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Research Article

Present Status and Scopes for Future Improvement of Agar Essential Oil Processing Microenterprises in Selected Areas of Bangladesh

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ABSTRACT

This cross-sectional study aims to explore the socio-demographic factors of the agar micro-entrepreneurs, the present status of production and marketing, the Covid-19 pandemic impacts and general problems of agar-based enterprises and their potential for further improvement. An exploratory survey was undertaken over 50 randomly selected micro-entrepreneurs (ME) and information was collected by face-to-face interview using a semi-structured questionnaire. As per respondents' feedback, majority (100%) of the respondents engaged in agar oil or agarwood chips and dust processing besides agar plantation. In a zest, most of the MEs were launched within the past 20 years and more than 50% of them were found to beinvolved agar plantation directly. For waste product management, the majority of the MEs had processed water as waste having a disposal amount of 101-400 kg/day. In the case of production and post-production activities, more than half of the respondents (54%) escaped longer pre-fermentation steps and extracted oil direct by hydro-distillation method using heating, collection, post-production and purification steps. Most of the extraction plants were locally fabricated (46%). The respondents did not run any promotional activity and their products did not comply with traceability. During the COVID-19 pandemic, most of the MEs had to face a substantial financial loss monthly and did not receive any financial support from GoB, NGOs, or other organizations. To secure the maximum benefits from these agar-based MEs, respondents proposed financial support and quality raw materials, availability of experts, financial support, proper transportation facilities, labeling, and opportunities for expansion of market facilities.

Introduction

Agar, eaglewood, gaharuor aloeswood, all are alternative names for the resinous fragrant and highly valuable heartwood produced by *Aquilaria agallocha* (Bardenetal, 2000; Das and Alam, 2001). Agarwood has been widely used as therapeutic perfumes, traditional medicine, religious purposes, and aromatic food ingredients (Liu et al., 2013). The agar trees have a long history in Bangladesh and have grown naturally in the Sylhet, Chittagong, Cox's Bazar, and Chittagong hill tracts for centuries. However, it is currently exceedingly difficult to obtain agar trees that have been grown organically. About 400 years ago (17th century) production of agarwood started in the Sujanagar union under BarlekhaUpazila of Moulvibazar district in Bangladesh. At present, there are more than 200 processing industries involved in the production of agarwood and agar oil in Bangladesh (Barden et al., 2000).

Agar is grown on long-term plantations. A productive plantation may have a cycle of up to 15 years. Normal management of short-cycle plantations only produces inferior 'agar attar' and essential oils (Boya oil). It is sold in the form of woodchips, wood pieces, powder, dust, oil, incense ingredients and perfume for several thousand US dollars per kilogram and it varies depending on the geographical location and cultural deposition. (LaFrankie, 1994; Barden et al., 2000; Gunn et al., 2004; Compton, 2007) When agarwood chips are processed into oil, the agarwood oil would be sold at US $ 30,000 per kg (Adhikari et al., 2021). Three products - wood chips, oil, and wood dust/powder are primarily used for trading agarwood. Agar oil is a component in French-style body and clothing fragrances as well as oil-

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based Arabian spray perfumes. Several companies in Bangladesh extract agarwood oil using traditional methods that have been practiced since ancient times. According to different studies, the chemical compounds in agar oil contribute to its medicinal properties and quality (Ishihara et al., 1991). The oil is considered a stimulant, used as a treatment for pleurisy, and it is carminative (Jayachandran et al., 2015). Agar is one of the most promising non-timber forest products (NTFPs) of Bangladesh and earned Tk.300 M through exports of attar (agar oil) in 2004 (Hayderet al. 2005).

