Standardizing Quality and Documentation for Export: A Study on Targeted Locally Grown Medicinal Herbs in Bangladesh

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ABSTRACT: This study investigates the standardization of quality control and documentation processes for locally grown medicinal herbs in Bangladesh, focusing on enhancing their export potential. Despite Bangladesh's rich biodiversity and a longstanding tradition of using medicinal plants, the export of these herbs is hindered by inconsistent quality and inadequate documentation. Our findings revealed that most producers and collectors have educational qualifications below the Secondary School Certificate (SSC) level and do not adhere to formal guidelines. Key issues identified include a lack of proper documentation practices such as record keeping, accurate labelling, and appropriate packaging. This research highlights the critical need for targeted training and education initiatives to improve adherence to Good Agricultural and Collection Practices (GACP). The study aims to align local practices with international standards by developing a framework that addresses these gaps, ensuring that exported herbs meet global market requirements. The findings are expected to contribute significantly to the sustainable development of Bangladesh's herbal industry and its successful integration into the global market.

Key words: Medicinal plant, export potentiality, quality control, global market.

INTRODUCTION

Traditional and complementary medicine (T&CM) is a crucial, yet often underappreciated, component of healthcare. Recently, there has been a global shift towards embracing alternative and traditional medicine, recognizing the therapeutic potential of herbs and plant-based remedies.[1] Bangladesh, with its rich biodiversity and long-standing tradition of herbal medicine, is at the forefront of this shift. This study examines the export potential of locally grown quality herbs in Bangladesh as evidence-based medicine, highlighting the country's untapped resources and the growing global demand for natural remedies.[2]

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Historically, Bangladesh has relied on traditional healing practices that have proven effective in treating various diseases. These culturally ingrained practices have stood the test of time, integrating over 550 medicinal plants into the nation's healthcare traditions.[3] These plants have long been used in traditional medicine and passed down through generations of homeopathic, Ayurvedic and Unani practitioners.[4] Now, with the support of modern scientific validation, this ancient knowledge is poised to gain worldwide recognition. The global market for herbal medicines is expanding rapidly as consumers increasingly seek natural, holistic alternatives to conventional pharmaceuticals.[5] For countries like Bangladesh, which is rich in natural resources, this trend represents a significant market opportunity, with projections suggesting that the herbal medicine market could reach US$ 5 trillion by 2050.[6] Bangladesh's diverse agro-climatic zones and fertile soil create an ideal environment for cultivating high-

quality herbs such as Basak (*Justicia adhatoda*), Neem (*Azadirachta indica*) Ghritokumari (*Aloe vera*), Kalomegh (*Andrographis paniculata*), Ashwagandha (*Withania somnifera*), and Tulsi (*Ocimum tenuiflorum*) each known for its unique medicinal properties.[7–9]

In Bangladesh, traditional medicine is frequently utilized with complementary and alternative medicine (CAM), and is widely accepted as one of CAM. It is well known that, on average, only 20–25% of the population in Bangladesh's rural areas has access to modern medications. The remaining 75–80% still rely on local traditional healers for medical care.[10,11] However, Bangladesh cannot export locally-grown herbs while upholding their quality, safety, and effectiveness. Bangladesh is fortunate to have a vast array of medicinal plant species.[12] In Bangladesh, 546 to 722 species are either growing or otherwise accessible. For the creation of Unani, Ayurvedic, Homeopathic and herbal medications, only around 255 medicinal ingredients are used.[2,13] However, fully realizing the export potential of these herbs requires the implementation of stringent quality control measures and evidence-based practices. Bangladesh must establish robust regulatory frameworks to ensure its herbal products' quality, safety, and efficacy. This involves adopting Good Agricultural Practices (GAP) for cultivation, Good Manufacturing Practices (GMP) for processing and rigorous quality control across the supply chain.[14,15] Such measures would enhance the global reputation of Bangladeshi herbal products and establish them as reliable, evidence-based treatments.[16–23]

Quality control in the production of medicinal herbs encompasses a range of processes to ensure that the final product meets established purity, potency and safety standards. These processes include selecting high-quality seeds, adhering to good agricultural practices (GAP), and implementing effective post-harvest handling techniques.[24] In addition, proper documentation throughout the production cycle is crucial for traceability, regulatory compliance and consumer confidence. Despite the potential for growth in the export of medicinal herbs, Bangladesh faces several challenges in meeting international quality standards.[25] These challenges include inconsistent quality control practices, inadequate documentation and a need for standardized protocols. Addressing these issues is vital to enhance the export potential of Bangladeshi medicinal herbs and in positioning the country as a reliable supplier in the global market.[26,27]

Objectives of the Study. The main objectives of the study are mentioned below.

- Assess current practices: To evaluate the cultivation, collection and processing methods used by medicinal herb producers and collectors, particularly their adherence to guidelines and documentation practices.
- Identify gaps and challenges: To identify the key gaps in quality control, record keeping, labelling and packaging practices, especially among producers and collectors with educational qualifications below SSC.
- Develop training programs: To design and propose targeted training and education initiatives to improve producers' and collectors' knowledge and skills in following Good Agricultural and Collection Practices (GACP).
- Align with international standards: To formulate recommendations and guidelines that align local practices with international standards, ensuring that the medicinal herbs are of export quality.
- Promote awareness: To raise stakeholders' awareness of the importance of proper documentation and quality control in the herbal industry, emphasizing its impact on global market competitiveness.

This study aims to develop and standardize quality control and documentation protocols for producing targeted locally-grown medicinal herbs in Bangladesh. By focusing on key herbs with high export potential, this research seeks to bridge the gap between local production practices and international market requirements. The outcomes of this study will provide valuable insights into the steps necessary to ensure the consistent production of high-quality herbs

and the establishment of robust documentation systems that support export activities.

MATERIALS AND METHODS

Study area. Cereal crop cultivation is widespread in Bangladesh. Traditionally, the commercial cultivation of medicinal plants has been largely confined to the Natore district, aside from their natural growth in hilly regions. However, recent years have seen a notable expansion of medicinal plant production into other districts, like Bogra, Jessore and Natore as key areas in this sector. As a result, specific regions within these districts have been selected as focal points for this study. The designated study areas include the Laxmipur-Kholabaria union in Natore; Sadarupazila, Sonatola, Sadar, Gabtoli and Shajahanpur upazilas in Bogra district; and Sarsa, Monirampur Sadar, Chaugacha, and Jhikargacha upazilas in Jessore district (Figure 1).

