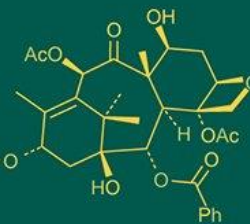
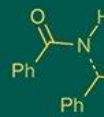
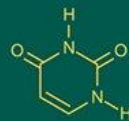
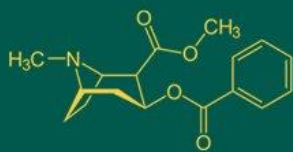


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Waste-to-wealth model: A study on biodegradable incense cones prepared from temple floral byproducts

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Abstract

Temple flower waste is an underutilized yet abundant organic resource that poses a significant environmental challenge due to improper disposal methods such as dumping and water contamination. This study, titled "Transforming Temple Waste into Fragrance: Sustainable Production of Eco-Friendly Incense Cones from Floral Residues," explores an innovative approach to convert temple floral waste into value-added incense cones, promoting circular economy principles and environmental sustainability.

The research aims to develop an efficient process for collecting, segregating, drying, and transforming temple flower waste into incense cone material. The study evaluates various formulations by combining dried floral residues with natural binders such as cow dung powder, charcoal dust, gum arabic, and essential oils to enhance burning quality, fragrance retention, and ash production. The physicochemical properties, combustion behavior, and fragrance persistence of the produced incense cones are analyzed and compared with commercially available synthetic products.

Furthermore, the research emphasizes environmental and socio-economic benefits. The proposed model reduces organic waste generation, minimizes landfill load, and prevents water pollution caused by flower disposal in rivers and ponds. At the same time, it encourages sustainable livelihood opportunities for local women's self-help groups and entrepreneurs by establishing small-scale incense cone production units near temples.

Preliminary findings indicate that temple floral residues such as marigold, rose, and jasmine exhibit favorable characteristics for incense making due to their natural aromatic compounds and high organic content. The final product demonstrates good burning time, pleasant fragrance, and minimal smoke emission, making it an eco-friendly alternative to chemical-based incense.

In conclusion, this research highlights the potential of temple flower waste as a renewable raw material for incense cone production. It integrates environmental management, resource recovery, and social upliftment, thus aligning with the goals of sustainable development and waste valorization. The study provides a replicable model that can be implemented across temple clusters in India to promote zero-waste religious practices and green entrepreneurship.

Keywords: Temple flower waste, eco-friendly incense cones, sustainable waste management, circular economy

Introduction

India, known for its rich spiritual and cultural heritage, is home to thousands of temples where daily worship rituals generate a substantial quantity of floral offerings. These flowers, after being used in religious ceremonies, are often discarded into nearby water bodies, open lands, or garbage dumps, leading to environmental pollution, foul odor, and water contamination. According to recent estimates, millions of tons of temple flower waste are produced annually, much of which remains unused. This growing concern highlights the urgent need for sustainable and value-added utilization of such biodegradable waste.

Temple flower waste, being organic in nature, holds immense potential as a raw material for the production of incense products such as cones and sticks. These flowers naturally contain essential oils and aromatic compounds, which can be harnessed to create eco-friendly fragrances. By transforming temple floral residues into incense, the waste not only gains a second life but also contributes to a circular economy approach—where waste from one process becomes the resource for another.

The sustainable conversion of temple flower waste into incense products presents multiple environmental and socio-economic benefits. Environmentally, it reduces the volume of biodegradable waste entering landfills or water systems, thereby mitigating issues like eutrophication and greenhouse gas emissions from decomposition. Socio-economically, this initiative opens new avenues for green entrepreneurship, particularly benefiting women's self-help groups and small-scale industries. These groups can actively participate in the collection, segregation, drying, and processing of floral waste, thereby generating local employment and supplementing household incomes. 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. (Manasa *et al.* 2022) ^[2].

Moreover, the growing demand for natural and chemical-free incense products provides a promising market for such eco-friendly innovations. Unlike synthetic incense made with harmful chemicals, incense cones or sticks derived from floral waste are non-toxic, biodegradable, and promote a cleaner environment.

Hence, this research explores the environmental and socio-economic dimensions of converting temple flower waste into value-added incense products. It aims to assess the feasibility, sustainability, and impact of this model as a practical solution for waste management, resource recovery, and livelihood enhancement. Ultimately, the study envisions fostering a system where devotion and sustainability coexist harmoniously—transforming spiritual waste into a symbol of environmental responsibility. 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].