Despite the significant economic role of agar oil and other agar-related products, little reliable information is available about the micro-enterprises, their socio-demographic status, present status, activities during agar production and post-production, COVID-19 pandemic impacts on the MEs, general problems and traceability, product certification and promotion. The current study was designed to examine the present status and scope for further improvement to enhance their potential contribution to socio-economic development. This paper gives an overview of the present status of some agar oil processing micro-enterprises and concentrates on further improvement of the agar oil processing micro-enterprises (MEs) in Bangladesh.

Methodology

The study utilized a one-time cross-sectional survey design to assess the present status and scopes for further improvement of agar oil processing. Information/data was collected by sample survey using a standard and pre-tested questionnaire. Purposive random sampling was followed for selecting the respondents for the quantitative data collection at the village level.

Location of the study

The study was conducted in Maulvibazar district, Bangladesh. The present status and scopes for further improvement of agar oil processing micro-entrepreneurs (MEs) were obtained from the villages Ahmedpur (2%), Borthal (92%), and Sujanagar (6%) in the Maulvibazar district, Bangladesh.

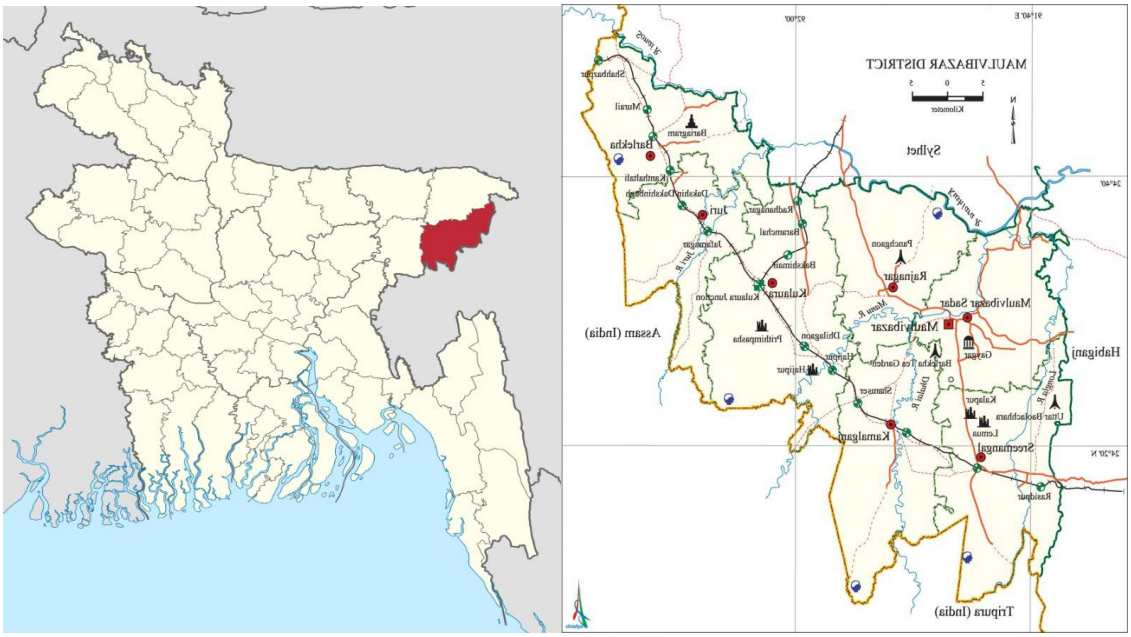

Figure 1: Maulvibazar District in Bangladesh

Sample Size

50 agarwood oil processing micro-entrepreneurs (MEs) were selected randomly from three villages of the study area.

Sample Collection

Essential information about agar microenterprises (MEs) was collected by using two enumerators who spent 5 days in the field. About fifty agar MEs were visited and the respondents were interviewed face to face. A structured questionnaire was used to collect information on agar processing from the selected respondents.

The questionnaire was designed with questions on the socio-demographic status of the respondents, the present status of agar micro-enterprises (SP-ME), activities during agar products production and post-

production, COVID-19 pandemic impacts on the MEs, general problems and traceability, product certification and promotion related questions.

