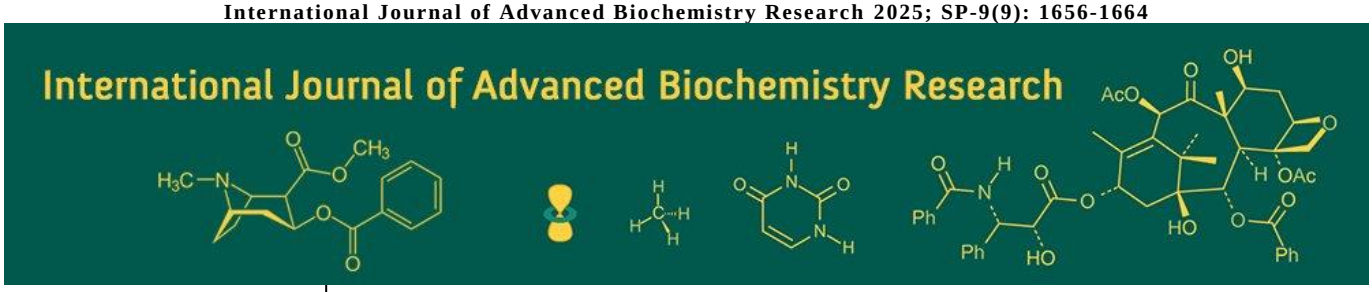

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Influence of different ingredients on the quality and economic feasibility of eco-friendly handmade incense sticks

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Abstract
In India, incense sticks have been in high demand since ancient times due to their religious significance and use in rituals. The primary reason for their use is religious, particularly in rituals and ceremonies. A few prominent brands, such as ITC, Cycle, Moksh, and Mysore Scents, dominate the Indian incense stick market. It is imperative for researchers to focus on developing new formulations of high-quality incense sticks based on natural products. The Indian government should implement regulations to dismantle the monopoly within the incense stick industry, thereby enhancing the appeal of incense products to consumers. Flowers are extensively utilized in the production of incense sticks and value added products. This study identified the use of various flowers in incense stick preparation. We determined the optimal composition for incense stick production, which involved a substantial amount of flower powder. Among all the combination treatments, T_{12} (Charcoal 10% + Sawdust 10% + Jigat 20% + Chrysanthemum 60%) yielded the most favourable results in terms of incense stick characteristics, aroma, and production cost. These flowers are frequently employed in the creation of value-added products and incense sticks. This study identified the flowers used in incense stick production in the region and determined the ideal composition, which included a significant quantity of floral powder. T_{12} (Charcoal 10% + Sawdust 10% + Jigat 20% + Chrysanthemum 60%) produced the best outcomes in terms of incense stick characteristics, aroma, and production cost among all combination treatments.

Keywords: Cost effectiveness, flower based incense, eco-friendly, incense stick, stick smell, charcoal, sawdust, jigat

Introduction
Traditionally, India has been using incense on many occasions, which may be of social or religious importance. In India, incense sticks are referred to as agarbatti. Agarbatti is a form of incense in which a bamboo stick holds the incense paste around it. India was the first country to prepare incense using a uniform system. In the modern system of incense making, medicinal priests are responsible for making incense. In many places worldwide, a belief system is prevalent that burning incense imparts mystical healing powers (Sahu *et al*., 2021) [7]

Long and cylindrical, incense sticks have a core made of wood or bamboo that is covered with aromatic substances. They add freshness to the air and emit pleasant scents when lit. Incense sticks are typically made from aromatic ingredients and a flammable binder. Since ancient times, various substances have been used for incense, either separately or in combination. These materials include plants, essential oils, resins, aromatic woods, and charcoal. Incense sticks are used in many religions to eliminate negative energy from the surroundings, fill the air with positive energy, and purify bad air (Jetter *et al*., 2002 and Lin *et al.*, 2008) [4, 5].