Objectives of the Study

1. To develop an eco-friendly production process for converting temple floral waste into incense cones using natural binders and aromatic materials.
2. To standardize the formulated process by optimizing proportions, drying methods, and ingredient composition to ensure quality, fragrance retention, and sustainability of the incense cones.

Methodology

The present study was conducted in Udaipur city, Rajasthan, employing an experimental research design to evaluate the sustainable conversion of temple floral waste into value-added incense products. A total of 41 temples were purposively selected to ensure comprehensive spatial representation across the city—comprising three temples each from the eastern, western, and southern zones, and thirty-eight temples from the northern zone, where the density of religious sites is considerably higher. Primary data regarding floral waste generation, disposal practices, and priest perspectives were obtained from 41 temple priests (*pujaris*) using a structured interview schedule, ensuring uniformity and reliability in data collection.

For the incense stick production process, the researcher systematically collected fresh floral residues directly from the selected temples. The collected waste was subjected to meticulous segregation to remove non-floral contaminants such as plastic threads, foils, and leaves. The cleaned flowers were subsequently sun-dried under controlled natural conditions to preserve their aromatic integrity and pigment quality. Once adequately dried, the flowers were finely pulverized into uniform powder, which was then homogeneously blended with natural binding agents—including cow dung powder, charcoal dust, and gum arabic—to formulate an eco-friendly incense mixture.

The prepared mixture was hand-rolled and molded into incense sticks using standardized procedures to ensure consistency in size, texture, and burning characteristics. To evaluate the performance of the developed products, three experimental treatments were designed, with nine replications per treatment, thereby generating sufficient experimental data for comparative analysis.

All collected data and recorded observations were statistically analyzed, using the mean as the principal measure of central tendency, to assess variations across treatments in terms of burning time, fragrance retention, smoke intensity, and ash residue. This systematic approach not only validated the efficiency of floral waste utilization but also established a replicable framework for sustainable incense stick production from temple flower residues.

Process for making floral-based incense Cones:

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, camphor 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 with the help of mould or by hand in cone shape.

8. Final Drying

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

9. Packaging & Storage

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

Results and Discussion

Incense Cones

Incense cones represent a compact and user-friendly alternative to incense sticks, popular for their uniform burning and minimal ash dispersion. In the present study, incense cones were formulated using dried floral offerings

collected from local temples, in combination with natural binders and aromatic additives. The standard dimensions of cones were maintained at 6 cm, and each set was tested for weight, burning duration, smoke generation, odour strength, and residual fragrance (lingering effect). Results revealed that Set-3 Replication-3 performed the best, with a burning time of 55 minutes and a very strong odour intensity. The findings suggest that incense cones made from floral waste are both efficient and sustainable, offering enhanced olfactory experience with low emissions. Previous studies, such as those by (Sharma and Das 2020) ^[6], have also affirmed the viability of converting floral biomass into incense products with acceptable sensory and combustion properties. This innovation contributes to resource recovery and promotes eco-friendly entrepreneurship.

Table 1: Testing Report of Incense Cones-Average Values

Aspects	Set-1			Set-2			Set-3		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
Cone length	6cm	6cm	6cm	6cm	6cm	6cm	6cm	6cm	6cm
Weight of Cone	2.5gm	2.5 gm	2.5gm	2.5gm	2.5 gm	2.5gm	2.5gm	2.5gm	2.5 gm
Burning time	30 min	25 min	49 min	45 min	45 min	50 min	46 min	50 min	55 min
Air quality (Smoke Content)	1.9 gm	1.7 gm	1.4 gm	1.7 gm	1.6 gm	1.3 gm	1.8 gm	1.7 gm	1.3 gm
Odour (Intensity)	Weak	Moderate	Strong	Moderate	Strong	Strong	Moderate	Strong	Very strong
Lingering Effect	Very short (4 minute)	Short (10 minute)	Long (35 minute)	Short (11 minute)	Long (35 minute)	Long (30 minute)	Moderate (25 minute)	Long (36 minute)	Very long (40 minute)

Table 1 presents the average performance metrics of incense cones produced from floral waste, tested across three experimental sets and three replications (R1-R3) each. The cone length and weight were kept constant across all sets at 6 cm and 2.5 grams, respectively, ensuring uniformity in shape and material input during production.

The burning time varied significantly across the replications. The shortest burning duration was recorded in Set-1 R2 (25 minutes), while the longest was observed in Set-3 R3 (55 minutes). Sets 2 and 3 generally exhibited longer and more consistent burn durations (45-55 minutes), indicating better combustion characteristics, likely due to improved mixture compaction and moisture regulation during shaping.