Data Generation and Analysis

The data generation phase for the study consists of the development of a questionnaire, interview of the respondents, quality control, data screening, data entry and analysis. Data analyses were carried out by data management software Excel and statistical software SPSS and data entry was carefully done to avoid errors. Finally, a few relevant tables were prepared according to the necessity of analysis and interpretation and to meet the purpose of the study.

Results

Socio-demographic Characteristics of the Respondents

The socio-demographic characteristics of the respondents have been presented in Table 1. In the case of age, more than half of the males (54%) were between the age group of 30-50 years old. So, mostly 30-50 years age group people dominated agar oil processing micro-enterprises (MEs). All the respondents were male and direct women's participation in the industry is invisible.

About 46% of respondents had experiences of 11-12 years followed by 36% who had less than 10 years. The rest of the respondents were veterans and had around 21-30 years of experience. So, agar oil processing micro-enterprises (MEs) of the surveyed area were found experienced enough in their agar business.

Most of the participants' family position was head of the family and 84% of the respondents were married. Only about 38% of the respondents were able to attend high school and more than half of them (52%) have monthly income in between Tk. 10000-25000. The agar-based occupation was the primary occupation for 86% of respondents. About 30% of the respondents were found to be in this occupation through inheritance as their fathers also were involved in agar production.

Table 1. Percentage distribution of the demographic information of the respondents

Particulars	Percentage (%)	Particulars	Percentage (%)
Village	Ahmedpur (2), Borthal (92), Sujanagar (6)	**Marital Status**	
Sex	Male (100)	Married	86
Age categories		Unmarried	14
Below 30 years	24	**Primary Occupation**	
30-50 years	54	Agar production	86
Above 50 years	22	Clothing shop	2
Experience		Driver	2
Below 10 years	36	Immigrant	2
11-12 years	46	Student	4
21-30 years	18	Teacher	4
Religion	Islam (100)	**Father's Profession**	
Category		Agar Production	30
Head	78	Clothing Shop	2
Elder son	6	Driver	6
Second son	2	Farmer	24
Younger brother	6	Govt. Employee	2
Younger son	8	Immigrant	26
Education Status		Shopkeeper	2
Primary	26	Teacher	4
High School	38	Veg. Business	2
SSC	16	Village Police	2
HSC	16	**Profession by born**	Yes (32), No (68)
BA/Honours	4	**HH Members**	
Monthly Income (Tk.)		4-6	68
10000-25000	52	7-9	24
25000-50000	38	10-13	8
50000-80000	10		

Present status of Agar Micro-Enterprises (SP-ME)

Number of MEs

The information related to the present status of Agar Micro-Enterprises (SP-ME) is presented in Table 2. It could be seen from the data that there are more than 10 MEs related to agar processing in the Maulvibazar district and all of them (100% of the respondents) deal with agar oil processing or agarwood chips and dust processing.

Table 2. Present status of Agar Micro-Enterprises (SP-ME)

Particulars	Percentage (%)	Particulars	Percentage (%)
Number of MEs		**Ownership of agar forests**	
0-4	0	Single	48
5-9	0	Multiple	52
>=10	100	**Types of agar MEs**	
Age of Respondents			
30-50 years	54	Natural	-
Types of MEs		Cultivated	36
Agar oil	100	Both	16
Wood chips and dust	100	Others	48
Agro processing machinery	94	**Management of MEs (Traders/SAP/Others)**	
Suppliers/traders of agar products	92	**Year of establishment**	
Other like agar garden	100	2000-2010	56
Ownership of MEs		2011-2020	44
Agar oil	48	**License**	
Wood chips and dust	92	Trade	60
Agar processing machinery	2	**Types of products**	
Suppliers	2	Agar oil	46
Other like agar garden	2	Wood chips and dust	94
Worker	0	7-9	24
History of MEs (years)		10-13	8
<6	12	**Storage Facilities**	Yes (98), No (2)
6-10	28	Own building	100
11-15	30	Rented building	0
>=16	30	**Waste Management**	
Profitable MEs		Solid Waste (kg/day)	
Agar oil	82	<1-41	100
Wood chips and dust	98	Process Water (lit/day)	
Agro processing machinery	0	40-400	44
Sales and distribution agency	2	Fermented Water (lit/day)	
Other like agar garden	24	5-60	46
Management of MEs (Field level producer		Store for reuse	100
Year of establishment		Used for other purpose	46
1998-2013	50	Recycle	46
Don't know	50	Disposal of bark	72

