

## Article

# Consumer Preferences and Markets for a Cultural Non-Timber Forest Product (*Boswellia serrata* Roxb.) Around Hindu Temples in Southwestern India

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**Abstract:** This paper considers the critical role of local markets in sustaining rural communities and forests through the trade of *Boswellia serrata* Roxb. gum-resin as a culturally significant non-timber forest product (NTFP). Despite its cultural significance in Hindu rituals, little is known about the market dynamics at the consumer end of the value chain. This is one of the first detailed studies on consumer behavior and seller economics of *B. serrata* gum-resin in temple contexts. Open-ended surveys with sellers and consumers reflect seller activities, incomes, and consumer perceptions within the markets, providing insights into the dynamics of the gum-resin value chain and the implications for sustainability. Challenges gum-resin sellers face are brought to light, with a notable struggle to secure a significant portion of the final product's value. Consumer perceptions are identified as a pivotal aspect influencing this NTFP's market dynamics. The study emphasizes the importance of understanding consumer demand and preferences in shaping market size and sustainability practices. The research advocates for establishing structured markets to enhance returns for harvesters and reduce costs for consumers. In providing insights into the socio-economic aspects of temple markets for *B. serrata* gum-resin, this study contributes to the understanding of NTFP value chains and their broader impact on the sustainability of forest-dwelling communities and forest ecosystems. The findings underscore the need for informed interventions and policy measures to address challenges, promote equitable practices, and ensure the long-term viability of NTFP-based economies.

**Keywords:** *Boswellia serrata*; consumer perceptions; cultural practices; gum-resin; market dynamics; temple markets



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## 1. Introduction

Local markets for non-timber forest products (NTFPs) have a significant impact on the social, cultural, and livelihood sustainability of rural communities and households [1,2]. Their use and material and non-material values offer potential incentives for sustainable forest use and management, which aligns with the goals of forest conservation and community well-being [3–5]. Local markets for NTFPs are extremely diverse, ranging from formal to informal; the latter has the absence of fixed prices and bartering as a common exchange medium [6,7]. Such local markets often escape national economic registers and statistics [8–10]; consequently, they remain under-recognized and under-appreciated for their potential to enhance local livelihoods through income diversification and poverty

alleviation [8,11]. However, as some NTFPs transition from local trade to supplying large urban markets, the risk of unsustainable harvesting grows in the absence of robust forest and resource governance institutions and mechanisms [12,13].

An essential aspect of analyzing NTFP value chains is understanding the role of traders, who often have a more direct effect on the livelihoods of NTFP harvesters compared to intermediaries [14,15]. These sellers are known for their adaptability, trading in whatever NTFPs are seasonally available and sufficiently abundant [13,16], effectively setting the unit price. The dominance of sellers and some intermediaries in short NTFP value chains are reported, though harvesters may also sell directly to final consumers [13,17]. Situations where sellers capture a significant share of the value can lead to low levels of trust between harvesters and sellers, as harvesters may feel exploited and powerless to negotiate better prices [18,19]. On the contrary, harvesters may lack the necessary skills, connections, and capital to engage with final consumers or intermediaries further up the value chain [20,21]. Consequently, in many NTFP markets, sellers play pivotal roles in shaping value chains.

Despite their prominence in value chains, sellers face numerous challenges, such as ensuring product quality, managing the unpredictability of harvest quantities, securing storage facilities, negotiating transportation, staying attuned to changes in consumer demand, and addressing various operational concerns [22,23]. In some instances, sellers must contend with fees for market access, bribes to officials, or haulage expenses, all of which add to their operational challenges [21,24]. The lack of coordination between harvesters and sellers, as well as the absence of market information and value addition to products, are common issues reported in NTFP markets [25,26]. Furthermore, competition among sellers can be intense, particularly when many offer similar products to a limited consumer base, making them price-takers rather than price-setters [16,27]. Surprisingly, there is limited literature that addresses the challenges faced by NTFP street vendors who exclusively sell a specific NTFP and may generate less income than those selling the same NTFP alongside other commodities [13,28].

Beyond sellers, consumers hold a pivotal role in NTFP value chains and incomes. Consumer demands and preferences significantly shape market dynamics, influencing the size and nature of local markets, which, in turn, have considerable implications for the sustainability of NTFP populations and the ecosystems from which they are sourced [29,30]. It is critical to understand consumer perceptions, as globally, most NTFP consumers are often unaware of NTFP gathering practices or collection locations [31,32]. Inadequately structured markets can result in poor returns for harvesters and sellers and increased costs for consumers [33,34].

In India, Hinduism is the most widespread religion, with its practices rooted in morality, identity, fear of death, anxieties of life, and beliefs about the afterlife [35,36]. Hindu temples are central to daily rituals and more elaborate ceremonies during festivals, as well as new moon and full moon days [37,38]. These cultural and religious practices often involve the use of plants and animals as offerings, with the majority of plant-based offerings being NTFPs [39]. This strong cultural demand for NTFPs is further influenced by the cultural practices of indigenous communities residing in forests, highlighting the significant biocultural relationship between forests, indigenous communities, and cultural traditions in India [40,41].

An illustrative example of the intersection between Hindu religious practices, NTFPs, and forest-based communities is the traditional use of gum-resin from *B. serrata* by the Soliga tribal people in southwestern India, who offer it to local and household deities [42]. Over time, this ritual gained wider acceptance, with increasing numbers of Hindu pilgrims visiting local temples adopting the same practice. Initially, the Soliga shared or bartered gum-resin with pilgrims, but as demand grew, they began selling it, leading to the emer-

gence of vibrant gum-resin markets around temple precincts. These markets have since become critical to the livelihoods of harvesters, street vendors, and shopkeepers.

*Boswellia serrata* Roxb. ex Colebr., commonly known as Indian frankincense, is a medium-sized deciduous tree found in dry deciduous forests across central and peninsular India. It exudes an aromatic oleo-gum-resin used in religious offerings, traditional medicine, and perfumery. While it is locally abundant in some regions, unsustainable tapping methods, habitat degradation, and forest fires have led to concerns about its long-term viability. Several studies have raised issues regarding overharvesting, debarking, and the lack of regeneration [42,43], placing the species under Near-Threatened status in parts of its range.

Although previous research has focused extensively on the ecological sustainability of harvesting and the livelihoods of forest-dependent communities, relatively little is known about the consumer-end dynamics of the gum-resin value chain. This study addresses that gap by examining the socio-economic profiles and perceptions of temple market sellers and consumers of *B. serrata* gum-resin in southwestern India. Building on earlier research that documented the roles of harvesters in the value chain [44], this research shifts attention to the upper end of the chain—specifically the shopkeepers, and street vendors—alongside the beliefs, motivations, and purchasing patterns of gum-resin consumers.

