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Preferential Use of Bamboos for Industrial Production of Incense Sticks †

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Abstract: The incense stick or agarbatti stick is used exclusively for religious purposes in almost every home in India, but now it is being used worldwide for its medicinal values. Bamboo, popularly known as green gold or poor man's timber, is a multipurpose, fast-growing woody species, which occupies an essential place in the people's diverse phases of life and culture. The primary concern of the different stakeholders of the bamboo sector is identifying the right choice of raw material to maximize incense sticks' production. On the other hand, the market functionaries take advantage of farmers' lack of knowledge of the demand–supply situation and make substantial margin money. Therefore, the paper evaluates the preference for the notable species, age, and the part of the culm of bamboo used for the industrial production of incense sticks. In Tripura, India, the investigation indicated that all study parameters were significantly different among the species, viz., *Bambusa polymorpha*, *Bambusa vulgaris*, *Bambusa cacherensis*, *Bambusa tulda*, *Bambusa balcooa*, *Melocanna baccifera*, *Dendrocalamus asper*, and *Dendrocalamus longispathus*. Among the bamboo species, *Bambusa tulda* is the most preferred one having a mean Likert scale of 4.89, followed by *Dendrocalamus longispathus* (4.06), *B. cacharensis* (3.54), *B. polymorpha* (3.50), etc. The most preferred age of bamboo culm is three-year-old culm (4.32), followed by four- and two-year-old culms. Therefore, it can be concluded that the middle portion of three-year-old culms of *B. tulda* should be preferably harvested to become the raw material for the agarbatti industry for better outturn and profit.

Keywords: bamboo raw material; outturn; incense stick; Likert scale; index score

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1. Introduction

The incense stick, also known as "*agarbatti*" in India, "*joss stick*" in China, and "incense" stick in other countries, appears to be an integral part of the worship of all cultures and is used for therapeutic purposes, as well as mosquito repellents and fresheners [1]. Incense sticks are long, cylindrical structures, having a bamboo core coated with fragrant materials, and burned during religious ceremonies, filling the atmosphere with fresh air and aroma to eliminate negative energy from our surroundings [2–4]. Bamboo is an important raw material in the agarbatti industry [5]. It is a fast-growing, widely present, renewable, versatile, and a low-cost natural resource, due to which it is aptly known as 'green gold' and 'poor man's timber' [6]. More than 1600 species of bamboo are distributed in the tropical and sub-tropical regions of the world [7]. As per [8], India has 125 indigenous and 11 exotic bamboos belonging to 23 genera. Four species of bamboo, viz., Barak (*Bambusa balcooa*), Bari (*Bambusa vulgaris*), Mirtinga (*Bambusa tulda*), and Muli (*Melocanna baccifera*), are used in bamboo-based incense sticks [9]. The durability and strength of bamboo are due to the physico-chemical characteristics of bamboo culms, which determine its end uses [10]. Bamboo constitutes around 50% parenchyma, 40% fibers, and 10% vessels and sieve tubes [11] with microscopic structures of the bamboo fibers consisting of cellulose,

hemicellulose, lignin, and pectin [12], thus showing remarkable variation both between and within species [13]. Bamboo culms have similar chemical constitutions to that of wood except for their high alkaline extract, ash, and silica contents [14], with lignin comparable to that of softwood and hardwood [15,16]. The scarcity of raw materials due to flowering [17], rapid depletion of bamboo resources [18], and increasing popularity of bamboo in the industrial sector as an alternative to wood [17] have resulted in a shortage of the species mainly used by the agarbatti industry. Bamboo incense stick production plays a vital role in the rural subsistence economy of the household income basket [19] by providing livelihood and enhancing income levels of women [20]. Indian agarbatti has a high demand both in the local and international markets [21]. India is presently one of the largest producers and exporters of incense sticks with global domination by countries such as the U.S.A., Brazil, and China [22]. India's incense stick market is likely to reach ₹7500–8000 crore with its exports to more than 150 countries [23]. Since there is no study on the choice of appropriate bamboo species, suitable age, and position of the culm, the present research evaluates the industrial production of incense sticks.