Growing profits from the MEs

The MEs that deal with wood chips and dust were the most profitable domain over the years according to the respondents (98%), followed by agar oil processing MEs which stood at 82%, and agar garden was the lowest (24%).

Management of the MEs

The information regarding the management of agar MEs of the field-level producers and traders/small processors is presented in Table 2.

Producers

The result showed that half of the field MEs taken into consideration for this survey were established between 1998 and 2013 and the establishment time of others remained unsure. In the current study, about 36% of the respondents dealt with cultivated agar plants and 16% had both cultivated and natural agar plants. Around 48% of respondents did not deal with agar plants directly. Only a few of the MEs (16%) are as old as more than 20 years. Regarding these MEs, about 60% of them were found to have obtained licenses and all of them were trade licenses. A license from the Bangladesh Forest Research Institute (BFRI) or any other authorities was not found.

Types of products

Most of the traders/small agar processors (94%) dealt with wood chips and dust from agar plants. The next was the agar oil processing in which 46% of the traders/small processors were involved. Only 2% of them were found to be involved in dealing with agar processing machinery and other -related activities.

Storage facilities and waste product management

Almost all the traders/small processors (98%) were found to have storage facilities and all of them had their own building for storage. Only 2% of the traders do not have any storage facility either as an owner or owned by renting.

There are different types of waste produced at the MEs, like solid waste, process water, fermented water, and other types of waste. For solid waste, about 54% of the MEs produced less than 1kg/day. The majority of the MEs reported to have processed water as waste of around 101-400 kg/day.

Production of agar products

Common pre-production activities

Table 3 represents the percentages of respondents involved in pre-production activities. About 52% of the respondents were involved in managing seedlings and management of fields, such as irrigation, weeding, and application of fertilizers. No information found about the activities regarding natural infections. Nailing is the only infestation technique practiced by the processors as reported by almost all the respondents. For the harvesting methods of woods, a part of them followed decortication with a chisel and logging with a saw and chopper (46%), while the majority of them were found to have followed other methods (54%). The wood processing contains chips and oil processing (5%), only oil processing (3%), woods and chips processing (2%), wood, chips and dust processing (1%), and lastly wood, chips, dust and oil processing (12%). Other than these, no pre-production activities were found during the interview.

Activities during production and post-production

Several steps are involved in production and post-production activities and respondents' feedback are presented in (Table 3).

Fermentation

Most of the respondents (54%) did not do any sort of fermentation during production. The rest of the respondents performed either water fermentation (44%) or used water formulation (2%) for their products.

Extraction

Hydro-distillation was the most practiced among a variety of extraction processes informed by the respondents (46%). The use of solvent extraction or supercritical fluid extraction or any other advanced methods are reported to have hardly been practiced.

Heating and distillation

Around half of the respondents maintain the process of heating and distillation using water as a medium. Amongst the 46%, more than half of them (54%) did not wait for days, 2% of the respondents performed heating or distillation for 7-8 days, while 38% were found to perform the heating process for 10 days and 2% of the respondents found to agree with heating for 12 days.

Collection

Scrapping was the most used method (46%) for collection. For keeping the products, different types of containers were used by 42% of the producers, among which 28% used glass and aluminum bottles and 14% used only glass bottles.