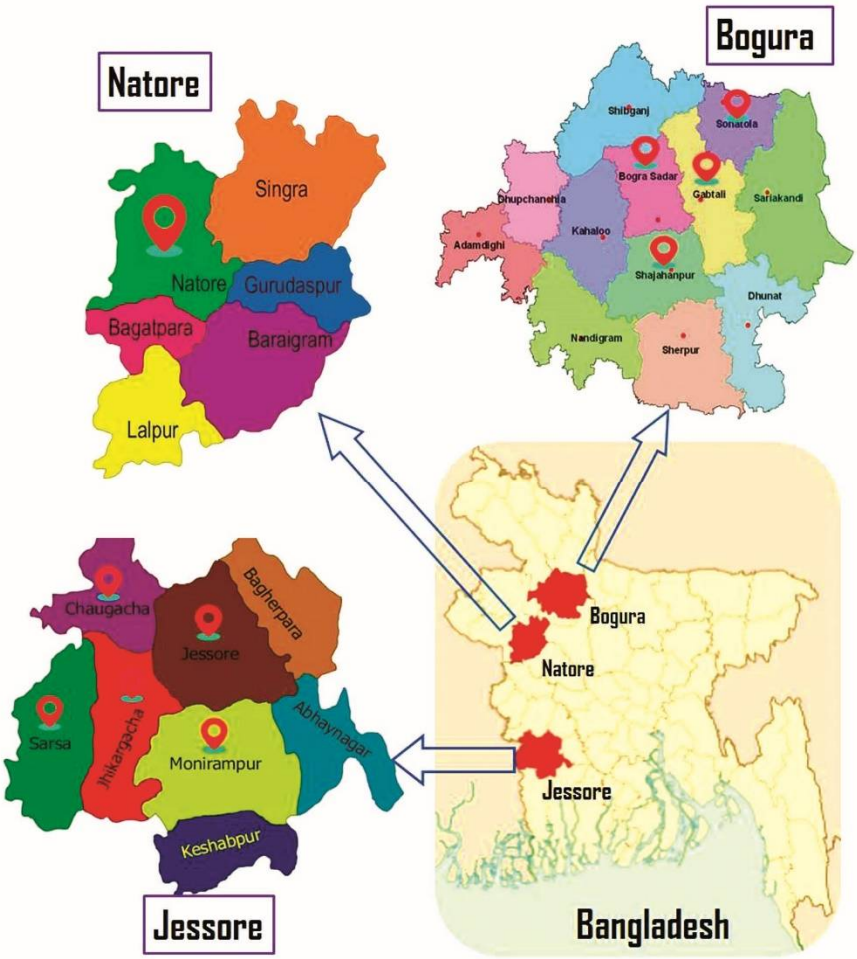

Figure 1. Highlighted Study Areas in Bangladesh.

Target population. Various phases and marketing activities facilitate the movement of cultivated medicinal plants from production to consumption. Within this process, stakeholders engage in key activities like cultivating, harvesting, processing, packaging, labelling, transportation, pricing, grading, storage and retailing. These key actors encompass producers, collectors, wholesalers, processors, pharmaceutical companies, agents representing foreign buyers and exporters. To understand the dynamics of this system the producers and the collectors were chosen as the target

population for interview. A total of 257 respondents were interviewed. Among these, 146 individuals represented medicinal plant producers, while 111 respondents were collectors involved in this sector. These interviews aimed to capture insights from those actively engaged in medicinal plants' production and collection processes, offering a holistic view of the marketing landscape within this industry in Bangladesh.

Medicinal plant selection: Among the 109 varieties of medicinal plants available in Bangladesh, only a handful find cultivation within homestead gardens and field areas. Initial surveys have indicated that Basak (*Justicia adhatoda*), Neem (*Azadirachta indica*) Ghritokumari (*Aloe vera*), Kalomegh (*Andrographis paniculata*), Ashwagandha (*Withania somnifera*) and Tulsi (*Ocimum tenuiflorum*) stand out as commercially viable. Conversely, the remaining species either see rare cultivation or are grown in negligible quantities, insufficient for significant commercial production. Hence, for this study, the six species have been selected as samples. These species represent a focal point for examination, chosen due to their prevalence in commercial cultivation compared to the limited commercial viability of other available medicinal plant species in Bangladesh.

Questionnaire preparation: The questionnaire was carefully prepared beforehand to cover all the necessary aspects of the research topic. Questions were formulated to investigate the production, processing, labelling, pricing and quality information about the selected medicinal plants. Questions were clear, concise and ordered in a logical sequence to facilitate smooth conversation during the interview. The questionnaire provided spaces to write down about the insufficiencies and drawbacks within any phase of the medicinal plant production and marketing. It also had the option to take honest opinions from the farmers and wholesalers about the ways the system could be improved. This structured approach allows consistency in data collection, as each participant is asked the same questions in the same manner.

Field operation and data collection: To ease the data collection, lists of current farmers and collectors were collected from the Department of Agricultural Extension from each district. This helped locating and identifying them. The interview was conducted directly *via* a one-to-one setting in a private space. In the case of producers (Figure 2), it was usually near the field and for collectors (Figure 3) it was in their store mostly. This made the whole experience relaxed and secured for both parties.

Figure 2. Data collection from producers.

The researchers explained the background, purpose and the objective of the study before taking the consent from the responders. The response for each question was written carefully on the question form. Each filled-up form was checked by a second researcher on the spot to resolve any errors.

Following the collection of data, a meticulous process of scrutiny and editing was undertaken to eliminate any potential errors or inconsistencies in the recorded information.

Data analysis: In total, 257 representatives from manufacturing companies and 15 distributors participated in the survey. All respondents were chosen at random from the pool. The Statistical Package for Social Sciences (IBM SPSS Version 26) and Microsoft Excel 2019 were used for the statistical analysis. The data were sorted, then put into an Excel file, and finally imported into the SPSS program after the participants' responses were gathered based on the questionnaire. The frequencies, means, and percentages were used to represent the results.

Figure 3. Data Collection from collectors.

RESULTS AND DISCUSSION

Two levels of research were conducted for this study: the producer, who grew the plants and the collector, who gathered the plant parts and gave them to the company or occasionally stored and processed them before giving them to the companies. In this result section, we will review the producer and collector separately. The study was conducted in three districts of Bangladesh, and we will evaluate the results by district.

Demographic area

Producer. Our extensive research involved data aggregation across three strategically selected districts: Natore, Jessore and Bogra. The comprehensive data collection process yielded a substantial dataset comprising information from 146 producers. This dataset was thoughtfully distributed across the districts mentioned above, with 96 producers hailing from Natore, 43 from Jessore and 7 from Bogra. Natore emerges as a focal point, providing a dominant share of 65.8% of the total dataset. Jessore and Bogra, while representing comparatively smaller proportions, play pivotal roles by contributing 29.5% and 4.8% of the dataset, respectively (Figure 4 and Table 1). This deliberate distribution reflects an effort to ensure a balanced and representative sampling, acknowledging each district's unique characteristics and dynamics.

