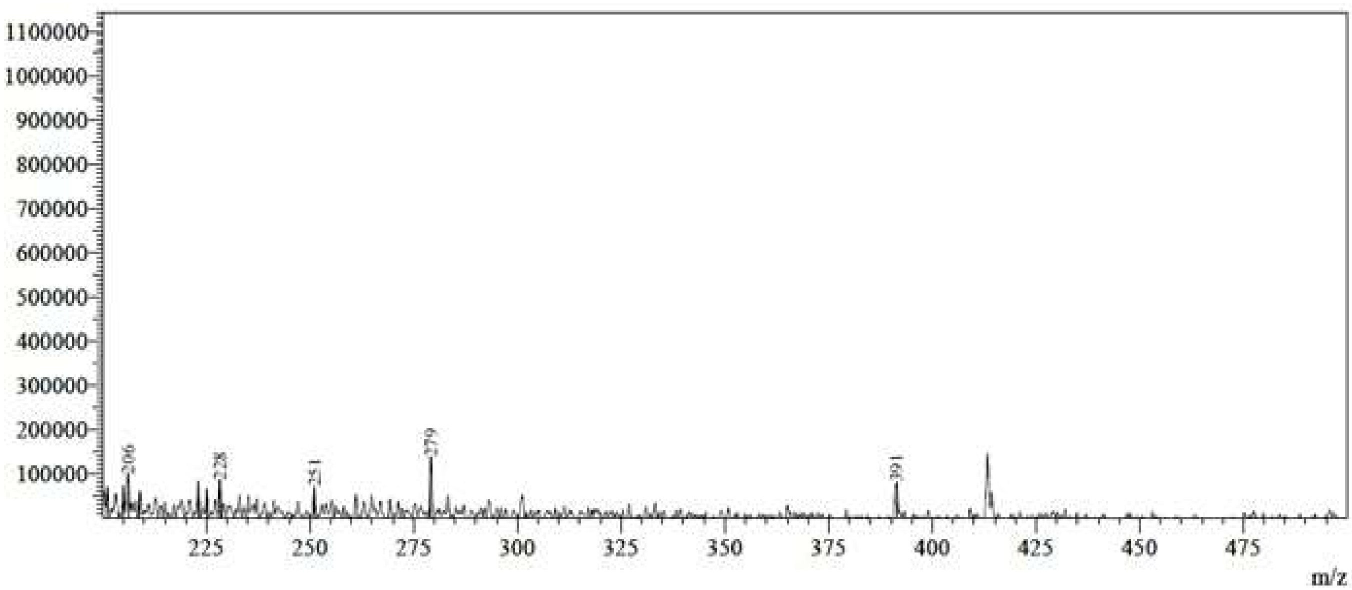

Fig. 1: LC-MS chromatogram of Ripe Papaya Fermenta.

Table 1: Phytochemical compounds identified in Ripe Papaya Fermenta by LC-MS.

S. NO.	Molecular weight	Molecular formula	Bioactive component
1.	206	$C_{13}H_{16}O_2$	2-butanone, 4-hydroxy-3-methyl
2.	228	$C_{14}H_{28}O_2$	Myristic acid
3.	279	$C_{18}H_{30}O_2$	spirohexane-5-one(linolenic acid)

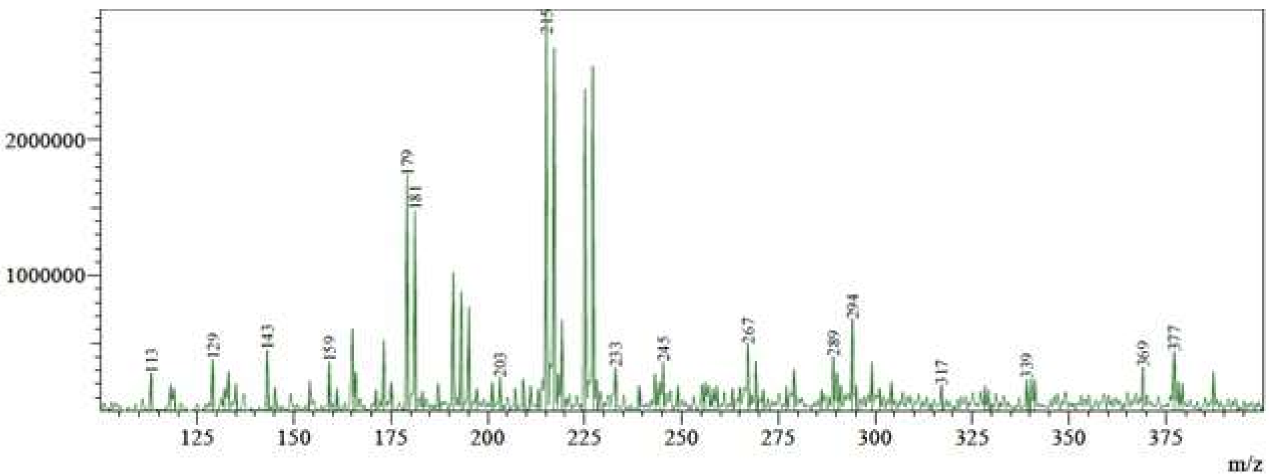

Fig.2: LC-MS chromatogram of Unripe Papaya Fermenta.

