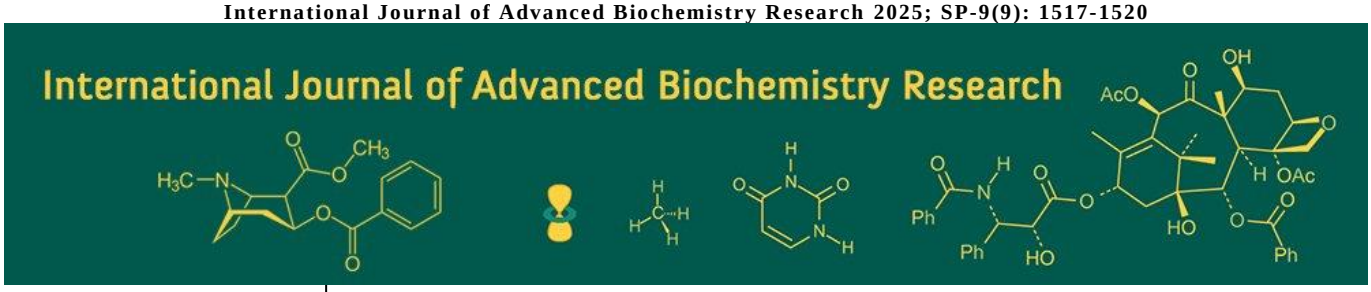

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Sustainable utilization of temple flower waste for incense stick production

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Abstract
The daily ritual of floral offerings in temples generates a significant quantity of discarded flowers that often end up in landfills or water bodies, contributing to environmental pollution. This research investigates the sustainable conversion of temple floral waste into value-added incense sticks as an eco-friendly waste management solution. Collected flower residues-primarily marigold, rose, and jasmine-were dried, powdered, and blended with natural binders to formulate incense paste. Laboratory analyses assessed key parameters such as moisture content, combustion rate, and fragrance retention to ensure product quality. Socio-economic evaluation highlighted potential income opportunities for local women's self-help groups through decentralized production units. The process promotes circular economy principles by transforming biodegradable waste into a marketable aromatic product. It reduces the ecological burden of floral waste disposal while fostering rural entrepreneurship. Results indicate that temple waste flowers can be efficiently repurposed without synthetic additives. This approach integrates environmental conservation with livelihood generation. Ultimately, the study demonstrates that sacred floral offerings can complete a sustainable life cycle, moving from spiritual devotion to fragrant utility.

Keywords: Temple floral waste, incense stick production, waste-to-value, sustainable resource management

Introduction
India's vibrant religious traditions involve daily offerings of fresh flowers at temples, generating a large quantity of floral waste that is typically discarded in open areas or water bodies. Occupational health risks from pesticide residues in floral waste were evaluated in French greenhouse workers. Surveys and biomarker tests revealed that 47% of florists handling untreated flower stock showed elevated pesticide metabolite levels, many imported flowers were not regulated under food pesticide standards, making exposure control more challenging. They recommended mandatory labelling of treated flowers, routine health surveillance, and enhanced training for floral industry workers. Their findings emphasized the overlooked toxicological risks in floral waste pathways, especially during manual segregation and composting processes, compared floral waste with other biodegradable waste types, revealing that floral waste decomposes 40% slower due to higher lignin and pesticide content. (Toumi *et al.* 2016 & Manasa *et al.* 2022) [7, 2].
This practice, while spiritually significant, contributes to environmental challenges such as foul odors, water pollution, and increased organic load in municipal waste streams. Addressing this issue requires innovative solutions that integrate environmental protection with socio-economic benefits. The reuse of floral waste has emerged as an innovative eco-solution, transforming waste into products like incense sticks and organic dyes. Their study, based on data collected from temple clusters, reported that converting 1 ton of flower waste could yield over 100 kg of compost and 15 kg of incense material, reducing landfill load by 30% (Soundarya *et al.* 2021) [5]. Floral waste generation in India surpasses 20 million tons annually, primarily due to cultural and religious events. Their study revealed that over 60% of this waste is improperly discarded in water bodies, contributing to eutrophication and harming aquatic ecosystems. This was emphasized the need for decentralized processing units at temple and market sites, estimating that on-site composting and upcycling could reduce open dumping by 45%. They advocated policy-level interventions and public-private

partnerships to ensure sustainable management and reuse of floral waste in urban and peri-urban landscapes (Racha *et al.* 2022) [4].

Aquatic pollution from floral waste was analyzed using water samples from three rivers in Vietnam, showing a 35% increase in biological oxygen demand (BOD) near informal disposal zones (Nguyen *et al.* 2024) [3]. A circular economy approach provides a practical framework by converting discarded materials into valuable resources, thereby closing the loop of production and consumption. Temple flower waste, rich in natural fragrance and organic compounds, presents a readily available raw material for manufacturing incense sticks—a product deeply rooted in cultural and commercial markets.