Collector. We yielded a robust dataset from 111 collectors distributed across the Bogura, Jessore and Natore districts during the study. Specifically, 96 collectors contributed to the dataset from Natore, 8 from Jessore and 7 from Bogra, forming a diverse and representative sample. Breaking down the contribution further, Natore stands out with an 86.5% share of the total data collected. Jessore and Bogra, while comparatively smaller in numbers, still play crucial roles, contributing 7.2% and 6.3% of the dataset, respectively (Figure 4 and Table 1). This distribution reflects a deliberate effort to ensure a balanced representation and a nuanced understanding of the diverse contexts within these districts.

Level of education

Producer. Regarding educational qualifications among the producers involved in our study, most

hold educational levels below the Secondary School Certificate (SSC). The predominant trend indicates that a substantial portion of the producers falls within this category. Furthermore, a notable segment of producers have successfully completed the SSC (Secondary School Certificate) level and some have advanced their education to the Higher Secondary Certificate (HSC) level and beyond.

Table 1. Demography, year of business establishment, way of learning of total population.

Parameter	Producer								Collector							
	Bogura		Jessore		Natore		Total	%	Bogura		Jessore		Natore		Total	%
	No.	%	No.	%	No.	%			No.	%	No.	%	No.	%		
Sample size	7	4.8	43	29.5	96	65.8	146		7	6.3	8	7.2	96	86.5	111	
Level of education																
Below SSC	4	57.00	33	76.70	84	87.50	121	82.88	2	29	6	75	48	50.00	56	50.45
SSC	0	28.60	9	2.30	8	1.00	17	11.64	1	14	1	13	25	26.00	27	24.32
HSC	1	0.00	0	0.00	1	2.10	2	1.37	0	0	0	0	3	3.10	3	2.70
Graduate	2	14.30	1	0.10	1	1.00	4	2.74	3	43	1	13	17	17.70	21	18.92
Post graduate	0	0.00	0	20.90	2	8.30	2	1.37	1	14	0	0	3	3.10	4	3.60
Year of business establishment																
1980-2000	2	28.57	4	9.30	6	6.25	12	8.22	4	57.14	5	62.50	8	8.33	17	15.32
2001-2005	0	0.00	1	2.33	17	17.71	18	12.33	0	0.00	2	25.00	13	13.54	15	13.51
2006-2010	1	14.29	8	18.60	20	20.83	29	19.86	2	28.57	0	0.00	19	19.79	21	18.92
2011-2015	2	28.57	19	44.19	32	33.33	53	36.30	1	14.29	0	0.00	34	35.42	35	31.53
2016-2020	2	28.57	9	20.93	21	21.88	32	21.92	0	0.00	1	12.50	22	22.92	23	20.72
2021-2023	0	0.00	2	4.65	0	0.00	2	1.37	0	0.00	0	0.00	0	0.00	0	0.00
Way of learning																
From father /relative	2	28.57	27	62.79	64	66.67	93	63.70	4	57.14	8	100.00	53	55.21	65	58.56
From training	0	0.00	1	2.33	2	2.08	3	2.05	0	0.00	0	0.00	14	14.58	14	12.61
Self	5	71.43	15	34.88	30	31.25	50	34.25	3	42.86	0	0.00	29	30.21	32	28.83

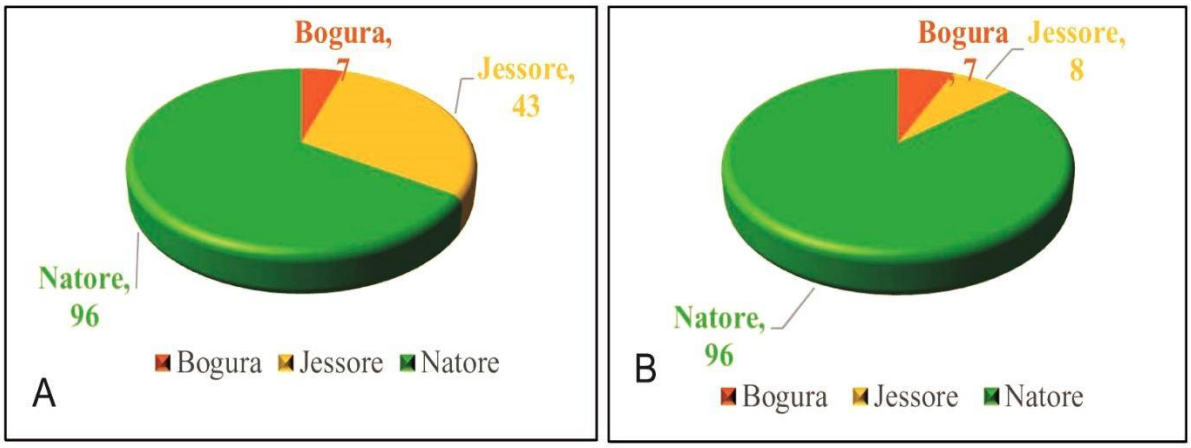

Figure 4. Area-wise distribution of producers (A) and collectors (B).

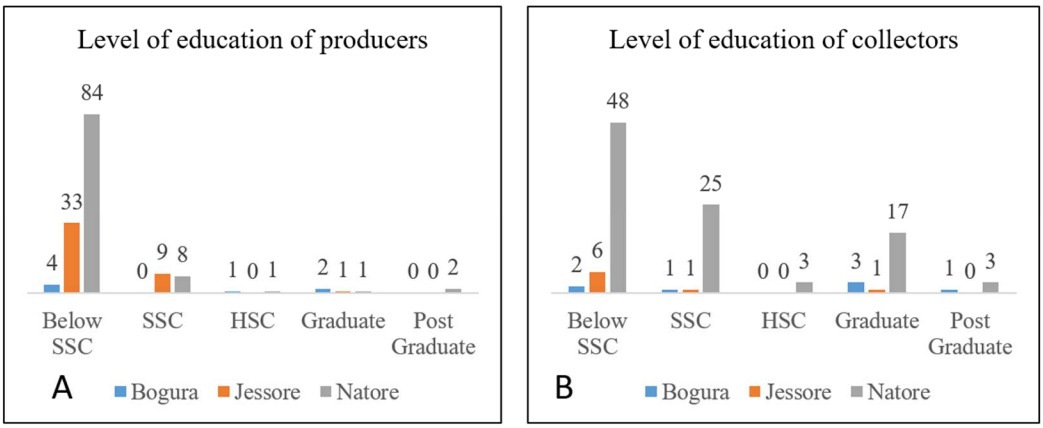

Figure 5. Level of education of producers (A) and collectors (B) in study areas.

Collector. Regarding the educational background of the collectors involved in our study, a predominant majority possess educational qualifications below the Secondary School Certificate (SSC) level. Notably, a significant portion of the collectors falls into this category. Additionally, some collectors have achieved educational qualifications such as completing SSC (Secondary School Certificate), HSC (Higher Secondary Certificate) or pursuing education beyond these levels.