2. Methodology

Study Area

The study was undertaken in one of the north-eastern states of India, Tripura, having an area of 10,491 km^2. It lies between 22°56′ and 24°32′ N latitude and 91°09′ and 92°22′ E longitude. For evaluating the preferred bamboo species, preferred age, and a desired portion of the culm, a questionnaire was developed using the Likert scale (1932) to test among 104 respondents, including entrepreneurs, managers, supervisors, workers, and academicians. The majority of respondents were women (59.6%) who were stick makers and artisans (45.2%), aged between 22 and 64 years, with educational qualifications of secondary school (49%), and working in private industries (83.7%). Respondents were invited to define their attitude to the statement by choosing among n grades. In this paper, n = 5, which denotes five scales, viz., strongly disagree, disagree, neither agree nor disagree (neutral), agree, and strongly agree.

$$X_i^{(\rho)} = \sum_{j=m_\rho}^{m_{\rho+1}-1} X_{ij} \qquad \rho = 1, \ldots\ldots, v$$

$$X_i = \sum_{\rho=1}^{v} X_i^{(\rho)} = \sum_{j=1}^{M} X_{ij}.$$

The above equation implies the response vector of the respondent i in the dimension ρ, and the total response vectors in all M items. Likert scale analysis was performed using MS Excel to identify the preferred bamboo species among the eight bamboo species (viz., *Bambusa polymorpha*, *B. vulgaris*, *B. cacharensis*, *M. baccifera*, *B. tulda*, *Dendrocalamus asper*, *Dendrocalamus longispathus*, and *Bambusa balcooa*), preferred age, and portion of the culm.

3. Results and Discussion

3.1. Preferred Bamboo Species

The grades for the Likert options of strongly disagree to strongly agree were assigned as 1 to 5, respectively. The analyzed data indicated that the most preferred bamboo species for industrial incense sticks was *Bambusa tulda*, with a Likert score of 4.88 out of five. The least preferred bamboo species was *Dendrocalmus asper* with a Likert score of 2.89 out of five (Table 1). Many bamboo species exist, but only six species, viz., *B. balcooa*, *B. vulgaris*, *B. tulda*, *B. nutans*, *B. bambos*, and *Melocanna baccifera*, are presently used in bamboo-based incense sticks [9,24,25]. The best-suited species for the Indian agarbatti industry is *B. tulda* [24] and it shows higher bulk density, basic density, and lower moisture content [26]. The reason for its preference over other species are the fiber dimensions of the culm, being length 1.45–3.0 mm, diameter 15–20 µm, lumen diameter 5–5.6 µm, wall thickness 3.2–7.5 µm, with approximate chemical composition of holocellulose 64%, pentosans 18%, lignin 25%,

and ash 2–3% [27]. It is one of the most grown/planted species by rural people because of its clean and straight culm, medium height, strength, and easy availability [28].

Table 1. Scores and ranking of preferential attributes from questionnaire survey for choice of bamboo species used in incense stick industry.

Parameters	*B. polymorpha*	*B. tulda*	*B. vulgaris*	*B. balcooa*	*M. baccifera*	*D. longispathus*	*B. cacharensis*	*D. asper*
Ease in availability/supply	3.40	4.92	3.29	2.56	3.75	4.03	3.42	2.80
Price of culm	3.40	4.83	3.30	2.15	3.62	4.00	3.46	2.83
Nodal length	3.51	4.92	3.43	2.44	3.56	4.13	3.61	2.89
Wall thickness	3.53	4.91	3.48	3.05	3.16	4.05	3.62	2.97
Outturn/max production	3.50	4.92	3.44	2.81	3.27	4.05	3.53	2.94
Number of sticks per kg	3.53	4.91	3.37	2.84	3.38	4.03	3.52	2.90
Smoothness of the stick	3.58	4.79	3.35	2.66	3.64	4.11	3.59	2.91
Overall mean	3.49	4.89	3.38	2.64	3.48	4.05	3.53	2.89
Rank	4	1	6	8	5	2	3	7

The easy availability or supply, intermodal length of the culm, and the productivity or outturn of agarbatti sticks of *B. tulda* contributed to it being the best raw material for the agarbatti industry. The percentage contributions (Figure 1) of all the attributes, viz., the availability, cost, intermodal length and wall thickness of the culm, the stick outturn, number of sticks per kilogram, and the sticks' smoothness, were almost identical, varying from 14% to 15%. The availability/supply and the intermodal length [29,30] contributed 15 percent each.