Post-production purification

Less than 50% of the respondents were not involved in post-production purification and the remaining 46% carried out purification operation. No specific information was available about the kind of purification methods used by the producers.

Operation duration

Most of the operations (30%) are year-round according to the feedback. Besides, 14% of the respondents continued operation for half of a yearand there were only 2% of the respondents who performed operations periodically.

Information about extraction plant

Establishment

Most of the extraction plants were locally fabricated (46%). Any information regarding extraction plants that were imported or assembled with imported accessories was not available and also no other establishment of extraction plants was found.

Installation

There was no installation found to be done by the suppliers among the respondents who own extraction plants (0%) as all the locally fabricated extraction plants were installed by local technicians (46%). Data shows no other type of installation.

Operation

The survey data indicates that the majority of the extraction plants were operated by the employees (36%) and 8% of the owners were found to be involved in the operation of the plants. It can be seen from the data that other than employees or owners no one operated the extraction plants.

Maintenance

Maintenance of the extraction plants includes the cost of the plants and expert requirement for trouble shooting. The data shows 20% of the extraction plants cost between the ranges of 3000-10000 Tk. Some respondents (8%) owned plants that were worth Tk. 10001-20000 and 18% of the respondents owned plants which cost between Tk. 20001-30000. The data also showed that 36% of the respondents who own extraction plants looked for experts.

Table 3. Production of agar products

Particulars	Percentage (%)	Particulars	Percentage (%)
Common pre-production activities		**Collection**	
Seedlings	52	Scrapping	46
Field Management (irrigation, weeding, fertilizer)	52	**Container Used**	
Infections	-	No container	58
Harvesting method of woods		Glass and aluminum bottle	28
Decortications with chisel	46	Glass bottle	14
Wood processing		**Post production purification**	Yes (46), No (54)
No processing	54	**Operation duration**	
Chips, oils	10	Year round	30
Oil	6	Half of the year	14
Wood, chips	4	Periodically	2
Wood, chips and dust	2	Other	0
Wood, chips, dust, and oil	24	**Establishment of Extraction plant**	
Activities during Production		Locally fabricated	46
Fermentation		Imported	0
No fermentation	54	Assembled with imported accessories	0
Water fermentation	44	Other	0
Water formulation	2	**Installation of extraction plants**	
Duration (20-25 days)	46	By supplier	0
Extraction		By local technician	46
Hydro-distillation	46	Others	0
Solvent Extraction	0	**Operation of the plants**	
Super critical fluid extraction	0	By owner	8
HeatingWater (Media)	46	By employees	36
Time of heating (days)		Others	0
0	54	**Maintenance of the plants**	
7-8	2	**Cost (Tk.)**	
10	38	3000-10000	20
12	6	10001-20000	8
Distillation		20001-30000	18
Water (Media)	46	Expert required for maintenance	36
Time of distillation (days)		Others	0
0	54		
7-8	2		
10	38		
12	6		

Traceability, Product Certification and Promotion

The majority of the respondents (88%) were positive about keeping records of the source of their raw materials (wood, chips and dust) whereas 12% of them were found with no certain records of the source of their raw materials. In the case of the labeling of products, most of the responses were negative (98%). Similarly, 100% of the respondents agreed that their products did not comply with traceability. When the participants were asked about the certification of their products by any third-party organization or GoB all of them responded negatively which implied that they did not have any certification for their product. Moreover, all the respondents (100%) did not run any promotional activity and most of them thought it unnecessary (84%) (Table 4).

Table 4. Traceability, Product certification and promotion

Particulars	Percentage (%)
Record on Source of raw material	Yes (88), No (12)
Labeling the products	Yes (2), No (98)
Complying with traceability	No (100)
Measures that add to Traceability	
Checking while processing	2
Medicine test	2
Record keeping	56
Testing	20
Do not know	20
Certification of product	No (100)
Running any promotional activity	No (100)
Reasons for not Running PA	
No need	84

Improvement scopes of the MEs

The key respondents shared their opinions on how to improve the current situation of the agar oil MEs. They suggested that some processes regarding different operations of the MEs should be modified in order to improve the overall operation.

