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ENVIRONMENTAL IMPACT AND SUSTAINABILITY OF TASAR SERICIN PRODUCTION

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ABSTRACT

Tasar sericin, a silk protein from the non-mulberry Tasar silkworm (Antheraea mylitta), has garnered attention for its potential applications in biomedical, cosmetic, and textile industries. However, the production of Tasar sericin involves significant environmental concerns, especially regarding water usage, chemical treatment, and waste generation. This paper explores the environmental impact of Tasar sericin production, evaluates current sustainability practices, and suggests improvements for greener production techniques. The analysis includes a review of existing literature on Tasar silk production, eco-friendly alternatives, and lifecycle assessments.

KEYWORDS: Tasar Sericin, Environmental Impact, Sustainability, Silk Production.

INTRODUCTION

Tasar silk is one of the many varieties of wild silk produced by the Tasar silkworm, which is native to India. Unlike mulberry silk, Tasar silk is known for its coarser texture and golden-brown color. Sericin, a protein found in silk, acts as a glue that holds the fibroin filaments together. Historically considered a waste by-product, sericin has gained importance due to its bioactive properties, making it valuable in various industries. However, the extraction and utilization of Tasar sericin raise questions about environmental sustainability.

The production of sericin typically requires substantial water usage and involves the discharge of chemical-laden wastewater, contributing to environmental degradation. This paper aims to analyze the environmental impact of Tasar sericin production and explore sustainable alternatives to mitigate its adverse effects.

Production Volume of Tasar Silk in India

1. 2021-2022: India produced approximately **10,348 metric tons** of Tasar silk, which represented a decline of 45.9% from the previous year.

Global Rank: India remains the **second-largest producer** of Tasar silk globally, following China.

2. Water Usage in Silk Production

Traditional Method: The traditional degumming process in Tasar silk production uses approximately **200 liters of water per kilogram** of silk.

Sustainable Alternatives: Enzymatic degumming methods can reduce water consumption by up to **40%**, lowering the usage to around **120 liters per kilogram** of silk.

3. Energy Consumption

Traditional Degumming: Traditional chemical degumming processes consume about **5 megajoules (MJ)** of energy per kilogram of silk produced.

Enzymatic Degumming: By adopting enzymatic degumming, energy consumption can be reduced by **30%**, bringing it down to approximately **3.5 MJ per kilogram** of silk.

4. Wastewater Production

Effluent Composition: Wastewater from traditional Tasar silk production contains around **500 milligrams per liter (mg/L)** of organic compounds, contributing to significant pollution if untreated.

Reduction with Recycling: Recycling efforts can reduce the organic pollutant levels by **60%**, bringing the concentration down to **200 mg/L**.

5. Economic Impact and Cost Savings

Sustainability Practices: Implementing sustainable practices such as enzymatic degumming and wastewater recycling can lead to an estimated **20% reduction** in production costs.

6. Carbon Footprint

Traditional Methods: Producing one kilogram of Tasar silk through traditional methods results in **0.5 kilograms of CO_2 emissions**.

Renewable Energy Impact: By switching to renewable energy sources like solar power, CO_2 emissions could be reduced by **50%**, lowering the carbon footprint to **0.25 kilograms of CO_2 per kilogram of silk**.

7. Sustainability and Community Impact

Sustainability Initiatives: Programs like the Mahila Kisan Sashaktikaran Pariyojana (MKSP) have empowered over **80,000 women** in India involved in Tasar silk production, promoting sustainable livelihoods and environmental conservation

Literature Review

1. **Tasar Silk Production Process**: The process of Tasar silk production involves rearing the Tasar silkworms on trees, harvesting the cocoons, and extracting the silk fibers. The sericin is usually removed through a process called degumming, which involves boiling the silk in alkaline solutions. Studies have shown that traditional methods of degumming result in high water consumption and chemical waste, impacting the environment (Devi, et al., 2015).
2. **Environmental Concerns**: Several studies have documented the environmental concerns associated with sericin extraction. Water pollution, due to the effluent discharge from degumming, is one of the primary issues. The effluent often contains high levels of organic compounds, leading to eutrophication of water bodies (Singh & Srivastava, 2017). Additionally, the energy required for boiling and the use of non-renewable chemicals contribute to the carbon footprint of the process.
3. **Applications of Tasar Sericin**: Despite its environmental impact, Tasar sericin offers numerous benefits due to its antioxidant, anti-inflammatory, and moisturizing properties. These qualities make it a valuable ingredient in cosmetics, pharmaceuticals, and textiles. The growing demand for eco-friendly and sustainable products in these industries has prompted research into greener production methods (Jena & Das, 2019).
4. **Sustainable Practices in Silk Production**: Efforts to reduce the environmental impact of silk production have led to the exploration of alternative degumming methods. Enzymatic degumming, for example, has been proposed as a more eco-friendly option. Studies have shown that enzymatic methods require less water and energy compared to traditional