Year of business establishment

Producer. Based on field observations, it was noted that the cultivation of medicinal plants emerged as a business venture between the years 1980 and 2000 in a particular region. This enterprise enjoyed little popularity among local producers during its initial stages. However, over the passing years, there was a noticeable upward trend in the interest and participation of natural crop producers in this medicinal plant cultivation. Between 2011 and 2015, the production of medicinal plants reached its peak, witnessing a substantial increase in the number of producers engaged in this endeavor. Nevertheless, the dynamics of the industry underwent a significant shift after that, leading to a gradual decline in the number of producers involved in medicinal plant cultivation. The subsequent sections will explore the factors contributing to this changing scenario. Several factors have played a pivotal role in shaping the region's current condition of medicinal plant cultivation. These factors, which will be discussed later, have contributed to the ebb and flow of interest and engagement among producers. Understanding the reasons behind this fluctuation is crucial for devising strategies to revitalize and sustain the cultivation of medicinal plants in the region.

Collector. Based on field observations, it was observed that the collection of medicinal plants emerged as a viable business venture between the years 1980 and 2000 within a specific region. Initially, this initiative did not garner widespread enthusiasm among local collectors. However, as time progressed, there was a discernible upward trend in interest and participation among natural crop producers in cultivating medicinal plants. Between 2011 and 2015, the collection of medicinal plants reached its pinnacle, experiencing a significant surge in the number of collectors engaging in this pursuit. However, the industry dynamics underwent a notable shift after that, leading to a gradual decline in the number of collectors involved in medicinal plant collection and sell. Subsequent sections will delve into the various factors contributing to this evolving scenario.

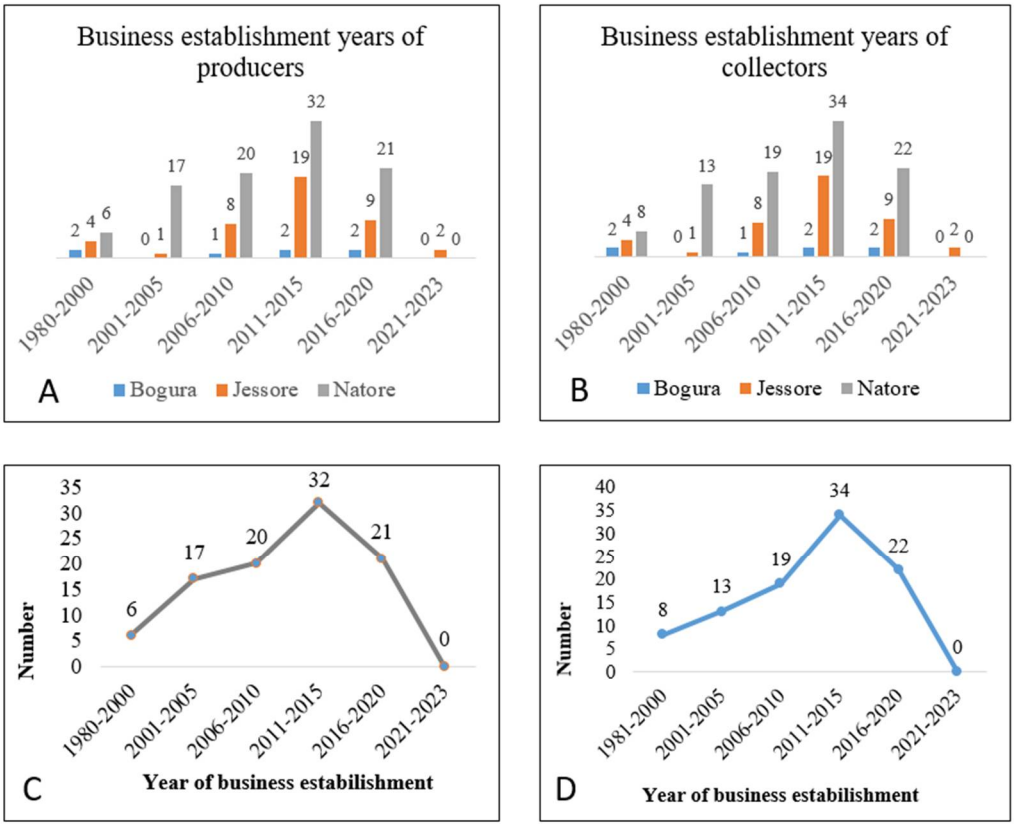

Figure 6. Different phases of business establishment of the producers (A) and collectors (B) in the study area and the trend of producers (C) and collectors (D) starting the business in Natore over the last 50 years.

Way of learning to collect/produce of the medicinal plants

Producer. During field observations, a notable trend emerged where a majority of producers (63.7%) initiated their involvement in medicinal plant cultivation by drawing inspiration from others, often observing the endeavors of peers or relatives. In certain instances, this entrepreneurial pursuit was passed down through generations, with fathers or grandfathers engaging in traditional crop cultivation and later transitioning to the production of medicinal plants. Interestingly, a subset of producers (2.1%) had received formal training in plant cultivation, equipping them with specialized knowledge in the field. Conversely, a noteworthy proportion of individuals (34.2%) embarked on their medicinal plant cultivation ventures independently, without external influence or formal training.

Collector. Among collectors, it was observed that a significant majority (58.56%) initiated their involvement in collecting medicinal plants through inspiration drawn from relatives or others. Many collectors entered the domain after observing the practices of their peers or family members engaged in similar activities. In some instances, the tradition of collecting medicinal plants was passed down through generations, with the influence of fathers or relatives who were practitioners of this trade. Notably, formal plant cultivation training was a limited resource among collectors, with only a few (12.61%) having received such specialized education. Conversely, a notable subset of collectors took an independent and self-driven approach to commence their business of collecting medicinal plants.

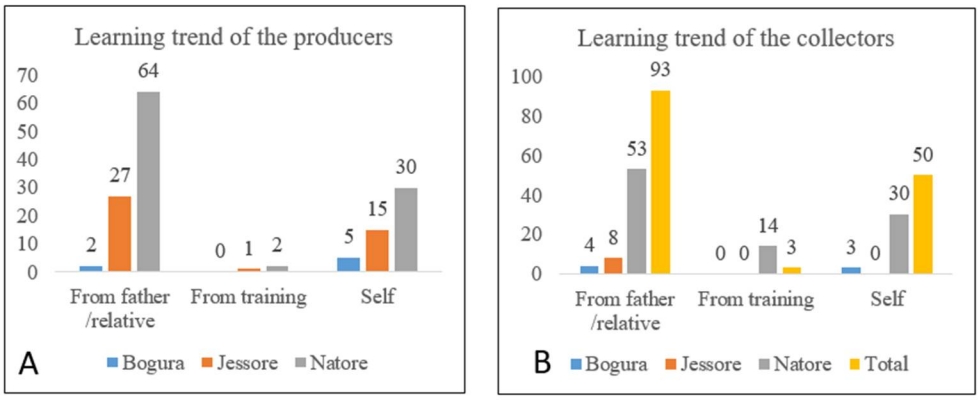

Figure 7. Way of learning of (A) the producers to produce medicinal plants and (B) the collectors to collect the plants.