### 1.1. Study Area

The study was conducted in the following three protected areas of Karnataka in southwestern India: Biligiri Rangaswamy Temple Tiger Reserve (BRT), Cauvery Wildlife Sanctuary (CWS), and Malai Mahadeshwara Wildlife Sanctuary (MMH) (Figure 1). These sites were chosen for their ecological richness, cultural and religious significance, and the presence of an active gum-resin trade. Located within the Western Ghats, a global biodiversity hotspot, all three sites are also major Hindu pilgrimage destinations that attract thousands of visitors annually.



**Figure 1.** Location of the study sites in southwestern India.

The Soliga tribal community, classified as a Particularly Vulnerable Tribal Group (PVTG), resides in and around these protected areas. Under the Forest Rights Act (FRA) of 2006, they are legally entitled to collect and sell non-timber forest products such as *Boswellia serrata* gum-resin. Although harvesting is permitted, the trade is largely informal and lacks institutional oversight.

The temple markets studied are situated within or near the protected areas, influencing the trade dynamics. Comparisons to non-protected sites may reveal differing governance and market structures, warranting further study.

#### 1.1.1. Biligiri Rangaswamy Temple Tiger Reserve (BRT)

Biligiri Rangaswamy Temple Tiger Reserve was declared a Tiger Reserve in 2010, and it is a crucial ecological bridge between the Eastern and Western Ghats, facilitating the movement of species across these mountain ranges. Its diverse topography and climate result in rich vegetation, from dry scrub and grasslands to evergreen and shola forests [45]. This habitat diversity supports a remarkable array of wildlife, including over 245 bird species (12 endemic), 1000 plant species, 36 mammals (excluding bats and rodents), and 145 butterfly species [46].

However, BRT faces challenges like the invasive alien *Lantana camara* [42,44], which has seen a tenfold increase in a decade [47], posing a threat to native species. Involving the local Soliga tribal community in conservation efforts and restoration projects is crucial for addressing this issue and ensuring the long-term health of the ecosystem [48].

#### 1.1.2. Cauvery Wildlife Sanctuary (CWS)

Cauvery Wildlife Sanctuary, established in 1987, is one of Karnataka's largest wildlife sanctuaries, and it plays a vital role in protecting the Cauvery River, the eighth largest in India [49]. The sanctuary boasts a mosaic of forest types, including dry tropical riparian, moist and dry deciduous, and scrub, along with pockets of semi-evergreen vegetation along the riverbanks [50,51]. This diversity shelters a variety of wildlife, including 22 species of large mammals and big cats, 10 species of reptiles, and around 41 species of birds [52,53].

The sanctuary faces issues like the invasion of alien plant species like *Acacia* and *Canthium* in riparian areas, and the management of recreational visitors who camp near the river [51,52]. Balancing tourism with conservation is essential for the sustainable management of this vital sanctuary.

#### 1.1.3. Malai Mahadeshwara Wildlife Sanctuary (MMH)

Malai Mahadeshwara Hills, designated as a wildlife sanctuary in 2013, is a popular pilgrimage center known for the Malai Mahadeshwara temple, which draws around a million visitors annually [43]. The sanctuary is home to a rich assemblage of wildlife, including tigers, leopards, Asian elephants, wild dogs, and the endemic Madras tree shrew [53]. With its potential to support even higher tiger populations, MMH is likely to be declared a tiger reserve in the near future [54]. However, MMH faces threats like *L. camara* invasion, fuelwood collection, stone quarrying, and religious tourism [55]. Managing these pressures while ensuring the well-being of the local Soliga communities is crucial for the long-term conservation of this ecologically and culturally significant landscape.

## 2. Materials and Methods

The main markets where the gum-resin was sold were identified during visits to the study area in 2018 and 2019 and confirmed via harvester interviews. These were the Biligiri Rangaswamy temple at BRT and the Chamarajeshwara temple markets at district headquarters, around 45 km from BRT, the Muthuraya temple market at CWS, and the Malai Mahadeshwara temple and Talabetta (foothill) markets at MMH. For this study,

surveys using questionnaire (see Supplementary Materials) were conducted with the actors at the upper end of the gum-resin value chain, namely the intermediary sellers (shopkeepers and street vendors) and the consumers (locals and pilgrims) in the markets. All of the surveys were conducted in the local language (Kannada) after obtaining respondents' verbal consent and ethical clearance from the ethics committees at Rhodes University and ATREE.

The shopkeepers and street vendors were considered 'sellers' and were interviewed using the same open-ended questionnaire. Shopkeepers who sold gum-resin were identified by visual observation of every shop in each marketplace as to whether they had gum-resin on offer. A total of 54 shopkeepers (MMH,  $n = 24$ , BRT,  $n = 16$ , CWS,  $n = 14$ ) were interviewed. This approach is likely to be a slight undercount, as it omitted those shopkeepers who sell gum-resin, but had no stock at the time of the survey. Street vendors of gum-resin were also identified by direct observation of who was selling gum-resin to pilgrims in the marketplace, and 41 were interviewed. A semi-structured questionnaire was administered to both shopkeepers and street vendors to understand their role in the *Boswellia serrata* gum-resin value chain. The questionnaire comprised approximately 40–45 questions and was divided into three main sections. The first section included quantitative and factual questions related to buying and selling prices, product sourcing, types of gum-resin, processing, packaging, units of sale, and income. The second section focused on open-ended questions regarding limitations and challenges faced in the trade, such as price fluctuations, adulteration, and market access. The third section gathered respondents' suggestions on improving market conditions and institutional support. This format enabled a combination of standardized data and qualitative insights, including perceptions on ecological availability, harvesting practices, and cultural significance.

Similarly, the perceptions of gum-resin consumers were assessed by means of a semi-structured questionnaire to 88 consumers, ranging between 15 and 20 per market. The local or pilgrim consumers were approached after they had been observed buying gum-resin from a local seller. Local consumers were regarded as those consumers living within a 50 km radius of the respective market, whereas if they from further afield they were regarded as pilgrims. The questionnaire included questions on the socio-economic backgrounds of respondents, as well as their knowledge of the source, use, and spiritual significance of gum-resin, and their perceptions of the local gum-resin market. We have now updated the instrument to include a few exploratory, open-ended questions on ecological awareness, such as perceptions of gum-resin availability in the forest, recognition of adulterants, and the impact of harvesting practices on resin quality. While such questions are not commonly asked in informal markets and may still be considered unfamiliar by many respondents, their inclusion reflects the growing relevance of sustainability in NTFP trade.