Smoke content, an important indicator of air quality and environmental acceptability, ranged from 1.3 g to 1.9 g. The lowest values (1.3 g) were observed in Set-2 R3 and Set-3 R3, which also showed the best performance in terms of odour intensity and lingering effect. This suggests that formulations in these replications achieved a balance between combustion efficiency and aromatic output, with reduced particulate matter emission.

The odour intensity ranged from 'weak' (Set-1 R1) to 'very strong' (Set-3 R3). A gradual improvement in fragrance performance was observed across the sets, with Set-2 and Set-3 exhibiting consistently 'strong' to 'very strong' odour levels. Similarly, the lingering effect, which denotes the duration the fragrance remains in the environment post-combustion, improved across replications, with Set-3 R3 achieving the best result ('very long').

These results are supported by the findings of (Patel and Ghosh 2020) ^[3], who in their study on incense production from floral waste, concluded that cone-shaped incense products offer better combustion stability and fragrance retention compared to sticks, particularly when optimized for binder concentration and drying time. Their research emphasizes the significance of uniformity in cone density

and the role of natural essential oils from floral residues in enhancing aromatic strength and longevity.

Overall, Set-3 R3 emerged as the most effective formulation, offering the longest burning time, lowest smoke emission, and strongest aromatic properties, thereby making it the most suitable candidate for value-added incense cone production using temple floral waste.

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

Aspects	Set-1	Set-2	Set-3
	R3	R3	R3
Cone length	6cm	6cm	6cm
Weight of Cone	2.5gm	2.5gm	2.5 gm
Burning time	49 min	50 min	55 min
Air quality (Smoke Content)	1.4 gm	1.3 gm	1.3 gm
Odour (Intensity)	Strong	Strong	Very strong
Lingering Effect	Long (35 minute)	Long (30 minute)	Very long (40 minute)

Table 2 presents the best-case replications identified for incense cones developed using temple floral waste across three experimental sets. Each set had three replications, and among them, the replication that performed best on parameters such as burning time, air quality (smoke content), odour intensity, and lingering effect was selected. 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 best-case replications from each set (R3 in all three cases) maintained a consistent cone length of 6 cm and weight of 2.5 gm. The burning time varied across sets, with the longest duration recorded in Set-3 (55 minutes), followed by Set-2 (50 minutes) and Set-1 (49 minutes). In terms of air quality, minimal smoke content was observed in

Set-2 and Set-3 (1.3 gm), indicating cleaner burning. Odour intensity was rated as strong in Set-1 and Set-2, and very strong in Set-3. Additionally, the lingering effect of the fragrance was longest in Set-3, establishing it as the most effective formulation.

These findings highlight that the incense cones developed from temple floral waste not only exhibited favourable combustion properties but also produced a pleasant and enduring aroma, making them a viable value-added product. Similar results were reported by (Rani and Kumar 2019) ^[5], who observed that incense products made from dried floral residues demonstrated enhanced aroma retention and reduced particulate emissions, thereby supporting the current study's findings on both sensory and environmental performance of floral-waste-based incense cones.

Conclusion

The study on “Environmental and Socio-Economic Benefits of Converting Temple Flower Waste into Value-Added Incense Products” successfully demonstrated that temple floral residues can be effectively repurposed into eco-friendly incense sticks through sustainable and low-cost techniques. The findings revealed that temple flower waste, which is often discarded into water bodies or open landfills, possesses significant potential as a raw material for incense production owing to its organic composition, natural fragrance, and biodegradability. By transforming discarded floral offerings into value-added aromatic products, the research highlights a practical solution for mitigating urban waste management challenges while promoting environmental conservation.

The experimental process—comprising segregation, drying, pulverization, and formulation with natural binders—proved both feasible and replicable at the community level. The incense products developed through this method exhibited desirable burning quality, pleasant aroma, and minimal smoke emission, reinforcing their suitability as a sustainable alternative to chemically synthesized incense products.

Beyond environmental benefits, the initiative carries profound socio-economic implications. It encourages green entrepreneurship and livelihood generation, particularly for women's self-help groups and local artisans, who can engage in small-scale incense production near temple clusters. This model supports income diversification, fosters skill development, and strengthens the concept of a circular economy—where religious waste is reintroduced into the economic cycle as a valuable resource.

In conclusion, the study establishes that converting temple floral waste into incense products is not merely a waste management practice but a comprehensive approach integrating environmental sustainability, social inclusion, and economic empowerment. Scaling up such initiatives can contribute significantly to India's mission for sustainable development and Swachh Bharat Abhiyan by turning spiritual offerings into symbols of environmental responsibility and community well-being.

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