Following guidelines to produce/collect and store the medicinal plants

Producer. To ensure the consistent and appropriate quality of medicinal plants and herbal substances, following Good Agricultural and Collection Practices (GACP) to cultivate herbal starting materials is imperative. Good Manufacturing Practice (GMP) principles applicable to the manufacturing, processing, packaging and storage of active pharmaceutical ingredients (APIs) extend to medicinal plants and herbal substances. In the context of herbal preparations, the production and initial processing of medicinal plants and herbal substances directly impact the quality of the API. Given the inherent complexity of naturally grown medicinal plants and herbal substances, coupled with limited analytical techniques for characterizing constituents solely through chemical or biological means, maintaining reproducible quality in herbal starting materials necessitates a robust quality assurance system for their collection, cultivation, harvest, and primary processing. The collection of medicinal plants in wild habitats presents unique challenges, including the potential for confusion with similar plants, environmental damage, lack of control and inadequately qualified personnel. While the following guideline on Good Agricultural and Collection Practice may not align directly with traditional GMP guidelines, it serves as a foundational framework for establishing an appropriate quality assurance system to address these specific considerations. But in field observation it was seen that maximum producer (97.2%) are not following any guideline (Figure 8 and Table 1).

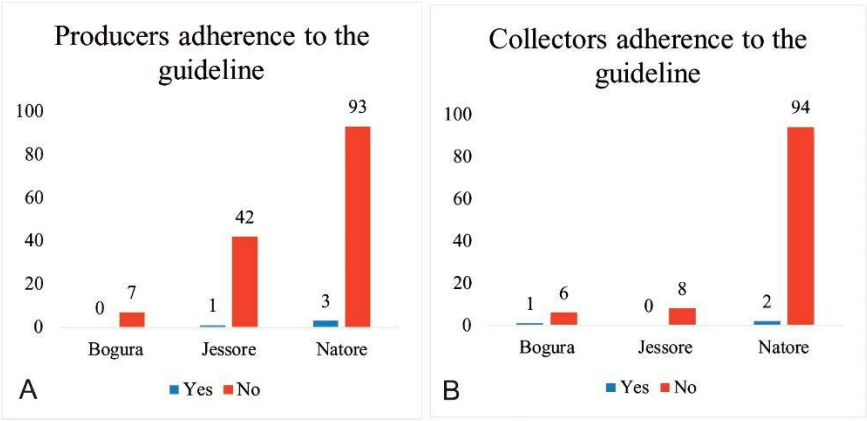

Figure 8. (A) Producers' adherence to the guidelines for producing and storing medicinal plants. (B) Collectors' adherence to the guidelines to collect and store medicinal plants.

Collector. A notable pattern emerged from the collectors' dataset, indicating that a majority of individuals engaged in the collection of medicinal plants often initiated their activities without adhering to any specific guidelines. In this context, it was observed that only a limited proportion of collectors followed established guidelines, with the majority operating without formal guidance (Figure 8 and Table 2). Unlike some industries where adherence to guidelines is more prevalent, the collection of medicinal plants appears to be characterized by a significant degree of independence and a lack of standardized practices. Many collectors rely on personal experience, tradition or knowledge passed down through familial or community networks rather than formal guidelines. This observation emphasizes the need for a closer examination of the existing practices and the potential implications for the sustainability and quality of medicinal plant collection. The exploration of why limited adherence to guidelines among collectors will be crucial in formulating strategies to enhance practices, ensure sustainable harvesting, and maintain the quality of locally grown medicinal herbs.

Record keeping

Producer. Effective record-keeping plays an essential role in ensuring quality control of herbal plant products. However, a noteworthy observation from our study is that a majority of producers (99.3%) need to maintain comprehensive records pertaining to crucial aspects of plant cultivation and processing (Figure 9 and Table 2). . Specifically, many producers need to document essential information such as the date when the plant started to grow, the timing of harvesting for sale, and guidelines on the optimal storage duration. This absence of systematic record-keeping poses challenges in maintaining traceability, understanding growth patterns, and implementing quality control measures throughout the herbal plant product lifecycle. The lack of documented timelines and storage guidelines may lead to variability in product quality, potentially impacting the efficacy and safety of the herbal products in the market. Recognizing the significance of record-keeping in ensuring the quality and consistency of herbal plant products, it becomes imperative to address this gap. Encouraging and facilitating producers to adopt robust record-keeping practices can contribute significantly to the enhancement of product quality, market competitiveness and consumer trust in locally grown medicinal herbs.

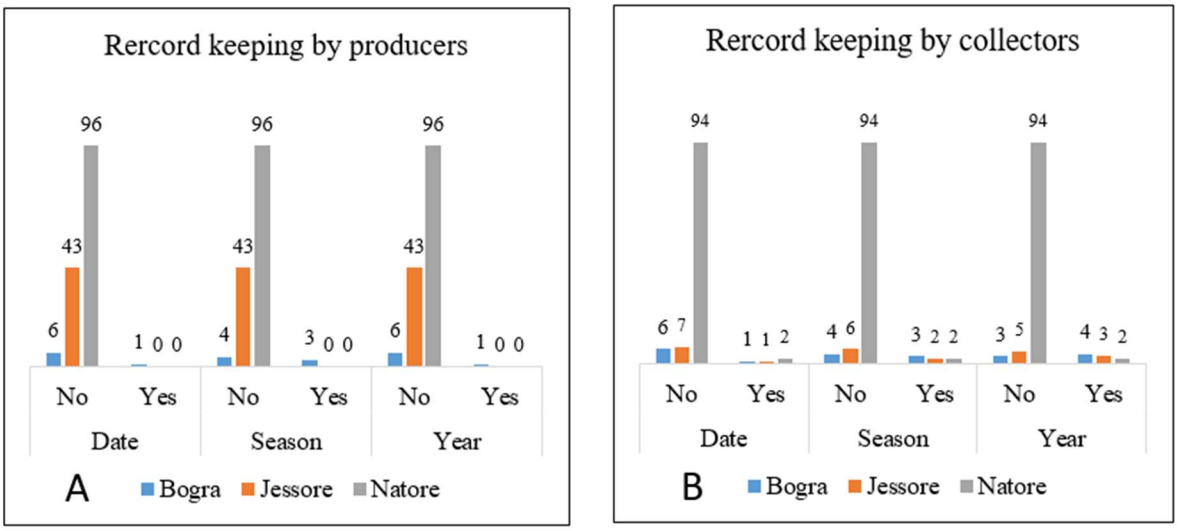

Figure 9. Practice of record keeping by producers (A) and collectors (B).