This research explores the collection, processing, and transformation of temple floral residues into high-quality incense sticks. It emphasizes not only the technical aspects of drying, grinding, and binding the floral biomass but also the economic potential for local communities, particularly women's self-help groups, to establish small-scale enterprises. By transforming waste into a marketable product, the study demonstrates how religious offerings can re-enter the value chain, reduce environmental burdens, and promote sustainable livelihoods. Through this model, temple floral waste management becomes a meaningful example of circular economy in action.

Objectives of the Study

1. To standardize collection and drying methods for temple floral waste.
2. To optimize conversion of dried residues into eco-friendly incense sticks.

Methodology

The study was carried out in Udaipur city, Rajasthan, using an experimental research design. A total of 41 temples were purposively selected: 3 temples each from the eastern, western, and southern zones, and 38 temples from the northern zone of the city. Data on floral waste were collected from 41 temple priests (pujaris) through a structured interview schedule.

For incense stick production, the researcher collected floral waste directly from the selected temples. The flowers were carefully segregated to remove non-floral materials, then dried under natural sunlight to preserve fragrance and quality. The dried flowers were finely ground into powder and blended with appropriate natural binders to prepare an eco-friendly incense mixture. This mixture was then shaped into incense sticks, completing the experimental process of converting temple floral residues into value-added products. "For incense stick preparation, three treatments were applied, with nine replications under each treatment to obtain experimental data. The collected data were subjected to statistical analysis using the mean as the primary measure."

Process for making floral-based incense sticks

1. Collection of Floral Waste

Gather fresh discarded flowers from temples or other sources the same day they are offered to prevent decay.

2. Segregation & Cleaning

- Remove non-floral materials such as plastic threads, paper, or stems.
- Rinse lightly if needed to eliminate dust or impurities.

3. Drying

- Spread the petals in a single layer on clean trays.
- Dry under natural sunlight (or in a dehydrator) until the petals become crisp and moisture-free.

4. Grinding

Grind the dried petals into a fine, uniform powder using a grinder.

5. Preparation of Base Mix

Combine the floral powder with natural binders such as gum powder (glue powder), charcoal or wood powder, and a small amount of water to form a smooth, pliable dough.

6. Fragrance Enhancement (Optional)

Add essential oils or natural aromatic resins (e.g., sandalwood oil) if a stronger or blended fragrance is desired.

7. Rolling/Extrusion

Roll the dough around bamboo sticks by hand or use an extrusion machine to create evenly coated incense sticks.

8. Final Drying

Place the freshly rolled sticks on drying racks in a well-ventilated area until completely dry and firm.

9. Packaging & Storage

Pack the incense sticks in moisture-resistant wrappers or boxes and store in a cool, dry place to retain fragrance and quality.

This process transforms discarded temple flowers into eco-friendly, fragrant incense sticks while minimizing waste and supporting sustainable production.

Results and Discussion

Table 1: Testing Report of Incense stick- Average Values

Aspects	Set-1			Set-2			Set-3		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
Stick length	20 cm	20cm	20 cm	20 cm	20cm	20 cm	20 cm	20cm	20 cm
Weight of stick	1.4 gm	1.2 gm	1.5 gm	1.6 gm	1.7 gm	1.5 gm	1.2 gm	1 gm	1.3 gm
Burning time	1 hour	1 hour 3 min	46 min	1 hour 3 min	58 min	1 hour 10 min	49 min	44 min	1 hour 8 min
Air quality (Smoke Content)	0.2 gm	0.1 gm	0.1 gm	0.1 gm	0.1 gm	0.1 gm	0.1 gm	0.1 gm	0.1 gm
Odour (Intensity)	Weak	Moderate	Strong	Moderate	Strong	Strong	Moderate	Strong	Very strong
Lingering Effect	Very short	Short	Long	Short	Long	Long	Moderate	Long	Very long

Grassroots involvement in waste initiatives in rural South Africa. Community-led programs, such as waste sorting and composting campaigns, achieved a 35% increase in recycling rates within one year (Suwerda *et al.* 2018) [6].