Table 2: Phytochemical compounds identified in Unripe Papaya Fermenta by LC-MS.

S. NO.	Molecular weight	Molecular formula	Bioactive component
1	113	$C_5H_8N_2O$	(+)-3,4 dihydroproline amide
2	129	$C_7H_{17}NO$	N,N-Dimethyl-o-(1-methylbutyl)-hydroxylamine
3	143	$C_8H_{13}FO$	5-fluoro-6-methyl-5-heptene-2-one
4	159	$C_4H_4N_4O_3$	pyrimidine-2,4 (1H, 3H)-dione, 5 amino, 6 nitroso
5	179	$C_9H_8O_4$	Caffeic acid
6	181	$C_{10}H_{15}NO_2$	[Bis-(2-hydroxyethyl)amino]benzene
7	204	$C_{13}H_{16}O_2$	2-butanone, 4-hydroxy-3-methyl
8	294	$C_{19}H_{3}4O_2$	Linolelaidic acid, methyl ester
9	317	$C_{15}H_{10}O_8$	Myricetin
10	318	$C_{15}H_{34}O_3Si_2$	1(+)-lactic acid, tert-butyldimethylsilylester (Propanoic acid)

Some of these compounds possess several biological activities. Spirohexane-5-one(linolenic acid) showed Hypocholesterolemic, Cancer preventive, Hepatoprotective, Nematicide, Antihistaminic, Antiarthritic, Anti-coronary, Antieczemic Antiacne, 5-Alpha reductase inhibitor Antiandrogenic (Akhilesh & Anusha, 2013), Anti-inflammatory (Zhao *et al*., 2007), lowers high blood pressure and also used to prevent heart attack (Stanley *et al*., 2007) and cancer; 1(+)-lactic acid, tert-butyldimethylsilylester (Propanoic acid) have Anti-microbial activity (Shahraz *et al*., 2011), Anti-inflammatory activity (Nakajima *et al*., 2018), exhibiting analgesic and antipyretic properties (Loaiza-Ambuludi *et al*., 2013; Turan-Zitouni *et al*., 2015), herbicides, controlling both monocotyledonous and dicotyledonous plants

(Degenhardt *et al.*, 2011; Eş I *et al.*, 2017) as a preservatives in bakery and cheese products (Sabra *et al.*, 2013; Del *et al.*, 2013), also used as artificial flavours and fragrances (Liu *et al.*, 2012), pharmaceuticals (Shams *et al.*, 2019). Anti-obesity, Antidiabetic, Lower fatty acid content in liver and plasma reduces food intake, exerts immunosuppressive action & probably improves tissue insulin sensitivity (Heimann *et al.*, 2022). It also plays an important role in inflammation, oxidative stress, lipid metabolism, and mitochondrial function (Macfabe, 2012; Nankova *et al.*, 2014; MacFabe, 2015). Caffeic acid (CA) is a phenolic compound synthesized by plant species and is present in foods such as wine, coffee, tea. It is a phenolic acid and its derivatives have antioxidant, anti-inflammatory and anticarcinogenic activity (Kaio *et al.*, 2019).

CONCLUSION

Papaya is a potential source of phytoconstituents with several biological activities. From the study, it has been discovered that the fermented papaya productscontain alkaloids, flavonoids, phenols, terpenoids and tannins etc. A few compounds with different biological activities have been identified from fermented papaya products including spirohexane-5-one, 1(+)-lactic acid, tert-butyldimethylsilylester and Caffeic acid. Fermented papaya products are a potential therapeutic functional food which help to reduce degenerative diseases such as diabetes, cancer, obesity. It also has anti-inflammatory, anti-oxidants, anti-microbial, Hypocholesterolemic and hepatoprotective potential. The investigation of these products major bioactive components laid the foundation for further investigation into the possible health advantages of these plants and the necessity of more pharmacological studies.

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FLAVORED GOAT CHEESE AS A VALUE ADDED PRODUCT

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Research Paper

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ABSTRACT

Flavored goat cheese has huge potential in developing into a successful value added product. Goat cheese is a delicacy and could serve and cater to high value customers in the high end city restaurants, cafeteria and markets specialized for value added products. Goat cheese is healthier and neutraceutically enriched compared to conventional cow cheese. The benefits of goat cheese are high and this should be marketed as specialty products with health and nutritional benefits for the targeted customers. This could be an effective opportunity for small indigenous goat milk and cheese producers to supplement their annual income through on farm production of flavored goat cheese and allied products for their high value targeted customers.