Collector. A parallel observation was made concerning collectors engaged in the process of plant collection, storage and subsequent sale. Similar to the scenario with producers, it was noted that a significant portion of collectors (96.39%) needs to maintain comprehensive records of the entire process (Figure 9 and Table 2). Specifically, there needs to be more documentation regarding the timing of plant collection, storage practices and details concerning when the plants are put up for sale. There needs to be more systematic record-keeping among collectors to maintain transparency, understanding the lifecycle of the collected plants and implementing quality control measures. The oversight in documenting crucial information about the collected plants may lead to uncertainties in product quality and storage conditions, potentially affecting the overall efficacy and safety of the herbal products being brought to market. Addressing this gap in record-keeping practices among collectors is vital for ensuring the traceability and quality of locally grown medicinal herbs. Encouraging and supporting collectors to adopt thorough record-keeping processes can contribute significantly to the overall quality assurance of herbal products, fostering consumer confidence and sustaining the long-term viability of the herbal industry.

Packaging and labeling

Producer. An essential aspect of ensuring product quality in the herbal industry is proper packaging and accurate labeling. However, a notable observation from our study indicates that many producers (99.39%) are not consistently adhering to these essential practices (Figure 10 and Table 2). Specifically, there needs to be more meticulous attention to proper packaging methods and the inclusion of comprehensive labeling information. The inadequacy in following proper packaging and labeling protocols could compromise the integrity of herbal products. Consumers rely on accurate labeling to make informed decisions about the products they purchase, and proper packaging is crucial for maintaining the freshness and efficacy of the herbs. Recognizing the importance of these factors in safeguarding product quality, it is imperative to address the current lapse in adherence. Encouraging and educating producers on the significance of proper packaging and labeling practices can significantly contribute to enhancing the overall quality assurance of herbal products. By doing so, the industry can not only meet regulatory standards but also build trust among consumers, ensuring the sustained success of locally grown medicinal herbs in the market.

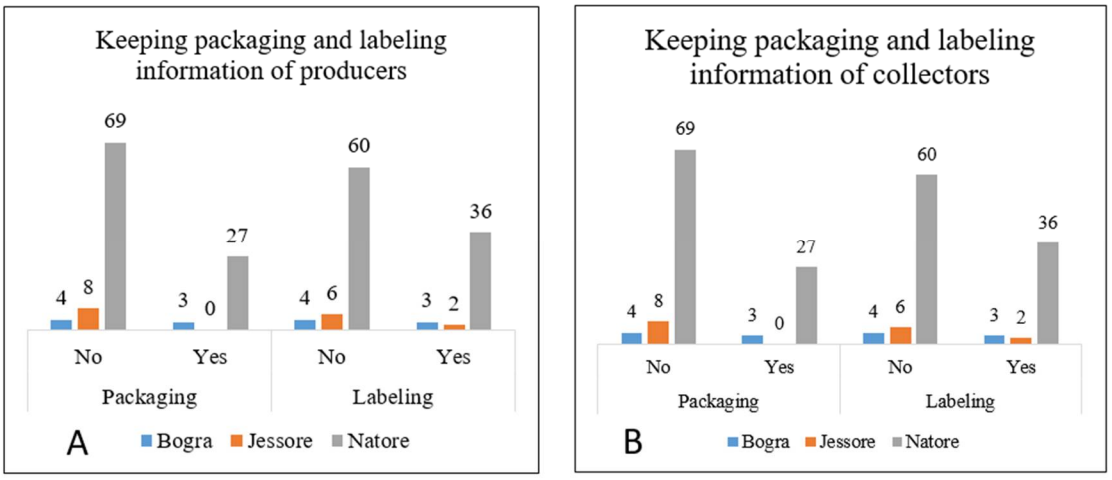

Figure 10. Practice of packaging and labeling information by producers (A) and collectors (B).

Table 2. Trends of practicing the guideline, recordkeeping, packaging and labeling.

Parameter	Producer					Collector				
	Bogura	Jessore	Natore	Total	Percentage	Bogura	Jessore	Natore	Total	Percentage
Guideline follow										
Yes	0	1	3	4	2.74%	1	0	2	3	2.70%
No	7	42	93	142	97.26%	6	8	94	108	97.30%
Record keeping										
Date										
Yes	1	0	0	1	0.68%	1	1	2	4	3.60%
No	6	43	96	145	99.32%	6	7	94	107	96.40%
Month										
Yes	3	0	0	3	2.05%	3	2	2	7	6.31%
No	4	43	96	143	97.95%	4	6	94	104	93.69%
Year										
Yes	1	0	0	1	0.68%	4	3	2	9	8.11%
No	6	43	96	145	99.32%	3	5	94	102	91.89%
Packaging										
Yes	1	0	0	1	0.68%	3	0	36	39	35.14%
No	6	43	96	145	99.32%	4	8	60	72	64.86%
Labeling										
Yes	4	0	1	5	3.42%	3	2	27	32	28.83%
No	3	43	95	141	96.58%	4	6	69	79	71.17%

Collector. A parallel concern was identified with collectors involved in the collection, storage and sale of plants. Similar to the scenario observed among producers, there is a noticeable lapse in adhering to proper packaging and labeling practices among collectors (63.06%) (Figure 10 and Table 2). The meticulous attention required for proper packaging and the inclusion of comprehensive labeling information is often lacking in the collection and distribution process. This oversight in adhering to packaging and labeling standards can have implications for the overall quality and safety of herbal products reaching the market. Consumers rely on accurate information and appropriate packaging to make informed decisions about the products they purchase, emphasizing the need for a consistent and standardized approach. Addressing this challenge requires a concerted effort to educate and guide collectors on the significance of proper packaging and labeling practices. By fostering awareness and emphasizing the importance of these standards, the herbal industry can enhance the overall quality assurance of its products, instilling confidence in consumers and promoting the sustained success of locally grown medicinal herbs in the market.

Bangladesh boasts a wealth of medicinal plants, and extensive studies have consistently highlighted the prevalence of herbal treasures, particularly in the northern regions such as Natore and Bogra. The northern part of Bangladesh, with its diverse ecosystems, serves as a rich repository of medicinal flora. These plants play a vital role in traditional medicine and have garnered increasing attention for their potential therapeutic benefits.[19] So, both the producer and collector segments of our study, data were collected from three strategically selected districts: Natore, Jessore, and Bogra. However, there were notable differences in the distribution of participants across these districts. Natore emerged as a dominant focal point in both segments. Both producers and collectors displayed a similar trend in terms of educational qualifications, with a significant majority (82.87% for producers and 48.65% for collectors) holding qualifications below the

Secondary School Certificate (SSC) level. However, there were also notable proportions of participants who had achieved SSC level or higher educational qualifications. This indicates a diverse educational background among participants in both segments, with a range of educational attainment levels observed. In both segments, a majority of participants initiated their involvement in medicinal plant cultivation or collection through inspiration from fathers or relatives (63.7% for producers and 58.56% for collectors). However, there were also subsets of participants (2.1% for producers and 12.61% for collectors) who had received formal training in plant cultivation or collection. Additionally, a notable proportion (34.2% for producers and 28.83% for collectors) embarked on these ventures independently, without external influence or formal training. This diversity in initiation methods suggests varied pathways into medicinal plant cultivation or collection, influenced by familial traditions personal interests and formal education.