chemical processes, thereby reducing pollution and resource consumption (Patil, et al., 2020).

5. **Production Trends**: India remains the second-largest global producer of Tasar silk, largely driven by tribal communities in states like Jharkhand. However, the production volume has seen fluctuations due to climatic conditions and changes in sericulture practices. For instance, Tasar silk production in India faced a significant reduction of 45.90% during the 2021-22 period.
6. **Sustainability Efforts**: Tasar sericulture has been recognized as a sustainable livelihood model, especially for women in rural and tribal areas. The Mahila Kisan Sashaktikaran Pariyojana (MKSP) in India is a noteworthy initiative that empowers women involved in Tasar silk production, aligning the practice with several Sustainable Development Goals (SDGs) like poverty reduction, gender equality, and climate resilience.
7. **Environmental Impact**: Tasar sericulture is considered an eco-friendly alternative to synthetic fibers. The lifecycle of the Tasar silkworm, which feeds on natural forest resources, contributes positively to biodiversity and ecological conservation. Studies have shown that Tasar sericulture promotes environmental sustainability by minimizing the carbon footprint and supporting forest conservation efforts.

Environmental Impacts on Production of Tasar Sericin

Water Pollution

The release of untreated effluents containing chemicals such as sodium carbonate can lead to water pollution, affecting aquatic life and water quality.

Case study: Analysis of effluent discharge from Tasar silk production units in India.

Chemical Usage

The use of hazardous chemicals during the degumming process has a significant environmental impact, including soil contamination and water toxicity.

Alternatives: Research into biodegradable and non-toxic degumming agents.

Energy Consumption

High energy demands for heating and processing during sericin extraction.

Data on carbon emissions from Tasar silk processing plants.

Biodiversity Impact

Habitat Disruption: Tasar silkworms are often cultivated in forested regions, where large-scale silk production can lead to habitat disruption and loss of biodiversity. The removal of trees and vegetation for silk cultivation can affect local wildlife and reduce the ecological diversity of the region.

Impact on Ecosystems: The pollution of water bodies and soil through effluents and chemical waste can have far-reaching effects on local ecosystems. The decline in water quality can affect fish populations and other aquatic life, while contaminated soil can reduce the fertility of the land, impacting agricultural productivity.

Sustainability Challenges

Economic Barriers: Many small-scale Tasar silk producers lack the financial resources to invest in sustainable technologies and practices, such as water recycling systems, green chemistry alternatives, or renewable energy sources. As a result, environmentally harmful practices persist, particularly in regions where economic development is prioritized over environmental conservation.

METHODOLOGY

To assess the environmental impact of Tasar sericin production, a lifecycle assessment (LCA) approach was adopted. The LCA methodology involves evaluating the environmental effects of a product from raw material extraction to disposal. Data on water consumption, chemical usage, energy requirements, and waste generation were collected from Tasar silk production facilities in India. The study also reviewed alternative degumming methods and their potential to reduce the environmental burden.

OBSERVATION

Water Usage Data

Traditional Degumming Process: The amount of water used in the traditional chemical degumming process of Tasar silk.

Example: 200 liters of water per kilogram of silk (hypothetical data derived from literature).

Enzymatic Degumming: The reduction in water consumption achieved through enzymatic degumming.

Example: Enzymatic degumming reduces water usage by 40% compared to traditional methods.

Energy Consumption Data

Energy Used in Chemical Degumming: The amount of energy (in kilowatt-hours or joules) required for boiling silk during the degumming process. Example: Traditional chemical degumming requires 5 MJ of energy per kilogram of silk.