Burning incense sticks is a long-standing custom used in various ceremonies, particularly in the Indian subcontinent, where it is referred to as agarbatti. In the United States and Asian nations, where Buddhism and Taoism are prevalent religions, incense sticks are frequently used. Incense sticks are widely burned by people in many countries, including Lebanon,

Jerusalem, the Arab world, Egypt, South America, Sri Lanka, Japan, China, Nepal, and Burma (Hazarika *et al*., 2018) [3]. The composition of incense powder may further vary based on the fragrance materials used and some trade secrets used by the major players in the market. Indian incense-based industries add diethyl phthalate **(**DEP**)** to the powder paste to reduce the smoke released from burning incense sticks (Lin *et al*., 2008) [5]. Fragrance materials provide aroma to incense products, which could be jasmine, rose, chameli, lavender, and mogra (Abbaszadeh *et al*., 2017) [1].

Incense sticks are highly valued in the Indian culture. Research indicates that incense sticks have been used since the dawn of Indian civilization, as early as 5000 BC. Several literary works, including the Vedas, Puranic texts, Bhagwad Gita, and Islamic history, reference burning incense sticks. Incense sticks have historically been used for prayer, meditation, worship, various ceremonies, air freshening, and as insect repellents (Sinha and Deb, 2016) [2].

Materials and methods

Collection of flowers

In Raipur (C.G.), rose, jasmine, and chrysanthemum flowers were collected from temples, trash garlands, and wedding ceremonies. To ensure proper drying, the collected material was spread out in thin layers and rotated periodically for approximately 12-15 days. A grinder was used to grind the sun-dried flower petals.

Fig 1: Flower powder making process

Other ingredients

Charcoal

Wood is cooked with very little oxygen to create charcoal, which is primarily composed of carbon. After the process, which can take days to burn off volatile substances such as water, methane, hydrogen, and tar, approximately 25% of the initial weight remains as black lumps and powder. This acts as an adsorbent for the smoke produced and is required for the proper burning of incense.

Sawdust

Sawdust is a tiny wood particle created when wood is cut or sanded. Wood dust was gathered from a factory that produced wooden furniture and then cleaned and finely sieved to achieve consistent particle sizes.

Jigat powder

Jigat is a binding material and an essential component in the production of incense sticks. Some tree species, such as *Listea chinensis*, can be separated by peeling off their bark. In the Indian state of Karnataka, the term "jigat" means "sticky." Currently, half of the demand is met by imported Jigat from Malaysia and Thailand. The All India Agarbatti Manufacturers Association (AIAMA) estimates that 10,000 tons of jigat are consumed annually.

DEP oil

The colorless substance known as diethyl phthalate (DEP) oil is a colorless, water-insoluble substance. Delaying evaporation extends the shelf life of fragrances when they are used as evaporation retardants.

Bamboo stick

Bamboo sticks have a firm, hollow, joined stem and are spherical, long (15-20 cm), and incredibly thin plant parts. High-quality, completed bamboo sticks are sold by incense stick vendors. Sticks must be stored carefully in moist, humid conditions because fungi can grow and weaken the sticks.

Formulation of incense stick

Each ingredient on the above list was carefully weighed and mixed. By gradually adding more high-quality water, the powder was transformed into dough. A tiny portion of the dough was removed after it was kneaded, rolled around thin, tiny bamboo sticks, and hand-pressed. The mixture was then rolled into a uniform incense stick shape. The incense sticks were then allowed to dry overnight at room temperature before use. The sticks were submerged in diluted DEP oil for aroma analysis. The sticks were ready for use after drying for several minutes.

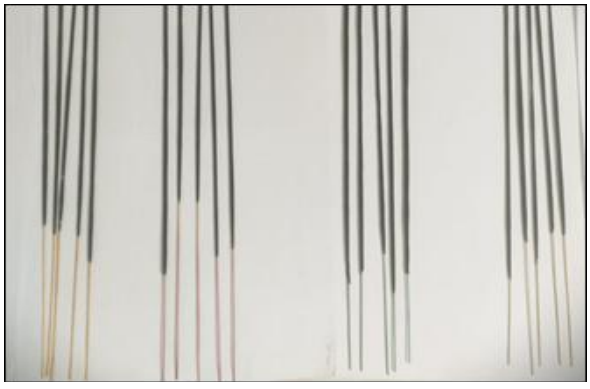
Jigat powder

Sawdust powder

Charcoal powder

Flower powder

Bamboo sticks



Incense sticks

Fig 2: Preparation of premix ingredient's

Quality characteristics of incense stick

Sensory evaluation, viz., score for stick color, score for stick smell, surface of incense stick, and cost of preparation were measured. A panel consisting of five students and five teachers from the Department of Floriculture and Landscaping evaluated the incense stick's color, appearance,