Based on field observations, it was noted that the cultivation of medicinal plants emerged as a business venture between the years 1980 and 2000 in a particular region. During its initial stages, this enterprise did not enjoy widespread popularity among local producers. The joint research initiative conducted by the South Asia Enterprise Development Facility (SEDF) and Interco-operation in Bangladesh, dated 2003, centers on evaluating the market potential of medicinal plants.[28] The study takes a comprehensive approach, estimating the value of the formal herbal sector at various stages, spanning from raw material to retail. The research scrutinizes the 30 most pivotal herbal products, estimating their volume and value, understanding primary sources and addressing quality concerns. Furthermore, the study identifies herbal products with the potential for increased production in Bangladesh. By pinpointing needs, constraints and opportunities within the sector, the research aims to propose interventions for SEDF, addressing actual challenges faced by small farmers and intermediaries. The study also suggests modernization strategies, including technology, techniques and market linkages, with the overarching goal of enhancing the medicinal plant sector and contributing to the improvement of rural incomes. After these initiatives the farmers got interest in herbal plant production. The period between 2011 and 2015 marked a significant surge in interest and participation among natural crop producers in medicinal plant cultivation, resulting in a peak in production levels. However, a subsequent shift in industry dynamics led to a gradual decline in producer engagement. Several factors have contributed to this changing landscape. Among them, the lack of unity among farmers, challenges in timely sales, instances of nepotism and exploitation by intermediaries and inadequate support from authorities have played pivotal roles. Additionally, factors such as increased labor costs, shortages of daily laborers during peak seasons and the absence of facilities for raw material preservation have further compounded the challenges faced by producers. These factors collectively underscore the complex and multifaceted nature of the issues impacting medicinal plant cultivation in the region, which will be explored in detail in the following sections.

Both producers and collectors displayed a lack of adherence to established guidelines, with a majority (97.26% for producers and 97.29% for collectors) operating without formal guidance. While some participants followed established guidelines, this was observed to be a limited practice in both segments. This highlights a common challenge in the herbal industry regarding the lack of standardized practices and the reliance on personal experience or tradition rather than formal guidelines. Both producers and collectors exhibited deficiencies in record-keeping practices, with many participants (>99% for producers and >91% for collectors) failing to maintain comprehensive records of crucial aspects such as plant cultivation, collection and storage. This absence of systematic record-keeping poses challenges in ensuring traceability, understanding growth patterns and implementing quality control measures in both segments. Both producers and collectors showed a lack of consistent adherence to proper packaging and labeling practices. Many participants did not pay meticulous attention to

packaging methods (99.32% for producers and 63.06% for collectors) or include comprehensive labeling information (96.57% for producers and 72.97% for collectors). This oversight can compromise the integrity, safety and marketability of herbal products in both segments, emphasizing the need for improved compliance with packaging and labeling standards.

A study carried out in the northern part of Bangladesh by Palash, M.S. *et al.* (2021) outlines similar findings to those made in our research. It emphasizes the consequences of differences in the quality of medicinal plants, which show themselves at different price points throughout a certain season. As our own investigation revealed, this diversity leads to variations in market prices and quality standards. It appears that a common issue in the research area is the lack of established guideline for providers of plant products to follow when it comes to production, collection and storage. Moreover, collectors do not follow any grading or standardization protocols during critical phases that include storage, packing and sales. The storage duration for various types of plant products exhibits considerable variability, spanning from a minimum of one month to a maximum of eight months. Commonly employed storage containers include spot-free plastic bags, polythene bags, jute bags, plastic boxes/trays, plastic drams and plastic pots. Notably, there exists a notable absence of standardized protocols governing storage, with prevailing practices being predominantly rooted in traditional procedure. The selection of storage methods is contingent upon individual preferences, perceived utility and cost-effectiveness considerations, rather than adherence to established guidelines.[19]

Another research conducted by Rashid *et al.* (2014) sheds light on issues resonating with our own findings, particularly concerning the challenges faced by producers and collectors engaged in medicinal plant cultivation. Through a comprehensive investigation, the study delved into multiple dimensions, encompassing the perceptions and experiences of farmers, the landscape of existing research and policy-making endeavors within the medicinal plant sector and the identification of various constraining factors hindering the efficiency and sustainability of plant production. One prominent challenge highlighted in their research is the deficiency in processing technology, notably in areas such as grinding, which inhibits the ability to effectively process and utilize medicinal plant materials. Furthermore, the study illuminates the pervasive inadequacies in transportation infrastructure, which pose logistical hurdles and impede the timely and efficient movement of plant materials from production sites to markets or processing facilities. Financial support emerged as another critical constraint elucidated in the study, with a notable absence of adequate governmental assistance hindering the investment and development of medicinal plant cultivation ventures. Moreover, the insufficient storage infrastructure exacerbates post-harvest losses and compromises the quality of medicinal plant products, thus impacting both economic viability and consumer satisfaction. The study also underscores the influence of local networking dynamics, which can either facilitate or impede the flow of information, resources, and market access for producers and collectors.[29]

In summary, while there were variations in specific aspects between producers and collectors, such as geographic distribution and initiation methods, there were also notable similarities in challenges faced, such as educational qualifications, adherence to guidelines, record-keeping practices, and packaging and labeling compliance. While educational qualifications below the Secondary School Certificate (SSC) level were prevalent among participants, diverse initiation methods were observed, influenced by familial traditions, personal interests and formal training. These findings underscore the importance of addressing common challenges and implementing standardized practices across both producer and collector segments to enhance the overall quality assurance of herbal products in the market.

Identification of problems

At present, about 70% of the world populations rely on traditional medicine for their primary healthcare needs, according to WHO estimation.[2] Even in the developed countries, complementary or alternative medicine (CAM) is gaining more popularity and is being developed. Despite having many limitations and challenges, including inadequate infrastructure, lack of knowledge and technological support, lack of incentives and absence of marketing facilities some traditional farmers are producing the herbs and some collectors are collecting the herbs for business purpose. According to the field survey conducted by our research team major challenges behind the decreasing trend in the farming and collecting are found as the followings:

A. Low educational levels of producers and collectors:

(i) Lack of awareness: Many producers and collectors have educational qualifications below SSC, which limits their awareness and understanding of the importance of quality control and documentation.

(ii) Difficulty in adopting guidelines: The complexity of existing guidelines and standards may be challenging for those with limited formal education to comprehend and implement.