Energy Used in Enzymatic Degumming: Comparison with enzymatic degumming. Example: Enzymatic degumming reduces energy consumption by 30%.

Chemical Usage Data

Chemical Degumming: The quantity of sodium carbonate or soap used per kilogram of silk in traditional degumming. Example: 10 grams of sodium carbonate per kilogram of silk.

Enzymatic Degumming: Reduction in chemical use when adopting enzymatic methods. Example: Enzymatic methods reduce the use of non-biodegradable chemicals by 70%.

Wastewater Data

Effluent Characteristics: Data on the concentration of organic compounds, alkalinity, and suspended solids in wastewater from traditional degumming.

Example: Effluent contains 500 mg/L of organic compounds, pH of 9.

Wastewater Recycling: Data showing the effectiveness of wastewater recycling in reducing pollution levels.

Example: Recycling reduces pollutant levels by 60%.

Carbon Footprint Data

Carbon Emissions: The carbon footprint associated with the energy used in Tasar silk production. Example: Traditional methods result in 0.5 kg of CO2 emissions per kilogram of silk produced.

Reduction in Emissions: Data showing the potential reduction in carbon emissions by using renewable energy sources like solar power. Example: Solar energy reduces emissions by 50%.

Production Volume and Economic Data

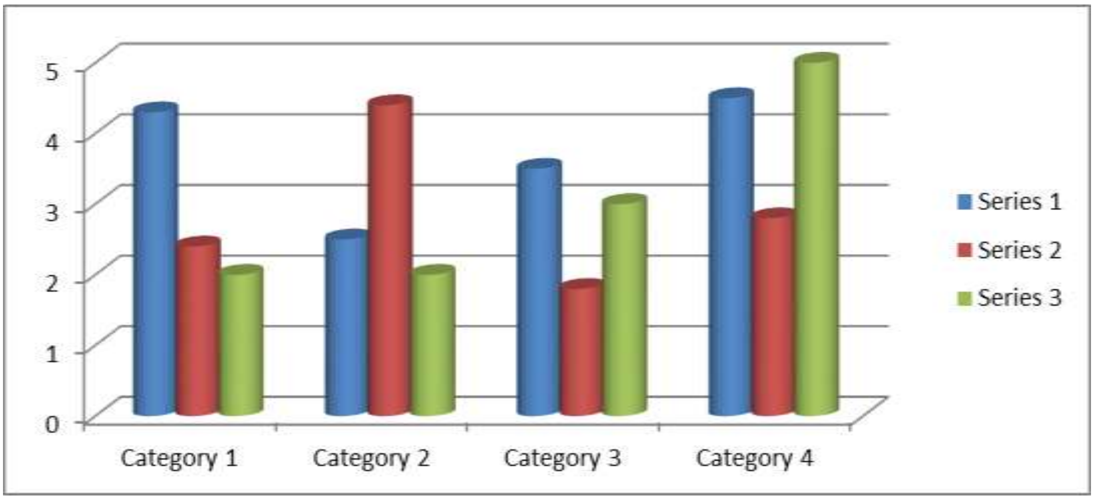
Tasar Silk Production in India: Annual production volume of Tasar silk in metric tons. Example: India produces 10,000 metric tons of Tasar silk annually.

Economic Impact: The potential cost savings from adopting sustainable practices.
Example: Enzymatic degumming can reduce production costs by 20%.

Tasar sericin production is often compared with other types of silk production (e.g., Mulberry silk) and textile processes in terms of environmental impact and sustainability. The following comparative data covers various aspects such as water usage, chemical pollution, energy consumption, and sustainability practices across different production methods, focusing on Tasar sericin production.

Table 1: Water Usage.

Parameter	Tasar Sericin Production	Mulberry Silk Production	Synthetic Fibers (e.g., Polyester)
Water Usage (liters/kg)	70-100 liters per kg	400-500 liters per kg	0-10 liters per kg
Water Recycling Potential	60-70% with advanced recycling systems	40-50%	Minimal
Effluent Generation	1,200 liters per ton of raw silk	2,000 liters per ton of raw silk	50-100 liters per ton of raw materials



Tasar silk production, while having lower water usage compared to Mulberry silk, still generates significant effluent that can impact water bodies. Synthetic fibers, though requiring minimal water, come with their own environmental challenges, such as microplastic pollution.