Table no.1 presents the average performance metrics of incense sticks prepared from floral waste, tested across three sets and three replications (R1–R3). The stick length was consistent at 20 cm across all sets and replications, indicating standardization in the preparation process. The weight of incense sticks ranged from1.0 g to 1.7 g**,** with Set-2 producing slightly heavier sticks overall, suggesting variation in binder consistency or compaction during rolling. Biochar derived from marigold and rose waste was tested for its ability to adsorb copper and zinc from wastewater. Experimental data showed that floral biochar achieved 65–80% removal efficiency, with increased sorption at higher temperatures and lower pH levels (Kumar *et al.* (2020) [1],

The burning time**,** a critical quality attribute, ranged between 44 minutes and 1 hour 10 minutes, with Set-2 demonstrating the most consistent and prolonged burn time, peaking at 1 hour 10 minutes in R3**.** In contrast, Set-3 exhibited shorter burn durations (as low as 44 minutes**)** but had high odour intensity and lingering effects, suggesting possible trade-offs between material density and aromatic performance.

The air quality parameter, measured via smoke content, remained low and consistent across all sets, ranging from 0.1 g to 0.2 g, indicating that the incense sticks produced minimal smoke—an important factor for indoor air quality and user comfort.

The odour intensity varied from weak to very strong, with Set-3 producing the strongest aromatic output in R3, rated as "very strong". This was corroborated by the lingering effect**,** which ranged from "very short" to "very long". Notably, Set-3 R3 demonstrated both very strong odour and very long lingering effect**,** indicating high aromatic performance.

These results suggest that while Set-2 excels in burning time and consistency**,** Set-3 exhibits superior fragrance intensity and post-combustion presence, making it potentially more appealing for users who prioritize olfactory experience over longevity. Overall, these findings underscore the importance of balancing material formulation, combustion characteristics, and sensory propertiesin the development of incense sticks from floral waste.

Based on above discussion, the best replication from each set has been identified and presented in below table.

Table 2: Best Case Replication Identified in Each Set for Incense stick

Aspects	Set-1	Set-2	Set-3
	R3	R3	R3
Stick length	20 cm	20 cm	20 cm
Weight of stick	1.5 gm	1.5 gm	1.3 gm
Burning time	46 min	1 hour 10 min	1 hour 8 min
Air quality (Smoke Content)	0.1 gm	0.1 gm	0.1 gm
Odour (Intensity)	Strong	Strong	Very strong
Lingering Effect	Long	Long	Very long

Table. 2 highlights the best-performing replication (R3) from each experimental set (Set-1, Set-2, and Set-3) based on the analysis of incense sticks developed from floral waste. The selection of optimal replications was guided by a multi-parameter evaluation including stick length, weight, burning time, smoke content, odour intensity, and lingering effect.

All three selected replications maintained a uniform stick length of 20 cm**,** ensuring standardization in product dimension. In terms of weight, the sticks ranged from 1.3 g (Set-3 R3) to 1.5 g (Set-1 and Set-2 R3)**,** with minimal variation indicating consistent material use and compaction.

Burning time**,** a critical quality metric, was highest in Set-2 R3 (1 hour 10 minutes)**,** followed closely by Set-3 R3 (1 hour 8 minutes)**.** In contrast, Set-1 R3 exhibited the shortest burn duration (46 minutes)**,** which, although lower, was compensated by relatively strong odour and lingering properties. Notably, smoke content remained low (0.1 g) across all best-case replications, demonstrating uniformity in air quality performance and reinforcing the environmental safety of the product.

In terms of sensory attributes, Set-3 R3 was rated highest with **'**very strong' odour intensity and a **'**very long' lingering effect, suggesting a superior aromatic profile. Set-1 and Set-2 R3 were both assessed as having **'**strong' odour and **'**long' lingering effects, indicating satisfactory consumer appeal.

Among the three, Set-3 R3 appears to be the most balanced replication, offering a combination of optimal burn duration, minimal smoke emission, and superior fragrance characteristics**.** This replication demonstrates high potential for consumer acceptability and market viability, particularly for users prioritizing aroma and environmental friendliness in incense products. These findings can inform further optimization and standardization of incense stick production using floral waste as a sustainable raw material.

Conclusion

This research demonstrates that temple floral waste, traditionally discarded as a pollutant, can be effectively transformed into eco-friendly incense sticks of commercial value. By standardizing methods for collection, drying, and processing, the study proves that discarded flowers retain sufficient aromatic and structural properties for high-quality incense production. The approach not only diverts biodegradable waste from landfills and water bodies but also supports circular economy principles by reintroducing discarded materials into the value chain.

Furthermore, the process offers significant socio-economic benefits, particularly by creating livelihood opportunities for local women's self-help groups and small-scale entrepreneurs. The successful conversion of sacred blooms into fragrant products highlights a practical model for sustainable waste management that combines cultural reverence with environmental responsibility. Overall, the findings affirm that temple floral residues are not merely waste but a renewable resource capable of generating wealth, reducing pollution, and promoting community-based green enterprises.

"What we call waste is often just a resource waiting for the right vision."

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