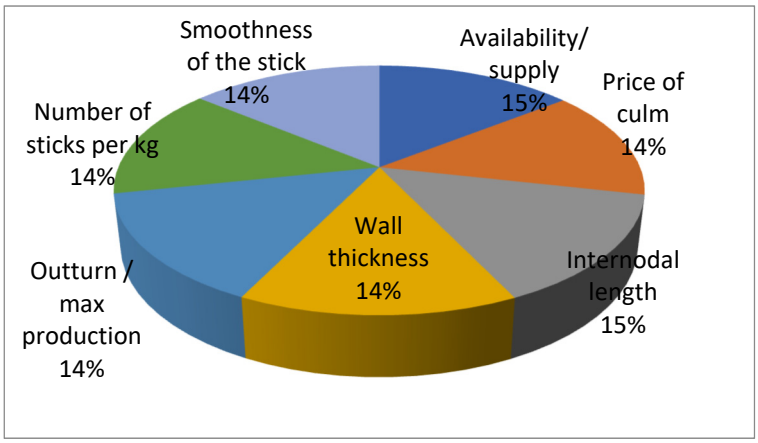


Figure 1. Percent contribution of different attributes for the choice of species for the incense stick industry.

3.2. Preferred Age of the Bamboo Culm

The respondent data revealed that the most preferred age of the culm for the production of industrial round sticks for agarbatti is three-year-old culm with a Likert score of 4.30 out of five, and the least preferred age of the culm is one-year-old culm with a Likert score of 2.42 out of five (Table 2). Similarly, refs. [31–33] reported that selective cutting of mature bamboo culms of more than three years of age in plots with a three–four year rotation cycle appears to be sustainable and more productive. The strength of bamboo increases as it becomes older due to the hardening of the culm walls. It was concluded that with age increment, mature tissues start to develop and continue to influence density, strength properties, growth of branches, and established root system in one- to three-year-old Malaysian bamboos [34]. It was reiterated that as bamboo matures, the culm wall thickness becomes

hard, resulting in maximum strength. Bamboo matures in about three years and it reaches its full strength [35–37].

Table 2. Scores and ranking of preferential attributes from questionnaire survey for choice of age of culm used in incense stick industry.

Parameters	One Year	Two Years	Three Years	Four Years	Five Years and Above
Ease in availability/supply	2.34	3.83	4.23	3.75	3.66
Price of culm	2.62	3.91	4.27	3.88	3.76
Internodal length	2.45	3.84	4.38	3.91	3.77
Wall thickness	2.36	3.81	4.34	3.88	3.75
Outturn/max production	2.33	3.75	4.31	3.84	3.69
Number of sticks per kg	2.42	3.82	4.34	3.85	3.70
Smoothness of the stick	2.50	3.84	4.30	3.94	3.80
Overall mean	2.43	3.83	4.31	3.86	3.73
Rank	5	3	1	2	4

The wall thickness and the strength properties have contributed to the most preferred age for industrial incense sticks. The percentage contributions (Figure 2) of all the attributes, viz., the availability, cost, intermodal length and wall thickness of the culm, the stick outturn, number of sticks per kilogram, and the sticks' smoothness, were almost the same, varying from 14% to 15%. The wall thickness and the intermodal length [29,30] contributed 15 percent each.