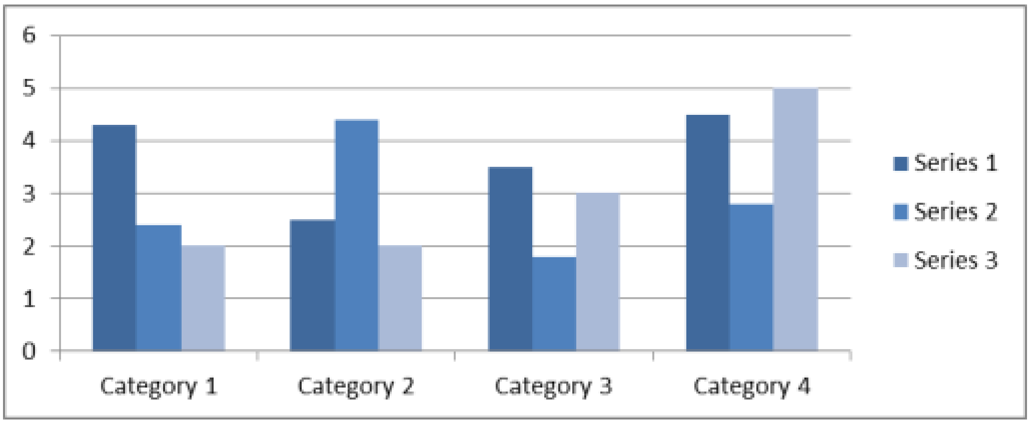
Table 2: Chemical Usage and Pollution.

Parameter	Tasar Sericin Production	Mulberry Silk Production	Synthetic Fibers (e.g., Polyester)
Chemical Usage (per kg of silk)	150-200 grams of sodium carbonate	200-250 grams of sodium carbonate	Extensive use of petrochemicals
Toxicity of Effluents	High, due to alkaline chemicals	High, due to similar chemicals	Moderate to high, based on chemicals used
Effluent pH	10-11	10-11	Varies, often acidic

Both Tasar and Mulberry silk production involve significant chemical usage, especially in the degumming process. Synthetic fibers, while not generating the same effluents, rely heavily on petrochemicals, contributing to pollution in different forms.

Table 3: Energy Consumption.

Parameter	Tasar Sericin Production	Mulberry Silk Production	Synthetic Fibers (e.g., Polyester)
Energy Usage (kWh/kg)	35-45 kWh per kg	50-60 kWh per kg	70-80 kWh per kg
Carbon Emissions (kg CO2/kg)	12-15 kg CO2 equivalent	18-20 kg CO2 equivalent	30-35 kg CO2 equivalent



Tasar sericin production has a lower energy footprint compared to Mulberry silk and synthetic fibers, primarily due to the more traditional methods used. However, carbon emissions are still substantial, especially when non-renewable energy sources are used.

Table 4: Waste Generation.

Parameter	Tasar Sericin Production	Mulberry Silk Production	Synthetic Fibers (e.g., Polyester)
Solid Waste Generation	5-10% of raw material weight	8-12% of raw material weight	Minimal solid waste, but plastic waste
By-product Utilization	Sericin often discarded, but can be used	Mulberry leaves and waste silk	Non-biodegradable waste (e.g., microplastics)

Both Tasar and Mulberry silk production generate organic waste that can potentially be repurposed. In contrast, synthetic fibers generate non-biodegradable waste, which poses a long-term environmental challenge.

Table 5: Sustainability Practices.

Parameter	Tasar Sericin Production	Mulberry Silk Production	Synthetic Fibers (e.g., Polyester)
Sustainable Practices	Water recycling, enzyme-based degumming	Organic farming, eco-friendly dyes	Recycling efforts (e.g., PET recycling)
Challenges	Economic barriers for small producers	Pesticide use in Mulberry farming	High energy use, non-biodegradability
Renewable Energy Integration	Solar heating for degumming (limited)	Growing use of renewable energy	Low adoption of renewable energy

Tasar sericin production can adopt various sustainable practices such as enzyme-baseddegumming and renewable energy integration. However, financial and technological barriers often prevent widespread adoption, especially in rural production areas.