Many respondents pointed out the pre-fermentation step during the production of agar oil. The pre-fermentation stage typically takes 20-21 days, which is a long time and delays the overall production process. If the time could be reduced to 7-10 days, the process would be more economical.

One of the major byproducts of agar oil is hydrosol. A large amount of hydrosol is produced in every batch of agar oil production, but it is discarded because the owners and workers of the MEs do not know how to utilize it. The respondents stated that utilizing the hydrosol would be a great improvement to their business as it would open up a new way to generate more income.

Most respondents shared that they did not have any professional training in determining the maturity of agarwood. Professional training and the use of modern technology and accessories to identify the maturity stage and infestation techniques would increase the efficiency of the process and improve the value of the oil.

Some respondents pointed out the need to expand the international market for agar oil and related products. They were interested in going global with their products and believed it could enhance their business and open up new possibilities for improvement for the agar oil MEs.

Problems regarding MEs

Different problems were found related to the MEs which are presented in Table 5.

COVID-19 pandemic impacts on the MEs

Almost all the owners of MEs (98%) responded positively about their production being affected due to COVID-19. Due to the pandemic, most of the producers or owners of MEs had to face a substantial loss in their monthly income. During the pandemic, 44% of the owners fell in the area of monthly income between 5000-10000 Tk and the overall income was observed to be decreased due to the pandemic. Also, the respondents did not receive any financial support from GoB, NGOs, or other organizations (Table 5).

Problems in getting inputs for MEs

Around half of the respondents (42%) replied positively to the question about facing any problems with getting inputs for their MEs. When asked particularly, it was found that 34% of them faced problems having capitals for operation which was the major problem as per their response, followed by the problems regarding raw material availability (14%). Some of the respondents pointed out problems related to equipment supply (2%), training conduction (2%), and political/legal/social (6%) (Table 5).

Problems related to outputs of MEs

Many of the respondents (44%) have different problems related to the outputs, namely, low quality, low productivity, and high post-harvest loss. When the participants were asked about the low quality of the products 30% of them responded positively and low productivity to which 14% of the respondents agreed. The major problem related to output was found to be high post-harvest loss (28%) (Table 5).

Marketing the products and problems related to marketing

Marketing of the products from MEs

The data shows that most of the products were sold in local markets (96%), and secondly to the international market (52%), while a small amount of products were marketed to capital cities (4%). In the case of local markets, Dalals (98%) and Mohajons (64%) were the major buyers, and very few of the respondents (8%) got the chance to sell their products to direct consumers/users (Table 5).

Table 5. General problems regarding MEs

Particulars	Percentage (%)
Production affected due to COVID-19	Yes (98), No (2)
Income During COVID-19 (Tk.)	
5000-10000	44
10001-20000	40
20001-40000	14
50000	2
Income during normal Situation (Tk.)	
5000-10000	4
10001-20000	34
20001-40000	4
40000-80000	22
Receiving support due to pandemic	No (100)
Borrowing money due to pandemic	Yes (8), No (92)
Selling asset due to pandemic	No (100)
Negative effect on employee management	Yes (2)
Impact of COVID in selling items	0
Impact of COVID for supplying items	0
Problem regarding inputs for MEs	42
Capitals for operations	34
Raw materials	14
Equipment supply	2
Training conduction	2
Labour Availability	0
Others: political/legal/social	6
Problem regarding outputs for MEs	44
Low quality	30
Low productivity	14
High post-harvest loss	28
Others: political/legal/social	0
Marketing the products	
Local market	96
Capital cities	4
International market	52
Others	0
Buyers in local Market	
Direct consumers/users	8
Faria	0
Dalal	98
Mohajon	64
Others	2
Marketing related problems	88
Procuring inputs/raw materials	2
Selling products	30
Price of products	84
High cost and lack of transportation	28
Weighing of storage	2
Others: political/legal/social	0
Problems regarding tax burden	Yes (50)
Problems related to common utilities	No (100)