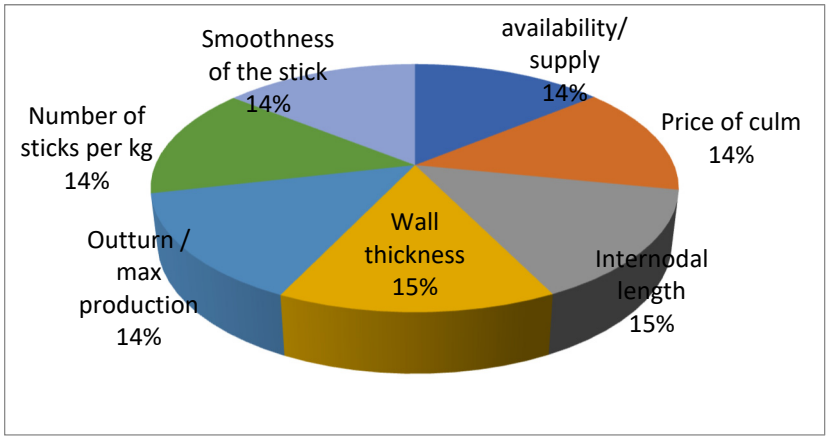


Figure 2. Percent contribution of different attributes for the choice of the age of culm for the incense stick industry.

3.3. Preferred Portion of the Culm

The analyzed data revealed that the most preferred portion of the bamboo culm for the production of incense sticks is the middle portion of the culm, followed by the bottom part (Table 3). Increasing specific gravity or density with increasing height levels of the culm was reported [29,38]. The variation in density of selected Philippine bamboos *B. blumeana* and *Gigantochloa levis* was studied [29]. A significant increase in density from base to top height levels in a culm was observed, where the density value increased toward the top for both species. The intermodal length and the physical properties of the middle portion of the culm contributed to the reasons for the preferred portion of the culm for industrial incense sticks. The percentage contributions (Figure 3) of all the attributes, viz., the availability, cost, intermodal length and wall thickness of the culm, the stick outturn, number of sticks per kilogram, and the sticks' smoothness, were almost the same, varying from 14% to 15%. The number of sticks per kilogram and the intermodal length [29,30] contributed 15 percent each.

Table 3. Scores and ranking of preferential attributes from questionnaire survey for choice of the portion of the culm used in incense stick industry.

Parameters	Bottom	Middle	Top
Ease in availability/supply	4.09	4.33	3.23
Price of culm	4.09	4.52	3.37
Internodal length	3.91	4.65	3.23
Wall thickness	4.19	4.63	2.74
Outturn/max production	4.20	4.64	2.78
Number of sticks per kg	4.05	4.64	2.89
Smoothness of the stick	4.12	4.46	3.34
Overall mean	4.09	4.55	3.08
Rank	2	1	3

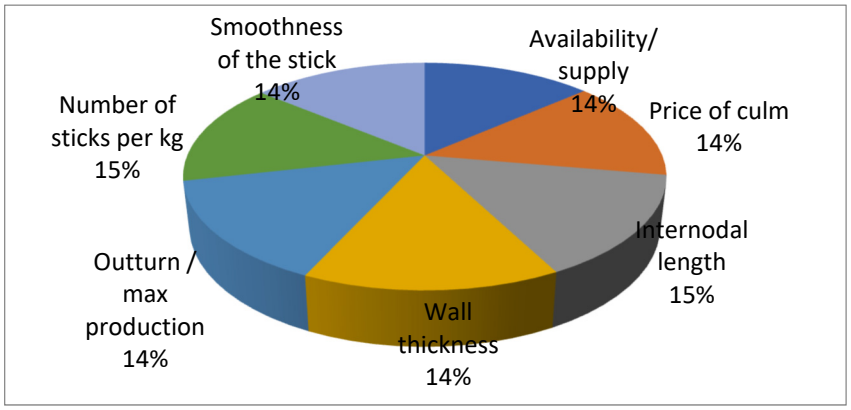


Figure 3. Percent contribution of different attributes for the choice of portion of culm for the incense stick industry.

4. Conclusions

From the present research, it can be concluded that the most preferred raw material for the industrial production of agarbatti sticks is the middle portion of the three-year-old culm of *B. tulda.* The variation in intermodal length, wall thickness, and physical properties could be the factors for the above. Further studies are required to find out the best species in terms of outturn and preferred physical and mechanical properties in demand at the national level to make the agarbatti sector more profitable.

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