### Data Analysis

Data were entered and organized using Microsoft Excel 2016 (Microsoft Corporation, Redmond, WA, USA) and analyzed using R version 3.6.1 (R Core Team, 2019), a statistical computing environment developed by the R Foundation for Statistical Computing, Vienna, Austria. Socio-economic data included demographics, pricing, selling units, and income for sellers; and demographics, usage patterns, knowledge, and willingness to pay for gum-resin among consumers. Continuous variables, such as buying and selling prices, were analyzed using the Kruskal–Wallis test, followed by Dunn's post hoc test for pairwise comparisons. Associations between categorical variables were assessed using the Chi-squared test, and correlations between continuous variables were assessed using Pearson's correlation coefficient. All statistical analyses were conducted using R version 3.6.1

(R Core Team, 2019), with the ‘dunn.test’ and ‘stats’ packages for non-parametric and correlation tests, respectively.

To identify consumer typologies, hierarchical cluster analysis was performed using a Euclidean distance matrix, based on 22 variables including demographic details, knowledge of gum-resin, and market perceptions from 88 consumers. Cluster differences were analyzed using the Kruskal–Wallis test for continuous variables and the Chi-squared test for categorical variables.

### 3. Results

#### 3.1. Seller Profiles and Incomes

Slightly more than half (57%) of the 95 sellers surveyed were shopkeepers (SK), and the remainder were street vendors (SV). Most (59%) were male (SK = 70%, SV = 48%), and 41% were female (SK = 30%, SV = 52%). The age of the sellers surveyed was well-distributed, with 16% being 18–30 years old; 26% were 31–40 years; 27% reported being 41–50 years; and 31% were older than 50 years. Three children, aged 8, 14, and 17 years old, who were selling gum-resin in the Talabetta market in MMH were also interviewed under parental guidance. Sixteen percent (SK = 9%, SV = 24%) of the sellers had never been to school, while forty percent (SK = 43%, SV = 37%) and forty-two percent (SK = 46%, SV = 37%) of them had 1–5 and 6–10 years of school education, respectively. Only 2% (SK = 2%, SV = 2%) of the respondents had more than 10 years of school education. Only street vendors shared information on their annual income, as their only source of cash income was from selling gum-resin. Twenty-four percent of the street vendors earned less than INR 50,000 (~USD 700) per year, sixty-three percent claimed to earn INR 51,000–100,000 (~USD 715–1400), and the remainder had a gum-resin income of more than INR 100,000 per year.

#### 3.2. Gum-Resin Buying and Selling

The shopkeepers bought gum-resin directly from harvesters who came to their shops. The buying ( $H = 43.1$ ,  $p < 0.05$ ) and selling prices ( $H = 40.7$ ,  $p < 0.05$ ) varied significantly across the study sites (Table 1), corresponding to the different types of gum-resin bought and sold. The buying price was highest at BRT and lowest at MMH, with CWS being intermediate between them. The post hoc Dunn’s test of selling prices reflected a significant difference between BRT–MMH and BRT–CWS ( $p < 0.05$ ), but not between CWS–MMH ( $p > 0.05$ ). Buying costs and selling prices at BRT were significantly higher than at the other two sites (Table 1).

**Table 1.** The mean price that intermediaries pay harvesters for gum-resin and the price they sell it to consumers in three temple markets (unlike superscripts denote significant differences between sites, i.e., within columns).

Site	Most Common Type of Gum-Resin Traded	Price at Which Bought from Harvesters (INR kg <sup>−1</sup> )		Price at Which Sold to Consumers (INR kg <sup>−1</sup> )		Difference (INR kg <sup>−1</sup> )		% Markup (kg <sup>−1</sup> )	
		SK	SV	SK	SV	SK	SV	SK	SV
BRT	Gum-resin stuck to bark	473 ± 87 <sup>a</sup>	466 ± 87 <sup>a</sup>	633 ± 79 <sup>b</sup>	616 ± 112 <sup>b</sup>	161 ± 38	150 ± 59	34	32
CWS	Soil-mixed gum-resin	248 ± 34 <sup>a</sup>	275 ± 35 <sup>b</sup>	373 ± 38 <sup>a</sup>	365 ± 21 <sup>a</sup>	124 ± 34	90 ± 14	50	33
MMH	Deadwood and bark scales	148 ± 14 <sup>a</sup>	147 ± 15 <sup>b</sup>	350 ± 27 <sup>b</sup>	362 ± 58 <sup>b</sup>	201 ± 35	214 ± 58	136	146
Mean	-	290	296	452	448	162	152	56	51

Note: SK = Shopkeepers, SV = Street Vendors, INR = Indian Rupees.

The street vendors also buy gum-resin from the harvesters who visit temple markets, or sometimes they visit the harvesters’ villages to buy gum-resin. The buying price ( $H = 17.7$ ,  $p < 0.05$ ) and selling price ( $H = 13.2$ ,  $p < 0.05$ ) varied significantly across the market sites, which the post hoc Dunn’s test indicated was between BRT–MMH ( $p < 0.05$ ), but no other



pairing. The buying and selling prices among street vendors at BRT were significantly higher than at the other two markets (Table 1). The markup by the shopkeepers across the study markets varied significantly ( $H = 16.7$ ,  $p < 0.05$ ), being highest at MMH, followed by BRT and CWS, and they were all significantly different from one another (Dunn's test,  $p < 0.05$ ). Street vendors at MMH also made the highest markup compared to BRT and CWS. There was a significant difference in the markup made by the street vendors across the study markets ( $H = 10.6$ ,  $p < 0.05$ ). Dunn's multiple pairwise comparisons highlighted significant differences between BRT–MMH and CWS–MMH ( $p < 0.05$ ), but none between BRT–CWS ( $p > 0.05$ ; Table 1).

Both shopkeepers and street vendors mentioned they made a higher markup when they sold gum-resin in smaller units. All of the sellers sold gum-resin in 'grams', 'paos', or 'handfuls'. There was no difference in the selling unit among the shopkeepers across the sites ( $\chi^2 = 1.6$ ,  $df = 6$ ,  $p > 0.05$ ), but there was a significant difference among the street vendors ( $\chi^2 = 73.3$ ,  $df = 6$ ,  $p < 0.05$ ). The proportion of shopkeepers selling gum-resin in grams was highest and similar at BRT and CWS (90%), as compared to MMH (71.4%). The remaining shopkeepers sold gum-resin in paos (=250 g) across all of the sites, and none by the unit 'handful'. All of the street vendors at CWS and MMH sold gum-resin in handfuls, as did 83.3% at BRT; the remaining street vendors at BRT sold gum-resin in paos. None of the street vendors used grams as a selling unit across all of the market sites.