No. of Pages: 4 **References: 7**

Keywords: Goat cheese, value added product, flavor, producers, neutraceutically, market, customers.

INTRODUCTION

Flavored goat cheese is a value added product which has many interesting perspectives to it. What is so interesting about it is that regular cheese is considered both a delicacy and a common food in many countries. When we start using goat milk to make cheese and add flavor to it, we get a product which is very unique but still a product which many people will eat. Adding this extra value to it brings the cheese from a regular food to the top of the delicacy foods list. Farmers who produce flavored goat cheese control the entire value chain, and as a result they have the potential to make huge profits off of their product (Caldwell, 2011). Flavored goat cheese is a very interesting product all the way from how it is produced to how it gets served in some very high end restaurants. The majority of goat cheese is produced by the farmer who milks the goats. By doing this there are a few levels of manufacturing that are skipped which results in higher margins for the person selling the goat cheese (Weinstein and Scarborough, 2011).

Milking their own goats and from that milk producers could make cheese and add extra value to it by adding flavor to the cheese, and they sell the cheese right to the customer (Noble Meadow Farms, 2018). This way the producer can make more money because they do not have to buy the milk or sell to a wholesaler. Flavored goat cheese is considered both a delicacy and a common food. Many people around the world eat cheese as a common food, but flavored goat cheese is usually used as a delicacy (Mourik, 2016). Because of this, the value of these specialty cheeses

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increases to many times its production value. Specialty products around the world always sell for more than regular products which are similar (McMahon, 2023). Goat cheese producers have to take advantage of this and add flavor to their cheese so that they can sell their products as specialty products for a higher premium than people selling their cheese as a common food product (What's Cooking America 2023).

Start Up for Goat Flavored Cheese

There are many things to look at and consider when wanting to market a new value added product. The amount of research needed, as well as survey and knowledge to gain before starting a value added product is immense. This is because we have to have some sort of an idea of whether or not this product will survive. We will take a look at the potential it has, if there is a market and what that market is, and all of the other aspects of this value added product. If we want this to be a successful product we will have to look at the primary and secondary research that will be needed. This will give us an idea on how well flavored goat cheese will do in this agricultural industry. We will also be taking a look at what a business plan is and how it can future help us with value added product; and we should look at regular goat cheese and kind of compare it to what we are trying to do. Because there is already a market for goat cheese, we need to find out what we can do differently to make flavored goat cheese compete in the same market.

Regular goat cheese, which is with no added flavor, is wildly popular because of its nutritional value and the actual taste of it. It has been around for many years and it is something that people have become accustomed to. If we want to market flavored goat cheese then we are going to have to incorporate these types of characteristics in our value added product. We can keep it just as nutritional as regular goat cheese, possibly adding more nutrition with our flavor, but changing the taste might be difficult because it is already liked. Taking something that is already established in the market and changing it is going to be the difficult part. Sure we can make our own goat cheese and sell that at the Farmers Market, but what we really want to do is something different. Flavored goat cheese will be different, but not too out of the norm that people will not give it a try. We need to think about the consumer and what they are going to want (Table 1).

Table 1: Merits and demerits of Flavored Goat Cheese Production.

Merits	Demerits
Potential of huge markets	Hard to establish a steady market base
Value added product which can be sold for a higher premium	Can be very labor intensive
Only a few producers nation-wide	Huge competition from cow cheese producers
Lower start-up costs than cow cheese	Hard to convince people that it is a better product than cheese made from cow milk

Farmers starting their own goat cheese operations may be overwhelmed by start-up capital costs of the industry, but there is a lot of potential for these farmers. There are farmers who start milking goats but they just sell their milk to local factories, but farmers who milk their goats and make their own cheese control the entire value chain and as a result they have both financial and economic potential with their flavored goat cheese operation (6). Since there are only a select few people who produce flavored goat cheese, it is a huge advantage to be able to control the majority of the market.Fig. 2 – Cow Cheese vs. Goat Cheese

Fig. 2 Comparison of Cow Chhese vs. Goat Cheese

Potentiality of goat cheese in terms of business opportunities

The sky is the limit when it comes to marketing flavored goat cheese. Every country in the world has a population which eats cheese (5). Cheese is one of the most common foods in the entire world. If a flavored goat cheese producer can recognize this, it might be possible to find international customers who want to buy the flavored goat cheese as a delicacy (2). This would be financially feasible and also produce endless opportunities as far as marketing is concerned. If a steady customer base can be built up, flavored goat cheese can be one of the best products to sell since it will be stable and secure. By adding flavor to goat cheese, there is a lot of value being added since it is being labeled as a specialty product after the flavor is added (5). This flavoring is the most expensive part of the entire cheese but as a result it will create a product which can be sold for more than 100% of its initial production costs (3). The flavoring is the trick behind creating a value added product which is unique and will generate revenue for a business starting in the flavored goat cheese industry. Goat cheese is also healthier and more neutraceutically enriched than cow cheese. It has lower calories, cholesterol, and even lower fat content than cow milk, and as a result it is healthier and should make the product more attractive for the general public. The hard part is trying to convince people that they should be buying flavored goat cheese instead of cow cheese.