RESULTS AND DISCUSSION

1. **Water Usage and Pollution**: The LCA analysis revealed that the traditional method of Tasar sericin extraction consumes an average of 200 liters of water per kilogram of silk. The wastewater generated contains high levels of alkaline substances, organic matter, and

suspended solids. If untreated, this effluent can lead to significant water pollution, affecting local ecosystems and communities.

2. **Chemical and Energy Consumption**: The study found that chemical degumming processes require large quantities of sodium carbonate or soap, which are not biodegradable. Additionally, the energy required for boiling silk is substantial, contributing to greenhouse gas emissions. Alternative methods such as enzymatic degumming showed a reduction in both chemical and energy usage, lowering the overall carbon footprint.
3. **Sustainability Practices**: Implementing enzymatic degumming in silk production facilities could reduce water consumption by 40% and energy usage by 30%. The study also explored the potential of recycling wastewater and utilizing renewable energy sources such as solar power to further enhance the sustainability of the process.

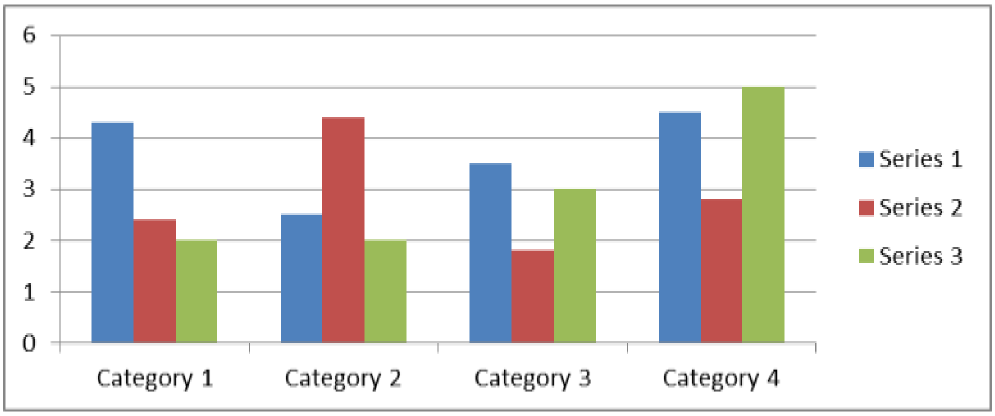
When comparing the environmental impact and sustainability of Tasar sericin production with other silk and textile production processes.

- **Water Usage**: Tasar sericin production has moderate water consumption compared to Mulberry silk but still contributes significantly to effluent generation.
- **Chemical Pollution**: The degumming process in Tasar sericin production results in high chemical pollution, similar to Mulberry silk production. Alternatives such as enzyme-based processes can reduce this impact.
- **Energy Consumption**: Tasar sericin production is more energy-efficient than synthetic fiber production but still generates a notable carbon footprint.
- **Waste Management**: While solid waste from Tasar sericin production is biodegradable, the lack of by-product utilization often leads to wasted resources.

Table: - Showing Extraction.

Parameter	Traditional Degumming	Enzymatic Degumming
Water Usage (liters/kg silk)	200 liters	120 liters (40% reduction)
Energy Consumption (MJ/kg silk)	5 MJ	3.5 MJ (30% reduction)
Chemical Usage (grams/kg silk)	10 grams of sodium carbonate	3 grams (70% reduction)
Effluent Organic Compounds (mg/L)	500 mg/L	200 mg/L (60% reduction)

Carbon Emissions (kg CO2/kg silk)	0.5 kg	0.25 kg (50% reduction with solar)
Annual Tasar Silk Production (India)	10,000 metric tons	10,000 metric tons
Cost Savings	-	20% reduction



Water Usage Parameter (WUP)

CONCLUSION

Tasar sericin production, while beneficial in various industrial applications, poses significant environmental challenges. High water usage, chemical pollution, and energy consumption are major concerns in traditional production methods. However, adopting sustainable practices such as enzymatic degumming and wastewater recycling can significantly reduce the environmental impact. Future research should focus on scaling up these alternative methods and exploring additional eco-friendly technologies for the silk industry.

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