smell, and general acceptability as sensory evaluations for this study. After coding, samples from each treatment were presented to the panel for assessment. According to Amerine *et al*. (1965), the judges' ratings were numerical scores that ranged from one-five points. The price of the bamboo stick used for various treatment and packaging materials, as well as the mixture of charcoal, sawdust, jigat powder, and flower powder, was calculated. According to Gomez and Gomez the results were statistically analyzed using a completely randomized design (CRD).

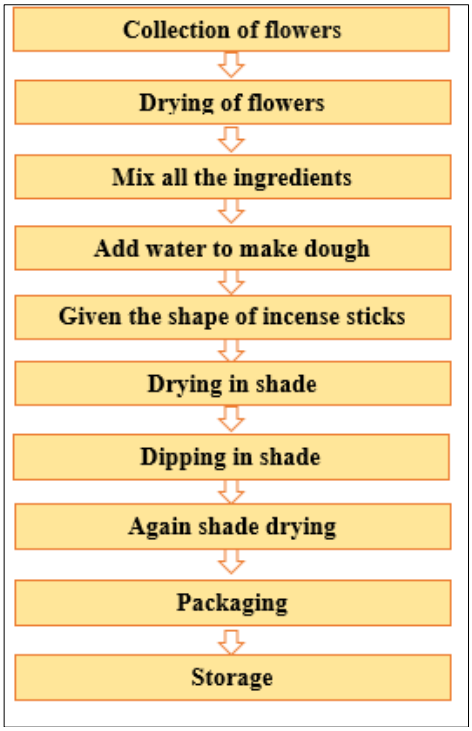


Fig 3: Flow chart for making process of incense stick

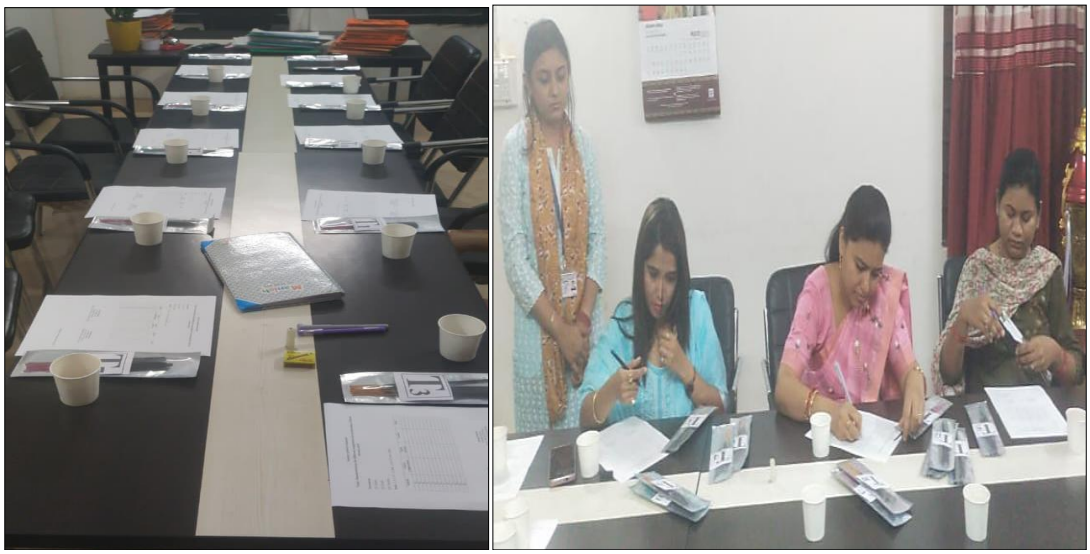


Fig 4: A view of sensory evaluated of incense stick by Pannel of judges

Fig 5: Packaging of incense sticks

Table 1: Treatment details

Treatment	Treatments combination
T_0	Charcoal 80% + Jigat 20% (Control)
T_1	Charcoal 60% + Jigat 15% + Rose 25%
T_2	Charcoal 40% + Jigat 20% + Rose 40 %
T_3	Charcoal 60% + Jigat 15% + Jasmine 25%
T_4	Charcoal 40% + Jigat 20% + Jasmine 40%
T_5	Charcoal 60% + Jigat 15% + Chrysanthemum 25%
T_6	Charcoal 40% + Jigat 20% + Chrysanthemum 40%

T_7	Charcoal 30% + Sawdust 10% + Jigat 20% + Rose 40%
T_8	Charcoal 10% + Sawdust 10% + Jigat 20% + Rose 60%
T_9	Charcoal 30% + Sawdust 10% + Jigat 20% + Jasmine 40%
T_{10}	Charcoal 10% + Sawdust 10% + Jigat 20% + Jasmine 60%
T_{11}	Charcoal 30% + Sawdust 10% + Jigat 20% + Chrysanthemum 40%
T_{12}	Charcoal 10% + Sawdust 10% + Jigat 20% + Chrysanthemum 60%

One-way ANOVA was used to analyze the experimental data, and CRD was used to analyze the data in this study.

Results and discussion

Stick colour

A sensory evaluation was conducted to assess the color of the incense sticks, with scores ranging from 1 to 5 assigned to each treatment group. Treatment T_0 was observed to have a black color, whereas T_{10} appeared brown, as noted by all members of the evaluation panel. Treatment T_0 (charcoal 80% + jigat 20%) received the highest score (4.67). Treatment T_0 obtained the highest score because the premix had the maximum amount of charcoal, which is black in nature.

The stick color that was found to have the maximum score in the treatment (Charcoal 80% + Jigat powder 20%) may be due to the most accurate incense sticks by black color according to Raja *et al.* (2023) [6].