So now we will have to do a good amount of research to see just how many people would try this out. This is called the primary research portion of value added production. Some of the different questions we need to ask here are; is there a market for flavored goat cheese? How much will the start up costs be? What will the price of the product be- producing and selling? Then we will need to do some secondary research. The secondary research is a little more specific with the kinds of customers, and also the different flavors that we can have and so on. Both of these types of research are very important when it comes to value added production. One thing is will need to find out is what kinds of customers our product is aiming for. This includes:

- Age
- Sex
- Education
- Income
- Marital status
- Size of household
- Number of income generators
- Recreational interests
- Household appliances owned

Then we will have to send out surveys and questionnaires to get even more specific in our research. This is a very important part of value added production. It gets into the minds of the consumers and lets us know detailed information that will aid us in our decisions. This is an example of some survey questions for the value added product of flavored goat cheese:

1. How often do you eat goat cheese?
2. What types of flavors would you prefer?
   A. Cranberry B. Herb and Garlic C. Roasted Pepper
3. How much would you pay for this product?

Once we have all of this information we can put it into cross tabulation (Table 2). This is a table that organizes all of the answers we get from the questions we ask for us to refer back to for information. This is an example of one:

Table 2: Example of Cross Tabulation.

Age eat	% of people that like goat cheese	% of people willing to pay more for flavored goat cheese	% of people who goat cheese at least once a week
15-20	20	5	5
20-25	40	20	30

The more research done the more we can see the potential that flavored goat cheese has in the market. Another question to answer is; where is this market going to be? Here with the flavored goat cheese we can look at producing it locally and selling it locally at a farmers market. Purchasing product locally today is a big factor when it comes to consumers. People like to know where their food is coming from and they like it when it is the community that is benefiting from the sales. Flavored goat cheese can easily be produced and sold locally or even throughout the province. If we cut out the middle man, do most of the work and labor ourselves then our product will be of better quality and also more affordable for us and for our customers. We can make a value chain that will demonstrate how our product gets from the farm to the farmers market. For example:

Producer (farmer, labor, goats, machinery)→ Farmers market→ Customer

This here is a general idea of what a value chain looks like. If we are going to produce and sell our product locally we do not need shipping, transportation, or retail to aid us. All of the steps taken for our value added product of flavored goat cheese comes from a business plan. A business plan is a necessity when it comes to value added products. It basically is everything we have already looked at and giving them a real spot in the production of our flavored goat cheese. Some of the aspects of a business plan are as follows:

1. Executive summary
2. Introduction (history and background)
3. Mission Statement (summary of goals and objectives)
4. Vision Statement (future goals)
5. Core philosophy (ideas and beliefs)
6. Main and subsidiary business areas
7. Goals and objectives (goals towards value added production and more on products)
8. SWOT (Strength, Weakness, Opportunities, and Threat) analysis
9. Challenged and opportunities (ideal market)
10. Action plan/ road maps
11. Financial plan

Something else to take into consideration is the supply and demand of other products. This will give you an idea of what competition is out there and how well they are doing in the market.

CONCLUSION

Flavored goat cheese is a value added product which has a lot of potential to become a successful product. It is a product that is eaten as both a delicacy and a common food in many different countries. It is a product which is produced on-farm on the majority of goat cheese operations and as a result it creates higher margins of profit for the producers. By adding flavor to goat cheese, a product is created which has a lot of added value and as a result it has potential to be sold in many different countries world-wide. Over all there is a lot to be learned before you start on a value added product project. You cannot just jump into the project without doing any research or planning. Knowledge is going to be your biggest helper and is going to aid you the most with your work. Having a great team and being organized are also factors that play a role in value added productions. Regular goat cheese is not a value added product, but when we put our own spin on it, adding flavor, selling it at a farmers market, we add the value to make it different and possibly very successful. The important take home messages being:

- The majority of flavored goat cheese is produced and sold by the same business.
- Flavored goat cheese is considered both a delicacy and a common food.
- There is a lot of potential for farmers who are starting their own flavored goat cheese operations.
- Flavored goat cheese has the possibility of becoming a product which can be sold in every country of the world. It has no ethnic or cultural drawbacks.
- Adding flavor to goat cheese adds extra value to the product and as a result it can be sold for more than a 100% profit margin.

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