All of the shopkeepers trading in grams stated that they processed and packed the gum-resin before selling it to the consumers, whereas this was not done when selling it by the handful or paos; furthermore, none of the street vendors processed gum-resin before selling it to the pilgrims. The processing involved cleaning the gum-resin and eliminating any particles that are not gum-resin, sun-drying it if the gum-resin was moist (the number of days depended on the level of moisture in the gum-resin), storing the gum-resin if it was bought in bulk, and packaging it in newspaper or plastic bags (Figure 2a,b). The overall markup by selling gum-resin in handfuls (INR  $214 \pm 58$ ) was higher than selling it in grams (INR  $154 \pm 44$ ) or in paos (INR  $138 \pm 50$ ), hence, processing or packaging of gum-resin did not increase the value share of the gum-resin across the study sites.

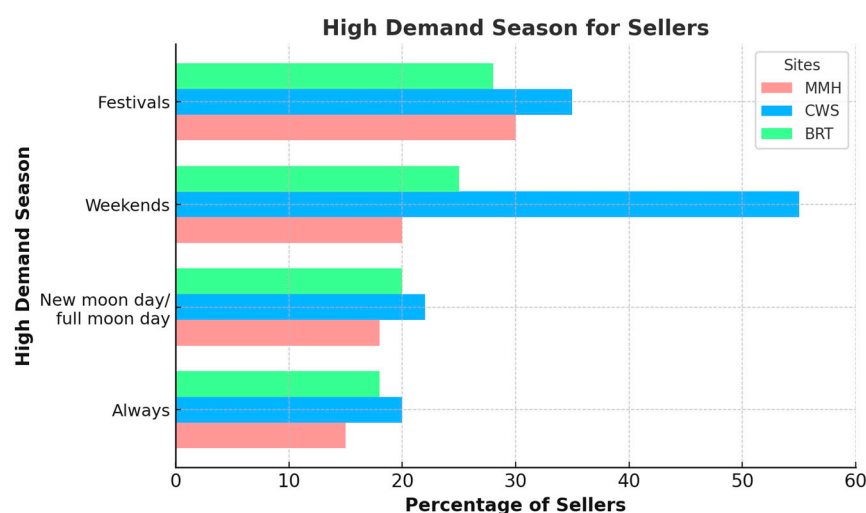


**Figure 2.** (a) Gum-resin sold in shops with other commodities and (b) soil-mixed type packaged in plastic bags at the Cauvery Wildlife Sanctuary (CWS) (Pictures taken during 2018–2019).

Nearly three-quarters (68.5%) of shopkeepers said they did not mix in any additives to the gum-resin that they bought from the harvesters, whilst almost one-third (31.5%) stated that they did. There was no difference across the markets ( $\chi^2 = 6.5$ ,  $df = 4$ ,  $p > 0.05$ ) in shopkeepers mixing additives before selling it to the consumers, but there was for street vendors ( $\chi^2 = 24.1$ ,  $df = 4$ ,  $p < 0.05$ ). Half of the street vendors at BRT and CWS said that they mixed *B. serrata* gum-resin with that from other species and with sand or soil, respectively. At MMH, 82% of street vendors said they mixed sand or bark scales or deadwood from other species. Street vendors stated that mixing additives to the gum-resin added weight to the product and, therefore, increased their income.

### 3.3. Periods of Highest Demand and Type of Gum-Resin

The high demand season for gum-resin varied significantly across the market sites ( $\chi^2 = 87.1$ ,  $df = 8$ ,  $p < 0.05$ ; Figure 3). Irrespective of the type of seller, most sellers (64%) highlighted that demand for gum-resin was greatest during festivals and weekends, compared to a minority (19%) who mentioned that demand was high during new or full moon days. In contrast, 17% said there is always a high demand for gum-resin; this was especially true at BRT and MMH. The types of gum-resin harvested and sold in the three study markets are described by Soumya et al. [43]. As there are different kinds of gum-resin, there was a variation in the demand for particular kinds of gum-resin in the markets ( $\chi^2 = 30.4$ ,  $df = 6$ ,  $p < 0.05$ ). Nearly half of the sellers felt there was no particular demand for any specific type of gum-resin (BRT—48%; MMH—42%; CWS—15%). However, some stated that the pure form of gum-resin was the most sought after by consumers (BRT—52%; CWS—25%; MMH—18%). However, the site-specificity was apparent when most sellers (60%) at CWS and 40% of those at MMH said that the soil-mixed type had the greatest demand.



**Figure 3.** Periods of highest demand for gum-resin across the study sites.

There was no difference across the study markets in overall satisfaction of shopkeepers ( $\chi^2 = 7.3$ ,  $df = 6$ ,  $p > 0.05$ ) and street vendors ( $\chi^2 = 7$ ,  $df = 6$ ,  $p > 0.05$ ) about the current demand for gum-resin. The highest percentage of shopkeepers at BRT were neutral (Table 2), and one of them mentioned “it does not matter if I am satisfied with sales of gum-resin, as I can cover up the losses by selling other products”. However, half of the street vendors at BRT and CWS (Table 2), and 30% at MMH, exhibited high levels of dissatisfaction about the current market for gum-resin. One of the street vendors in the Malai Mahadeshwara temple market at MMH said “the inconsistency in the selling prices in this market is highly disturbing”.

**Table 2.** Level of satisfaction among traders regarding the current market (% of respondents).

Market	Level of Satisfaction					
	Very Satisfied		Neutral		Highly Dissatisfied	
	SK	SV	SK	SV	SK	SV
BRT	21	17	65	33	14	50
CWS	22	0	56	50	22	50
MMH	28	30	43	40	29	30

Note: SK = Shopkeepers, SV = Street Vendors.



### 3.4. Market Constraints

Overall, nearly half of the shopkeepers and street vendors felt that there were no constraints. Among those who did identify one or more constraints, there were clear differences between the markets ( $\chi^2 = 35$ ,  $df = 10$ ,  $p < 0.05$ ). For example, 37% of them at BRT highlighted that “nobody in this market wants to buy the deadwood or scaly bark type that is mostly sold in MMH”. Nearly 15% of the sellers in all of the markets said they do not receive enough of the pure form of gum-resin that most consumers prefer. However, 30% of sellers at CWS and 23% at MMH felt the forest department officers do not let them sell the pure form because the officials believed that it is obtained by damaging the trees. Some street vendors at MMH (22.5%) stated that there are restrictions on who can sell, namely that only street vendors from specific communities were allowed to sell at the Talabetta market in MMH.