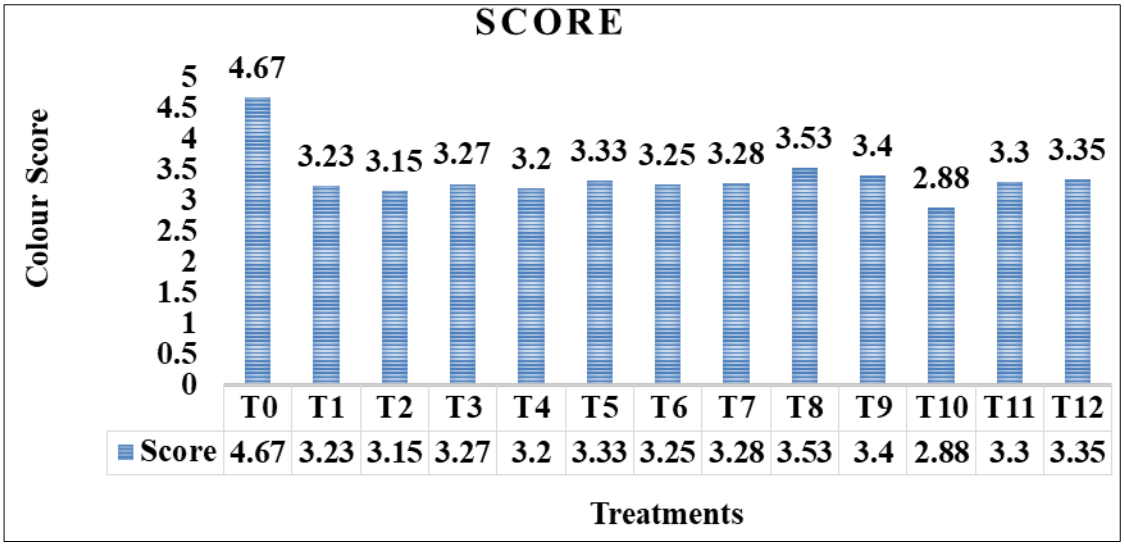


Fig 6: Sensory evaluation score for stick colour of incense sticks

Stick smell

The stick fragrance was evaluated using a sensory scoring scale ranging from 1 to 5. A sensory evaluation was conducted to assess the aroma of the incense sticks, in which treatment T_0 received the lowest score of 2.20, whereas treatment T_{12} received the highest score of 4.73, indicating a pleasant fragrance.

The highest stick smell score was recorded for the treatment comprising 10% charcoal, 10% sawdust, 20% jigat powder, and 60% flower powder. Raja *et al.* (2023) [6] reported that treatments with lower amounts of aromatic materials were often perceived as having weak or unremarkable aromas, emphasizing the importance of fragrant additives like flower powder in incense formulations.

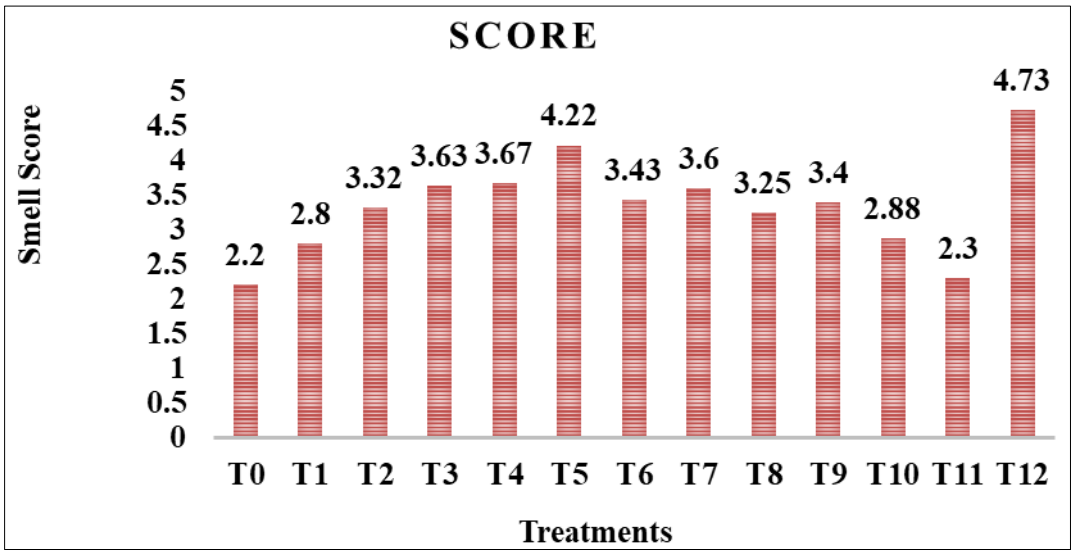


Fig 7: Sensory evaluation score for stick smell of incense sticks

Surface of incense stick

The stick surface smoothness and roughness were measured using a sensory scoring scale ranging from 1 to 5. Sensory evaluation revealed that treatment T_0 was perceived as smooth, whereas treatment T_{12} was considered rough by most panel members. Treatment T_0 (charcoal 80% + jigat 20%) received the highest score of 4.67, making it the smoothest stick in the experiment. The high score for T_0 may be due to its premix containing a high amount of charcoal and jigat powder, whereas the roughness of T_{12} is likely caused by the high proportion of chrysanthemum flower powder in the premix.

The highest stick surface score was observed in the treatment containing 10% charcoal, 10% sawdust, 20% jigat powder, and 60% flower powder. According to Raja *et al.* (2023) [6], the sensory evaluation of surface quality relies on human perception through touch and visual inspection, making uniformity and smoothness key factors in determining surface appeal.