B. Absence of formal training:

(i) Lack of training programs: There are few, if any, formal training programs available to educate producers and collectors on best practices in cultivation, harvesting, documentation and quality control.

(ii) Inadequate resources: Producers and collectors may lack access to the resources necessary for proper training, such as educational materials, field experts and workshops.

C. Inconsistent documentation practices:

(i) No standardized procedures: There is a lack of standardized procedures for record keeping, labeling and packaging, leading to inconsistent documentation practices across the industry.

(ii) Time and effort constraints: Producers and collectors may perceive documentation as time-consuming and not immediately beneficial, leading to its neglect.

D. Lack of regulatory oversight:

(i) Weak enforcement of standards: The absence of strong regulatory oversight means that adherence to guidelines and standards is often voluntary and inconsistently enforced.

(ii) Limited government support: There is insufficient government intervention in providing the necessary infrastructure, training and incentives to ensure compliance with international standards.

E. Economic pressures:

(i) Focus on quantity over quality: Economic pressures and the need for immediate income may push producers and collectors to prioritize quantity over quality, leading to shortcuts in documentation and quality control.

(ii) Inadequate financial incentives: Without financial incentives or access to premium markets for higher-quality products, there is little motivation to invest in proper documentation and quality practices.

F. Poor infrastructure:

(i) Lack of access to technology: Limited access to technology and digital tools hinders the ability to maintain proper records and traceability of medicinal herbs.

(ii) Inadequate facilities: The absence of adequate facilities for proper storage, packaging and labeling contributes to quality degradation and non-compliance with export standards.

G. Cultural and traditional practices:

(i) Reliance on traditional methods: Many producers and collectors rely on traditional cultivation and processing methods, which may not align with modern quality standards and documentation requirements.

(ii) Resistance to change: People may resist adopting new practices and technologies, especially when

they conflict with long-standing cultural traditions.

These problems collectively contribute to the challenges faced by the medicinal herb industry in Bangladesh, particularly regarding quality control, documentation and export readiness. Addressing these issues is crucial for improving the industry's global competitiveness.

Recommendation to improve the situations

The export policy from 2015 to 2018 actively encourages stakeholders to engage in producing and exporting herbal products and medicinal plants in Bangladesh. To facilitate the development of this sector, the Herbal Product Development Council, established under the Ministry of Commerce, plays a pivotal role in orchestrating necessary steps. Operating as a public-private partnership, the "Medicinal Plant & Herbal Product Sector of Business Promotion Council" focuses on boosting export activities and overall business promotion within the sector. The recommendations derived from the field survey conducted by the research team offer a comprehensive strategy to address the challenges faced by producers and collectors in the herbal and medicinal plant industry:

1. *Implementation of training programs:*

Educational workshops: Organize regular workshops and training sessions for producers and collectors to educate them on Good Agricultural and Collection Practices (GACP), focusing on quality control, record keeping and proper documentation.

Field demonstrations: Conduct hands-on field demonstrations to show best practices in cultivation, harvesting and post-harvest processing of medicinal herbs.

2. *Development of user-friendly guidelines:*

Simplified manuals: Create easy-to-understand manuals and guidelines in local languages that outline the essential steps for proper cultivation, collection, documentation and packaging.

Visual aids: Use visual aids like posters and videos to demonstrate key practices, making the information accessible to those with limited literacy.

3. *Enhancement of documentation practices:*

Standardized record-keeping templates: Introduce standardized templates for record keeping producers and collectors can easily fill out, covering aspects like planting dates, harvesting methods and quantities.

Labeling and packaging protocols: Establish clear protocols for accurate labeling and packaging to ensure that products meet export standards.

4. *Certification and incentive programs:*

Certification schemes: Develop a certification program for producers and collectors who adhere to recommended practices, offering them recognition and potential access to premium markets.

Incentives for compliance: Introduce financial or material incentives for those who consistently follow the guidelines and produce high-quality, well-documented medicinal herbs.

5. *Strengthening collaboration with industry stakeholders:*

Partnerships with NGOs and government agencies: Collaborate with non-governmental organizations and government agencies to provide resources, training and support to producers and collectors.

Industry-led initiatives: Encourage larger herbal product manufacturers to sponsor training programs and offer technical assistance to small-scale producers and collectors.

6. *Monitoring and evaluation:*

Regular audits: Conduct regular audits of the practices of producers and collectors to ensure compliance with guidelines and identify areas for improvement.

Feedback mechanism: Establish a feedback mechanism where producers and collectors can report challenges they face in implementing the new practices, allowing for continuous improvement of the guidelines.

7. Utilization of technology:

Mobile applications: Develop simple mobile applications that can assist producers and collectors in maintaining records, accessing guidelines and receiving real-time advice.

Digital traceability systems: Implement digital traceability systems to track the origin, quality and handling of medicinal herbs throughout the supply chain.

These recommendations provide a roadmap for addressing various challenges and seizing opportunities within the herbal and medicinal plant sector in Bangladesh. The multifaceted approach encompasses cultivation practices, financial considerations, market strategies, quality control and long-term planning to ensure the holistic development of the industry.

CONCLUSION

The export of high-quality herbal plants from Bangladesh holds immense importance, offering economic, cultural and environmental benefits. In the global market, there is a rising demand for natural remedies, aligning with Bangladesh's rich tradition of herbal medicine. By exporting quality herbal plants, the country can contribute to the growing global health and wellness trends, showcasing its cultural heritage and traditional knowledge. It also holds the potential to generate foreign exchange earnings and create employment opportunities, particularly in rural areas where many herbal plants are cultivated. The findings underscore the immense potential for exporting locally grown, high-quality herbs as evidence-based medicine from Bangladesh. The study reveals the significance of strategic cultivation practices, adherence to quality standards and the establishment of evidence-based credentials for medicinal herbs to tap into the international market. While the research identifies the substantial export potential, it also sheds light on the need for targeted interventions, including educational programs for producers, adherence to international quality standards and streamlined export procedures. Recognizing the potential economic and health benefits, the study sets the stage for informed policymaking and industry development initiatives that can position Bangladesh as a key player in the global herbal medicine market.

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AUTHOR CONTRIBUTION

Conceptualization, Dr. Sitesh Chandra Bachar (S.C.B.), Dr. Md. Aslam Hossain (M.A.H.); methodology, S.C.B., M.A.H.; Development of questionnaire, S.C.B., M.A.H.; Conduction of survey, Rajib Das (R.D.), Ahmad Niaz Rahman (A.N.R.); Statistical Analysis, R.D., A.N.R.; Data curation, S.C.B., M.A.H.; writing—original draft preparation, R.D., A.N.R.; writing—review and editing, S.C.B., M.A.H.; visualization, R.D., A.N.R.; supervision, S.C.B., M.A.H.; project administration, S.C.B., M.A.H.; funding acquisition, S.C.B. All authors have read and agreed to the submission of this version of the report.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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