### 3.5. Sellers’ Suggestions to Improve the Gum-Resin Market

The suggestions by shopkeepers and street vendors on improving the gum-resin market were significantly different across the markets ( $\chi^2 = 48.2$ ,  $df = 6$ ,  $p < 0.05$ ), although one-third of all of the sellers (33.6%) had no suggestions and believed nothing would change in the markets. Both shopkeepers and street vendors (BRT—51.4%; CWS—70%; MMH—17.5%) suggested grading the gum-resin and fixing a price for each grade that is specific to each market. For example, one shopkeeper said, “when I buy a kilogram of gum-resin from a harvester for 100 rupees, some other shopkeeper may buy the same kind for lesser price and mark up more, which is unfair to both me and that harvester”. Sixty percent of the sellers (SK and SV) at MMH suggested having a separate marketplace specifically for gum-resin sellers, but none at BRT and CWS did so. A street vendor was highly dissatisfied with the current gum-resin market at MMH and said that “shopkeepers selling snacks or clothes also sell gum-resin in this market making it very difficult for me to sell gum-resin; gum-resin is the only product I sell here”. Another street vendor at MMH said, “the temple authority people sometimes chase us away when we approach pilgrims to sell gum-resin in front of the temple where gum-resin is offered, so we need a defined place to sell gum-resin”.

### 3.6. Consumers’ Perceptions About Gum-Resin Market

Of the 88 consumers surveyed, 48% were male and 52% were female. All were Hindu pilgrims and were buying gum-resin to offer to the temple deities (Figure 4a), or to carry it home to offer it to home deities. In the temples, a place is allocated where pilgrims can offer gum-resin; there is also a stand set outside the temples with hot charcoal where pilgrims sprinkle powdered gum-resin to emit the incense. A smaller stand is used in households (Figure 4b), which also uses hot charcoal to burn the gum-resin to emit the scent (Figure 4c).

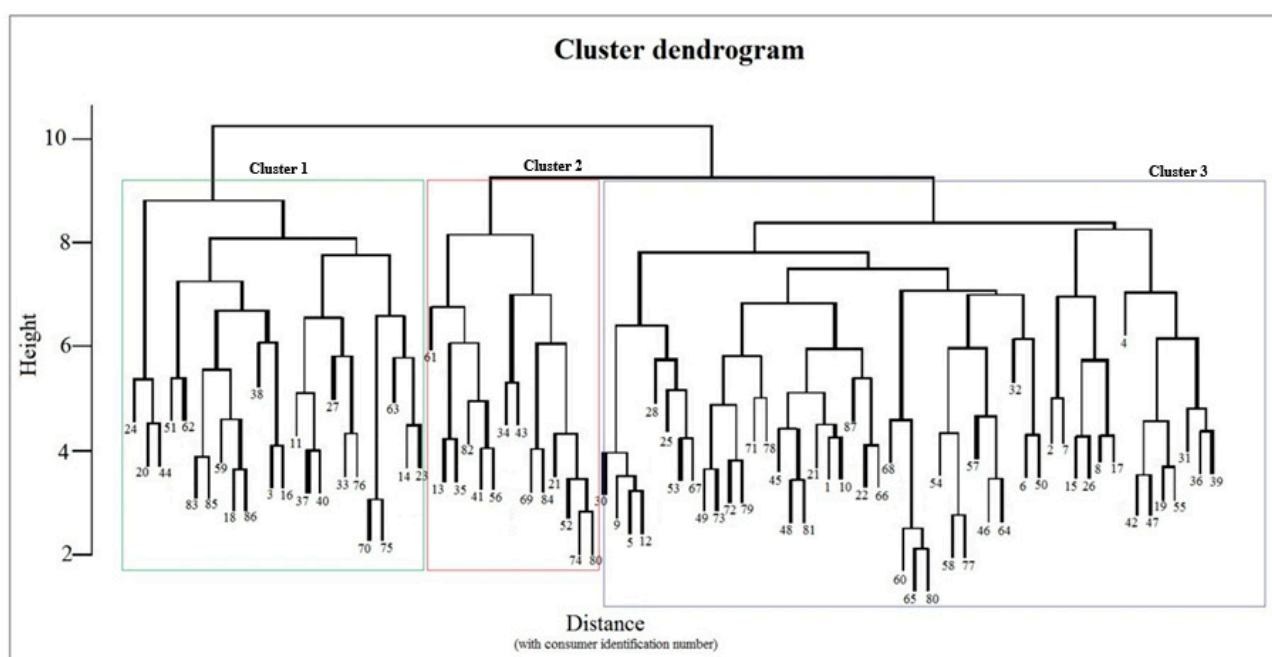


**Figure 4.** (a) Pilgrims offering gum-resin outside the temple at MMH, (b) stand used to offer gum-resin in a household, and (c) gum-resin burning on the stand (Pictures taken during 2018–19).

Most of the consumers in the markets were pilgrims (83%), and 17% were locals. However, 80% of the consumers had previously visited the respective markets and were aware of where to find gum-resin. The consumers were categorized into five age groups, as follows: 18–30 (28%), 31–40 (15%), 41–50 (17%), 51–60 (14%), and >61 (26%) years. Eighteen percent of the respondents had never been to school, twenty-two percent had 1–5 years of education, thirty-five percent had 6–10 years of education, and twenty-five percent of the respondents had more than 10 years of school education; nearly half of the respondents were literate. Fifteen percent stated that they had no income, eleven percent earned INR 50,000–100,000 (~USD 700–1400) per year, nineteen percent earned INR 110,000 and INR 300,000 (~USD 1540–4200), and fifty-five percent had an income of more than INR 310,000 (~USD 4340) per annum.

### 3.7. Gum-Resin Consumer Clusters

The cluster analysis categorized three distinct types of consumers, accounting for 91.6% of the variance (Figure 5). Clusters differed significantly concerning two continuous variables, namely age and the number of years of schooling, and six categorical variables (Table 3). The first cluster (traditionalists) contained 27% of consumers and was characterized by relatively elderly consumers with low levels of formal education (Table 3). In contrast, cluster 2 (educated conformists) encompassed 16% of the consumers, characterized as young to middle-aged, with generally high levels of education (Table 3). Over half (57%) were grouped into cluster 3 (ritualistic mix), spanning a wide range of ages and education levels, but with specific patterns of gum-resin knowledge and use (Table 3). The annual income of educated conformist consumers was generally higher than that of the other two clusters (Table 3).