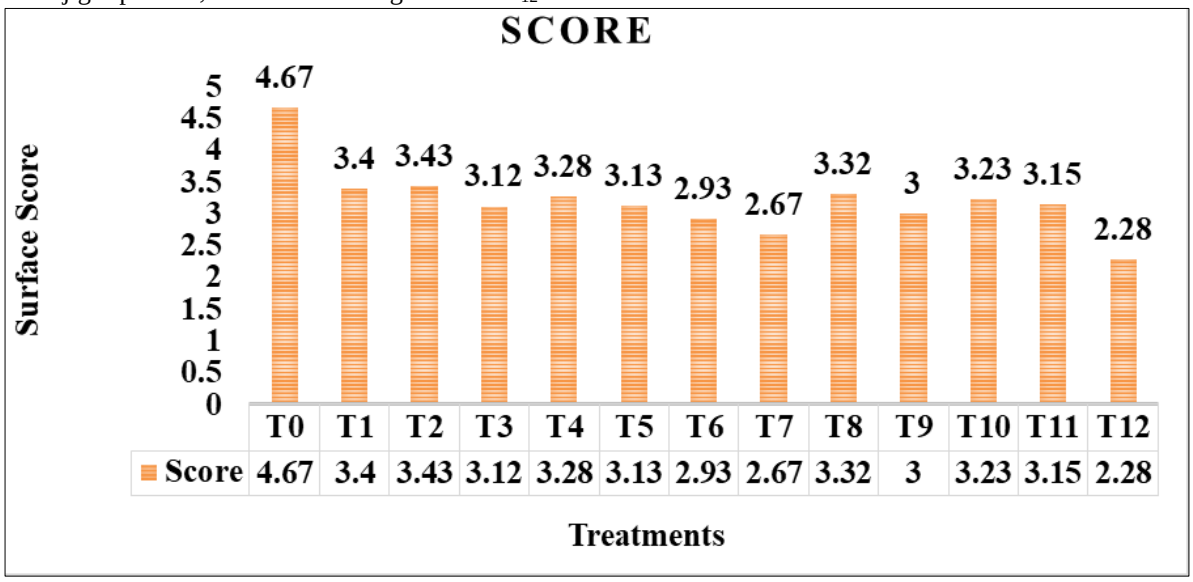


Fig 8: Sensory evaluation score for stick smell of incense sticks

Cost of preparation

Total cost

The highest total cost was recorded in the control treatment T_2 (Charcoal 40% + Jigat 20% + Rose 40 %) at ₹210.39, which did not contain any cost-reducing agents such as sawdust or floral materials. This indicates that high charcoal content significantly increases production costs. The lowest total cost of ₹ 150.89 was observed in T_{10} (charcoal 10% + sawdust 10% + jigat 20% + jamine 60%).