Problems in marketing

88% of all the respondents were found to face various marketing-related problems among which the price of the products was faced by most of them (84%). Besides the pricing, selling the products and high cost and lack of transportation facilities also stirred up problems for many of the respondents (30%, and 28% respectively). None of the respondents had any problems in marketing due to political/social/legal issues (Table 5).

Other problems

The respondents were asked about having any problems regarding tax burden to which 50% of them replied to have problems but when asked about problems related to common utilities, all of them replied negatively.

Discussion

Agarwood is a precious non-timber forest product that has been utilized by several cultures for religious, cultural, and therapeutic purposes (Ador et al., 2021). In Bangladesh, it is among the promising and valuable products normally processed into incense and marketed globally, especially in the middle East and Southeast Asia (Baksha et al., 2009). The present study was carried out to explore the demographic, and socioeconomic condition of the people involved in agar plantation and agar-based MEs. In addition, to find out about the management of MEs, production, cultivation, marketing condition of the agar-based products, the overall problems related to agar-based MEs and discussion about different scopes for future improvement.

Bangladesh is one of the most densely populated countries with only 9.8% of land covered by forests. So, the plantation of agar trees has both socioeconomic and environmental benefits (FD and FAO 2007; Rahman et al., 2007). The socio-demographic results showed that most of the agar respondents were involved in agar plantation and other related businesses for many years which indicates their experience and dedication to this field. For the majority of them, it is their main occupation though their income is not very high. However, agar cultivation has changed the lifestyle of rural people as it has created new job opportunities. Hence, the agar sector could act as a potential source of jobs and empowerment in Bangladesh to uplift the socio-economic conditions of the rural people.

Due to over-exploitation and population pressure, existing forests including the natural sources of agar have been degrading rapidly (Talucder et al., 2016). As a result, the owners of agar forests are relying more on cultivated agar plants than naturally grown ones. The results from Table 2 indicate that the majority of the respondents have more the 10 MEs with multiple owned agar forests. The formation of agarwood is a plant's defense mechanism mainly against any wounding and infection caused by fungal pathogens which can sometimes be done manually (Mohamed et al., 2010). The respondents in this study were not found to be aware of the formation process of agarwood. The main types of products the MEs are dealing with are agar oil, agar woods, chips, and dust which they found to be more profitable. They also focused on storage facilities to ensure the quality of products and they have well-arranged waste management as they recycle and reuse the majority of the waste. It can be assumed that this step reduces the burden of waste on the surrounding environment.

The natural agar formation is done by physical damage to the tree caused by pests and infections, animal grazing, or thunder strikes (Wu et al., 2017; Tan et al., 2019). This can also be done by artificial methods like the nailing method, drilling method, aeration method, agar wit method, burning chisel drilling method, infestation by reared insects etc. (Chowdhury et al., 2016). In this study, almost half of the respondents were found to follow decortication with a chisel as their harvesting method. The owners and others were not that much aware of the different methods of harvesting which could be the result of not enough academic training and knowledge obtained in this area. Most of the respondents opt for no processing which could be due to the complexity and expenses of processing while some processed the wood, chips, dust, and oils. Professional training related to the formation and cultivation process would increase the yield as well as the value of the derived agarwood products. It can be seen from the results that they prefer water fermentation or no fermentation and use locally fabricated extraction plants for the extraction of agar oil. Besides, they only used hydro-distillation. The use of modern technology or extraction process was not found to be used by any of the owners and they are not knowledgeable about the modern technologies. The respondents were also found to be less aware of the traceability of their products. Though the majority of them had records on the sources of their raw materials they did not follow any overall procedure that could comply with the traceability of their products. Even some of them had no idea about this whole procedure and around 90% of them felt that there was no need for any promotional activity or traceability to market their products. Traceability is crucial to ensure sustainable harvesting and marketing of the product as it is based on more strictly defined and more detailed information regarding all the steps in the agarwood supply chain is required (Kanazawa, 2017). Many of the respondents were found aware of the need for further improvement and proposed different ideas with which more