**Figure 5.** Cluster dendrogram of 88 consumers of gum-resin at five temple markets at three sites.

Regarding gum-resin knowledge and practices, the highest percentage of traditionalists and ritualistic mixes believed that the use of gum-resin results in blessings from the deity to which it was offered. Likewise, a large proportion of educated conformists (85.8%) used gum-resin because either their elders or their parents asked them to do so, believing that their prayers would not reach the deity unless gum-resin is offered. Some used gum-resin only because everyone else was doing so. When asked if gum-resin was

significant in Hindu mythology, 70.8% and 98% of traditionalists and ritualistic mixes, respectively, responded that gum-resin increases devotees' inclination towards god and enhances one's sense of the deity. However, 85.7% of consumers in the educated conformist cluster had no knowledge of the significance of gum-resin in Hindu rituals.

**Table 3.** The profiles for three distinct consumer types and their statistical inferences.

Variable		Clusters			Statistics
		Traditionalists	Educated Conformists	Ritualistic Mix	
Age (years)		55–80	19–50	18–65	H = 43.1 $p < 0.05$
No. of years of schooling (%)	0	58.4	0	4	H = 43.3 $p < 0.05$
	1–5	25	0	26	
	6–12	16.6	42.9	70	
	>12	0	57.1	0	
Annual income in INR (%)	0	37.5	14.3	4	$\chi^2 = 28.3$ $p < 0.05$
	50,000–100,000	25	14.3	4	
	110,000–300,000	16.6	28.7	18	
	>310,000	20.8	42.7	74	
Knowledge on reason for using gum-resin (%)	It gives god's blessings	58.3	7.1	68	$\chi^2 = 30.4$ $p < 0.05$
	Elders say prayers do not reach the god if do not offer gum-resin	16.7	42.9	4	
	Parents asked to do so	20.8	42.9	6	
	Everyone else does so	4.2	7.1	22	
Knowledge on significance of gum-resin in Hindu mythology (%)	Increases the pilgrim's inclination towards god and enhances one's sense of deism	70.8	14.3	98	$\chi^2 = 53.5$ $p < 0.05$
	No knowledge	29.2	85.7	2	
Consumers' willingness to pay more (%)	Pay whatever is asked to buy gum-resin	95.8	42.8	94	$\chi^2 = 26.7$ $p < 0.05$
	Cannot pay more	4.2	57.2	6	
	Handful	70.8	78.5	68	
	50–100 g	8.4	7.1	20	
Quantity usually bought (%)	110–250 g	20.8	0	4	$\chi^2 = 18.7$ $p < 0.05$
	260–500 g	0	14.4	2	
	>500 g	0	0	6	
	Rub some crushed gum-resin on palm and smelling it	41.7	50	12	
Techniques to identify best quality of gum-resin (%)	Place on burner—if it does not emit a good aroma it is bad-quality	33.3	50	50	$\chi^2 = 16.8$ $p < 0.05$
	No knowledge	25	0	38	

Most consumers in all clusters said that they would pay as much as they were asked for gum-resin. Another traditionalist said, “one cannot fix the price on something so precious; to offer it to the deity I would pay as much as is asked by the sellers”. Nearly one-third of consumers in all clusters bought gum-resin in handful quantities. The others bought large quantities, either because they were a large group or they intended to take some back home with them.

The consumers were asked about how they identify the quality of the gum-resin. All of the educated conformists had ways to identify the best quality gum-resin. More than one-third of traditionalists, half of the educated conformists, and 12% in the ritualistic mix suggested rubbing some crushed gum-resin on one's palm and smelling it, and if it provides a strong aroma, then it is good-quality. The highest proportion of respondents in all clusters, i.e., one-third of traditionalists, and half of educated conformists and the ritualistic mix suggested offering the gum-resin, and if it does not emit a good aroma

then it is not of good-quality. One of the respondents in the ritualistic mix at the MMH temple market said that “the gum-resin sold in this market is not of good quality; I offer it just for the sake of it and never carry it home”. One-fourth of the respondents in the traditionalists cluster and 38% in the ritualistic mix did not know how to identify the best quality gum-resin. A ritualistic mix consumer in the Talabetta market said that “the gum-resin sold here is so cheap so we do not care if it is of good quality or not, we just buy and offer it”.

#### 4. Discussion

Reliable data on local NTFP trade are often lacking, especially in informal markets [8]. While *Boswellia serrata* gum-resin is widely exported for its medicinal properties [56], little is known about its role in local markets, where it holds cultural significance. At the study sites, gum-resin is used in temple rituals and is believed to enhance emotional well-being and spiritual experience [57,58]. Although this study does not comprehensively quantify trade volumes, it provides indicative estimates based on vendor-reported sales, offering valuable insights into the economic and cultural relevance of gum-resin in temple-based value chains.

All of the value chain actors in the current study used gum-resin in their households and also offered it to the deities in the temples [43]. The interviews conducted with the shopkeepers and street vendors highlighted their role in the gum-resin value chain and consumers’ perceptions on the quality, availability, and cultural significance of gum-resin.

The distance between the three study sites is less than 100 km, and there is not much difference in the socio-economic backgrounds of the communities residing in the three areas [59]. Thus, the demand for home use of the gum-resin does not vary greatly. However, there are considerable differences in the markets because it is based on the number of pilgrims. Spiritual beliefs and practices of the communities residing in the three areas are connected to the deity at MMH ‘Mahadeshwara’ or ‘Madappa’, and so are the pilgrims who visit these temples. Informal conversations with the sellers and the consumers surveyed at BRT and CWS mentioned that according to Hindu mythology, the deity at MMH is more powerful than the deities at BRT or CWS. The popularity of MMH can be linked to this, and, hence, the market at MMH is much larger and more established than the other two. This confirms the findings of Cocks et al. [60] and Kim et al. [61], highlighting that the demand for culturally important NTFPs will persist, and may even grow, even in times of modernization, because use is based on cultural and spiritual beliefs and worldviews.