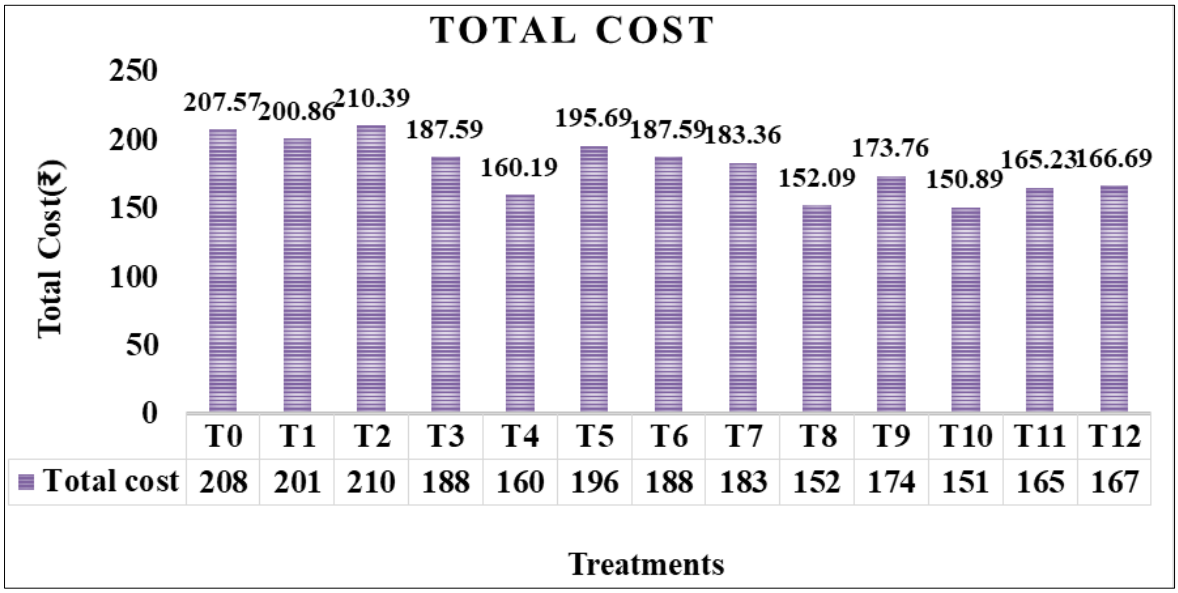


Fig 9: Total cost of incense sticks

Net profit

Treatment T_{12} (Charcoal 10% + Sawdust 10% + Jigat 20% + Chrysanthemum 60%) recorded the highest profit of ₹229.97, which was significantly superior to all other treatments at the 5% level of significance, based on the critical difference. The control treatment T_0 (charcoal 80% + jigat 20%) resulted in the lowest profit (₹70.76), indicating that the traditional formulation without any floral or sawdust

addition was significantly less profitable than the other treatments.

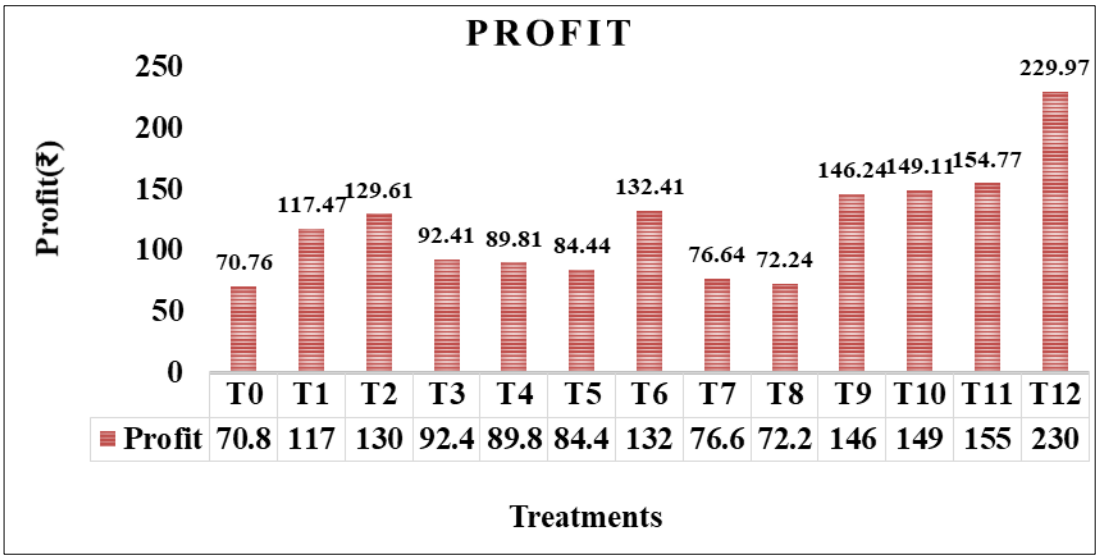


Fig 10: Net profit of incense sticks

Benefit cost ratio

The Benefit: Cost (B:C) ratio for different treatment combinations of raw materials used in the formulation. The B varied significantly among the treatments, indicating the impact of raw material composition on economic returns. The highest B:C ratio of 1.38 was recorded in Treatment T_{12} (Charcoal 10% + Sawdust 10% + Jigat 20% + Chrysanthemum 60%), while the control (T_0) showed the lowest B:C ratio of 0.34.