economic benefits can be earned from agarwood products. Agar oil hydrosol is a byproduct that is produced in abundance in the agarwood industry and is thoroughly underutilized. It is an aromatic compound that is claimed to have chemical properties with positive antioxidant activity and biological activity (Mohamad Kahar et al., 2021). So, finding new ways to utilize hydrosol would be economically profitable for the MEs.

Different types of problems and risks are part of every business. The owners and the other respondents of the selected MEs also faced many problems and unavoidable situations that affected their business over time. During the time of COVID-19, all types of businesses and enterprises faced difficulties in terms of lower sales and loss of employee income (Hidayah et al., 2022). The impact on small cottage industries and micro enterprises was even stronger (Khan et al., 2021). Similar to the reports, the respondents of the agar MEs suffered in terms of their monthly income. It can be seen from the results of Table 5 that, many of the owner's incomes reduced to half during the time of the pandemic. They did not get any support during that time. Though they did not have to sell any assets or borrow money, it can be assumed that due to COVID-19, they suffered to maintain their regular business and lifestyle. Other than the pandemic they also came across some general problems which affected the inputs, outputs, production, and marketing of the agar woods and related products. Many found it difficult to arrange capital for the input due to low income and low quality of products and overall low productivity was also observed during the study which could be caused by lack of adequate knowledge and proper training. Another major problem suffered by the owners was during the marketing of the products. Most of them lack strategic movement to market their products in big cities and are mainly marketed locally. Though some successfully targeted the international market the amount is not satisfactory. Besides, while targeting the local market, they failed to get deserved prices for their products due to the inevitable involvement of dalals, and mohajons, who got in the middle and bought products at a lower price from them and sold them at a higher price. In this process, the producers had no access to sell their products directly which caused a loss in their sales. Apart from that the price of the product can also fluctuate as the dalals, and mohajons set the price at will sometimes.

Conclusion

The socioeconomic characteristics revealed that the majority of the people in the study areas depended on agar oil processing and agar-based business for their livelihood. From this study, it can be concluded that the agar oil processing business was accepted by the respondents as a profitable one. The most profitable fields related to agar MEs were wood chips and dust over the years so further improvement in this field can make it a more profitable business. Activities involved during pre-production, production and post-production were partially done that can produce low-quality products. The respondents can do these activities properly during the production of agar products. They can reduce the time for pre-fermentation and also rather than discarding the hydrosol produced during production, purefying and selling it to the market will be a good option to increase their business. Also, training on good quality products, maturity identification, insect infestations, etc will help them to compete in the international market and expand their business globally. Most of the respondents were keeping records of the source of their raw materials but did not label the products. All the respondents did not run any promotional activity and their products did not comply with traceability. Proper guidelines and training about recording, labeling, traceability, product certification and promotion can help the respondents to enhance their product acceptance. During the COVID-19 pandemic, most of the producers or owners of MEs had to face a substantial loss in their monthly income and did not receive any financial support from GoB, NGOs, or other organizations. The GoB, NGO, or other organizations should help them to overcome such situations so that production is not affected. The main problems facing the MEs include a lack of capital for operations and raw materials, marketing-related problems, market insecurity due to Dalal and Mohajon, tax burden, low quality, and productivity. Both government and non-government organizations can play a role in overcoming these problems. To ensure an increase in agar oil processing and also to increase its profitability, the problems and constraints which were identified by the respondents should be solved by the concerned authorities.

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