##### 4.1. Shopkeepers’ Role in the Gum-Resin Value Chain

Shopkeepers buy gum-resin from the harvesters either in exchange for cash or groceries. This echoes Robinson et al. [62] and Pandey et al. [63], who highlighted that the Soliga harvesters sell gum-resin to the shopkeepers, usually in the closest market to their homes, in exchange for cash, or to buy their monthly or weekly household supplies. The current study found that the shopkeepers processed the gum-resin and preferred packaging it themselves, either in plastic bags or in newspaper parcels. None of them bought gum-resin from the harvesters if it was already packaged. This follows Te Velde et al. [64], who argued that when harvesters are distant from consumers in a value chain, the intermediaries like shopkeepers play key roles in processing and packaging before selling it to the consumers. In contrast, Nadkarni [65] reports that in small towns of Rajasthan (northern India), the harvesters play key roles in collecting NTFPs, negotiating the prices, and also processing them before supplying them to the intermediaries who then hire laborers (they can be the harvesters too) to pack the NTFPs.

In this study, one-third of the shopkeepers added dilutants to increase the weight of the gum-resin and thereby increase the markup. This is similar to the findings of Jensen [66] and Cunningham and Long [67] who argue that when an NTFP is in short supply and has high demand, or is of low-quality, the sellers are more likely to add dilutants to enhance either the quality or the weight of the product, and thereby generate a higher income. A few shopkeepers surveyed in this study also said that they did not dry the gum-resin completely because the retained moisture increased the weight, and hence income. This contradicts the findings of Kilchling et al. [68] in Switzerland, where they found that shopkeepers prioritized NTFP quality over quantity. This difference may be related to the nature of the product traded and whether consumers can easily discern and appreciate higher quality. If they cannot, then some level of dilution will go undetected and will increase the income of the shopkeeper. Sarker and Das [69] highlight that middlepersons, like shopkeepers who track their markup, often make the highest profit in NTFP value chains. However, the shopkeepers in the temple markets do not track the markup made through selling gum-resin, specifically because they sell other commodities (Figure 2a) as well, and the profits from gum-resin contribute only a tiny proportion of their overall business profits.

#### *4.2. Street Vendors' Role in the Gum-Resin Value Chain*

In contrast to shopkeepers selling an array of goods, street vendors sold only gum-resin as their primary source of cash income. The street vendors used the most convenient way to procure gum-resin from the harvesters; they either visited harvesters in their villages or approached them in the temple markets. The majority of the street vendors in this study had low education, which is in common with many studies on NTFP vendors elsewhere [13,70]. Poor education and a lack of formal skills have been interpreted as an underlying reason for involvement in NTFP trade, especially because it also requires limited capital investment. However, in contrast to studies that highlight poverty as a driver of NTFP commercialization, the average annual income earned by the gum-resin street vendors was USD 700–1400, which is higher than the national and international poverty-line standards (USD~450 per annum) [71]. Hence, this study highlights the importance of gum-resin as a cultural NTFP that can contribute to poverty alleviation, provided it is based on sustainable harvests. This counters the oft-held perception that the use and trade of NTFPs is just a survival strategy and does not lift people out of poverty [72,73], and fits within the upper tercile of studies summarized by Shackleton and Pullanikkatil [74]. This potential for poverty alleviation is particularly important for forest-dwellers, who often have limited means and opportunities to earn sufficient cash incomes.

The level of markup and income varied according to several aspects of the trade. For example, the street vendors at BRT travelled to the surrounding villages to purchase gum-resin, which they then resold in the temple markets. This was not the case at MMH or CWS, where the harvesters came to the sellers. This may also be due to the temple renovation that was happening at BRT during the study. Hence, the street vendors were forced to buy the gum-resin from the harvesters in their villages and transport it to sell it in the markets far from their own villages. Overall, the street vendors earned a higher value share than the harvesters in all of the study sites [58]. This follows the findings of Mugido and Shackleton [16], reporting that when the NTFP harvesters live far from the markets, the traders or middlepersons make the highest markup, compared to when the markets are close to the villages.

This study also reported the difference in markup made by the actors of the value chain when they use different units of measurement. Street vendors who sold gum-resin in handfuls enjoyed a higher markup than those who sold in paos. This was especially true for the MMH temple market, which attracted more pilgrims, and therefore higher sales



than the other two markets [58]. Ingram et al. [75] found that better-organized sellers who sell NTFPs in popular markets can earn almost double of those who are less-organized or operate in sluggish markets. It was also noted from the current study that the popularity of temple markets at MMH and the high demand for gum-resin prompted some of the street vendors to add dilutants. This finding is supported by Dhiman et al. [76], who argued that when the demand for a plant-based product is high and the species distribution in a region is scarce, the likelihood of adulterants or dilutants being added increases.

There was a high level of dissatisfaction about the current markets among many of the street vendors who sell only gum-resin. This was not the case with shopkeepers who had a diverse range of wares and commodities to sell and generate income. The level of dissatisfaction among the street vendors was higher at BRT and CWS than at MMH. This further indicates the weak market for gum-resin at BRT and CWS that could favor street vendors. Pirard et al. [77] suggest that dissatisfaction among small-scale business people can be related to a lack of government intervention in establishing institutional intermediaries. Such institutions can provide livelihoods to the street vendors by hiring them as collectors who can bring gum-resin from the harvesters to the market and sell it through institutions. Rather than relying on government cooperative institutions like LAMPS (Large Adivasi Multi-Purpose Societies), which primarily focus on large-scale NTFP trade and have historically restricted gum-resin harvesting, community-led initiatives should be prioritized. Under the Forest Rights Act (FRA) of 2006, the Grama Sabha, a legally recognized village assembly comprising all adult members of a village, holds the authority to manage and regulate the collection and trade of NTFPs, including gum-resin. Encouraging Grama Sabha to take the lead would ensure that harvesters and street vendors benefit lawfully while maintaining sustainable resource use. If needed, LAMPS could still play a role in Karnataka, but the primary responsibility should rest with legally empowered local institutions. Further data on the percentage of harvesters benefiting from such interventions would help strengthen this argument.

#### *4.3. Sellers Gum-Resin Market Constraints and Suggestions*

The sellers were pessimistic about any changes that they expected in the gum-resin market in future, and, therefore, they did not express the constraints as freely as expected. One seller said that “nothing will change here even after you conduct research and report the situation of the market to the policy maker”. Nonetheless, most of the sellers who mentioned some constraints related to the gum-resin markets were concerned about the scarcity of the pure form of gum-resin, because that was what the consumers preferred [58]. However, the sellers who bought pure gum-resin were scared of forest officers who wanted to block the trade of pure gum-resin because they believed the harvesters deliberately damaged trees to stimulate the flow of the gum-resin. Informal conversations with the forest officers reflected their awareness about the pure form of gum-resin and the fact that it oozes from damaged bark on the trees. However, awareness has to be created that such injuries can be formed due to other agents, such as wind or animals. This is where research and training can play a significant role, such as the importance of training forest staff with appropriate knowledge about all of the NTFPs within the forests they manage, as Heinen and Shrestha-Acharya [78] highlight. Indeed, it is not just about training, but about valuing and sharing all knowledge forms to better manage the resources and the landscapes in which they are found [79].