The results indicate that raw material composition significantly influences product economic efficiency. The highest B:C ratio obtained in Treatment T_{12} (1.38) reflects the economic advantage of substituting a major portion of charcoal with Chrysanthemum flower powder and sawdust while maintaining the proportion of Jigat. The improved profitability in T_{12} can be attributed to the reduced cost of raw materials (due to lower charcoal content) and possibly higher market demand or value of the floral fragrance produced by Chrysanthemum.

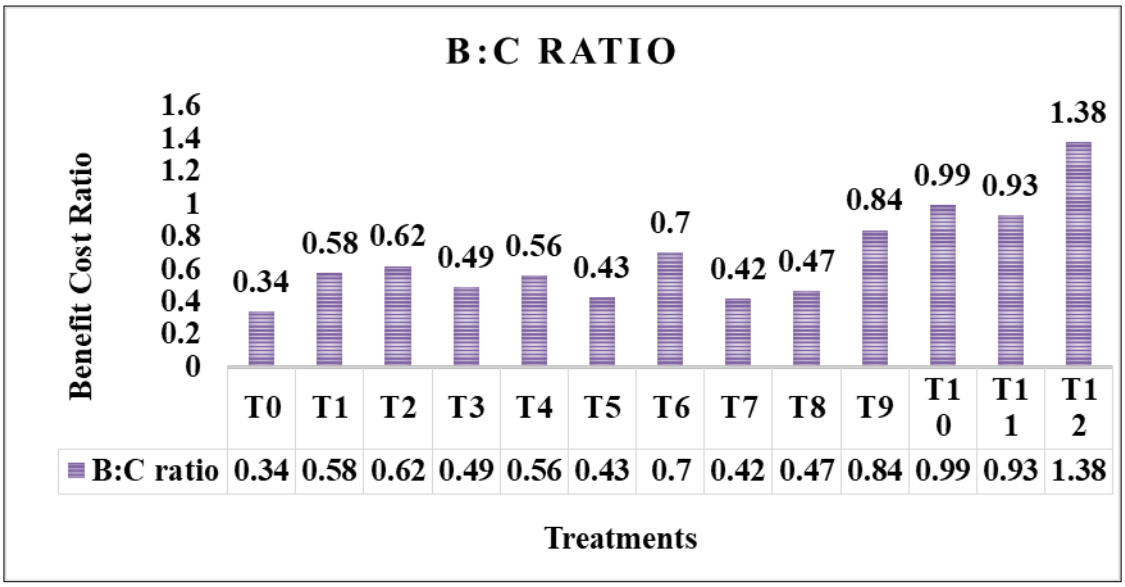


Fig 11: Benefit cost ratio of incense sticks

Discussion

Agarbatti (incense sticks) are used at weddings, religious gatherings, and places of worship. This alone illustrates the significance of agarbatti. The demand for agarbatti is rising in both domestic and international markets owing to product variety expansion and quality improvement. India is the world's largest producer of agarbatti. Each product sold has an associated price and cost. Market, product quality, promotional efforts, and target market all affect the price that the consumer must pay. Every product has a life cycle, just like people, from conception to death, after which it must be modified or replaced.

Conclusion

This study demonstrated the use of chrysanthemum, jasmine, and rose flowers to produce environmentally friendly incense sticks. The best composition of all the treatments was T_{12} (charcoal 10% + sawdust 10% + jigat 20% + chrysanthemum 60%), which most likely had the ideal concentration of fragrance ingredients to create a pleasing and well-balanced aroma. The high rating suggests

that the panelists thought the fragrance was pleasing and potent enough to be noticed without being overpowering, which a desirable feature in incense products is. The ideal ratios of sawdust (10%), jigat (20%), and charcoal (10%) offered the perfect balance of binding capacity, structural integrity, and combustibility, enabling the incense sticks to burn steadily and evenly.

This investigation may result in product commissioning and open new business prospects.

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Disclaimer (Artificial Intelligence)

The authors hereby declare that NO generative AI technologies, such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators, were used during the writing or editing of this manuscript.

Competing Interests

The authors declare that no conflicts of interest exist.

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