The street vendors who sold gum-resin in the temple markets at MMH faced two significant challenges. The first was the temple authorities chasing them away and not letting them sell gum-resin to the pilgrims near the temple. This is not unusual, with many studies noting that informal traders of NTFPs or small items are deterred or actively chased away

by established institutions or authorities because they do not have permits, or by retail traders who decry the competition from the informal traders [80,81]. In MMH, this challenge can be related to the temple authorities failing to allot specific areas near the temple for street vendors. This finding is supported by Loader and White [82], who mention that sellers remain dissatisfied when there is a demand for a product but the authorities in power fail to manage the market and the sellers. The second challenge was that only members of certain communities were ‘allowed’ to sell gum-resin. This is related to the lack of social equality and the right to conduct business at MMH [83]. Inequality based on caste, gender, and status has been innate to the region for generations. Hence, the recommendations from Mutenje et al. [84] and Westholm [85] can be considered in the three study sites, which argue for state-managed programs or institutional interventions in situations where social inequality exists, resulting in the marginalization of specific groups.

#### *4.4. Consumer Expectations and Religious Beliefs*

The cluster analysis characterized three types of gum-resin consumers based on their age, education, and knowledge of gum-resin. Most consumers in clusters 1 and 3 were aware of the significance of gum-resin in Hindu mythology, and its cultural significance. The consumers in cluster 1 were mostly middle-aged to elderly and had limited formal education and a low income. In contrast, those in cluster 3 were young to middle-aged and had relatively high incomes. The consumers in cluster 3 expected better qualities and more sustainably harvested gum-resin. This echoes Schunko et al. [29], who found that educated NTFP consumers demand sustainably harvested NTFPs. Hence, the level of education of NTFP consumers is a key factor in shaping NTFP commercialization in a region. Therefore, these findings specifically highlight that the consumers in clusters 1 and 3 can be considered as constant buyers who would want to buy gum-resin, and any unavailability would harm their spiritual well-being. As Cocks et al. [60] and Rai et al. [86] (whose study was conducted at BRT) argue, restricting the use of culturally important NTFPs can negatively impact the spiritual well-being of the users. Therefore, it is important to promote sustainable harvesting to meet the consumers’ needs.

Most of the consumers bought gum-resin in ‘handfuls’, signifying that very few carried additional quantities back home. However, measures in ‘handfuls’ are not precise or standardized [87]. Introducing standard measurements and improving processing and packaging techniques are frequently recommended to improve NTFP trade to enhance the sellers’ income. Likewise, if the gum-resin quantity is standardized and processing is carefully conducted, as per consumers’ expectations, the traders are likely to have more satisfied customers and earn higher incomes. Jensen [66] found that a high degree of product transformation and processing may not result in a high product value, but value can be added according to consumer perceptions; historical, cultural, and religious significance; the origin of the product; and so on. Hence, Meinhold and Darr [27] recommend that when the consumer can differentiate the quality of the product and consistently seek products of a high-quality, the harvesters and traders should focus on achieving a high and consistent quality to obtain price premiums through procuring and selling the best quality gum-resin. If they have low-quality gum-resin, they should sell it to consumers, like those in cluster 2, who are the least-bothered about the quality, perhaps at a lower price.

Most of the consumers only purchased sufficient gum-resin for their immediate needs whilst at the temple, but about one-quarter, mostly at BRT and CWS, purchased larger volumes to take some back to their own homes. The consumers at MMH felt that much of the gum-resin on offer there was low-quality, and consequently, they did not purchase extra to take home. Mujawamariya and Karimov [88] observed that when harvesters collect gum-resin unsustainably, it can lose its quality, which then negatively influences

the market for the product. Siddiqui [88] points out the urgency to identify indicators to rank gum-resin quality and promote the best quality in the markets that can better satisfy consumers' needs. Yadav and Dugaya [89] suggest that consumers in India increasingly prefer products that are sustainably harvested and retailed in an ecologically and socially sound manner. It is therefore important that the gum-resin traders consider this when selling gum-resin to educated and urban consumers. Gum-resin traders should separate products by quality, take extra measures in packaging good-quality gum-resin (for example, branding and labelling it with storage instructions) that consumers would want to carry home, and sell the low-quality gum-resin to the consumers to offer near the temple. As Kilchling et al. [68] observe, NTFP consumers who can financially afford to buy attractively packaged products and can understand the importance of sustainably harvested NTFPs would buy it even if they do not need it, with an intent to help the harvester communities.

## 5. Conclusions

This study examined the socio-economic characteristics of actors at the upper end of the *Boswellia serrata* gum-resin value chain in temple markets of Karnataka, India. Shopkeepers and street vendors were the only intermediaries, with no observed gender inequality but some evidence of social vulnerability, particularly at the Talabetta market in MMH, where children were engaged in selling gum-resin.

The findings reveal that street vendors, despite having limited capital and education, earned incomes above national and international poverty thresholds. This was largely due to the cultural and ritual significance of gum-resin, which led consumers to willingly pay a premium. As religious tourism increases, the demand for gum-resin is likely to grow, reinforcing its importance as a livelihood resource for forest-dependent communities.

However, the trade remains informal and unregulated. Differences in pricing practices, unit measurements, and access to harvesters affect income stability and market consistency. To address these constraints and support sustainable growth, governance mechanisms need to be strengthened.

We recommend empowering Grama Sabhas under the Forest Rights Act (Section 3 (1) (i)) to take the lead in organizing gum-resin markets. These local institutions can oversee collection, grading, basic processing, packaging, and fair pricing, ensuring that benefits reach harvesters, vendors, and consumers. Unlike LAMPS, which has focused on centralized and large-scale trade, Grama Sabhas are legally authorized and more suited to manage local, culturally-driven NTFP markets.

The diversity of consumer preferences documented in this study offers a baseline for targeted awareness and market development strategies. Finally, future research should explore the spiritual symbolism of *B. serrata* gum-resin and assess culturally acceptable alternatives to reduce ecological pressure on the species while continuing to support rural incomes.

**Supplementary Materials:** The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/f16060911/s1>.

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