POLICY PAPER 132

Strategies and Policies for Enhancing the Global Footprint of Indian Spices

NATIONAL ACADEMY OF AGRICULTURAL SCIENCES, NEW DELHI
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Preface

Indian spices have long been at the heart of global trade, offering unique flavours, aromas, and health benefits that are integral to cuisines and cultures around the world. With a rich heritage and diverse production, India stands as the world leader in the cultivation and export of spices. However, in an increasingly competitive global market, it is essential to not only preserve this tradition but also to enhance the global footprint of Indian spices.

Currently, our spice production stands at 11.8 million tonnes (Mt), harvested from 4.76 million hectares (Mha). In comparison, the 2013-14 spice output was 5.8 Mt from 3.2 Mha showing that the two-fold increase in spice production has been primarily driven by higher yields. In the fiscal year 2023-24, the export of spices and spice products is estimated at 1.5 Mt, valued at ₹ 36.9 thousand crores (4.46 billion US$) and these are projected to reach 206 thousand crores (25 billion US$) by 2047.

This Policy Paper, “Strategies and Policies for Enhancing the Global Footprint of Indian Spices,” aims to present a comprehensive approach for the sustainable growth and global expansion of India’s spice industry. By examining existing challenges and opportunities, it seeks to outline strategic initiatives, policy interventions, and innovative solutions that can elevate Indian spices to greater international prominence.

The focus is on ensuring that India’s spices remain competitive, sustainable, and relevant in global markets, while preserving their unique identity. Emphasis should be placed on basic, applied, and trans-disciplinary research that empowers growers to adopt disruptive technologies and innovative practices, reducing production costs and enhancing growth, profitability, and sustainability. India needs to be at the forefront of the latest and most innovative technologies to maintain its dominant role in the spice industry. Additionally, the vast chemical potential of minor spices remains largely unexplored for novel applications. During spice production and processing, risk management programs such as Good Agricultural Practices (GAP), Sustainable Agricultural Practices (SAP), Biodiversity-Friendly Agricultural Practices (BAP), and Best Harvest & Post-Harvest Practices (BHP) are essential for minimizing contamination risks and reducing microbial load, agrochemical residues, and foreign matter. Developing critical insights to enhance the efficiency of spice value systems across the production economy is another key focus, aimed at increasing income for primary producers while safeguarding the interests of other stakeholders along the value chain.

Against this background, the brainstorming session organized by the National Academy of Agricultural Sciences (NAAS), with Dr. D. Prasath as the Convener, is indeed very timely. I am pleased to note that most of the research organizations, developmental

agencies and industries involved in the spice sector participated in this session. I would like to extend my thanks to the Convener (Dr. D. Prasath), Co-conveners (Dr. Lijo Thomas and Dr. Sudhakar Pandey) and the participants for their valuable inputs. My sincere appreciations are due to the Reviewers, Dr. V. A. Parthasarathy & Dr. Nirmal Babu and the Editors, Dr. V. K. Baranwal & Dr. R. K. Jain for bringing out this policy document. I hope this document serves as a guide for policymakers, industry stakeholders, and agricultural leaders to collaborate in strengthening India's position as the world's spice hub.

March 2025
New Delhi

(Himanshu Pathak)
President, NAAS

Strategies and Policies for Enhancing the Global Footprint of Indian Spices

1. INTRODUCTION

India produced 11.8 million tonnes (Mt) of spices from an area of 4.76 million hectares (Mha) during 2023–2024 and accounts for 40% of global spice production (Spices Board, 2024). The global spice market is expected to grow at a CGAR of 5.2% from 2021 to 2026 and is projected to reach Rs. 226 thousand crores (27.4 billion US$) by 2026 (MarketsandMarkets, 2024). India plays a major role in spices export trade globally. In 2023-24, India exported 1.54 Mt of spice worth Rs. 36.9 thousand crores (4.46 billion US$). The major exported spices are chillies, cumin, coriander,turmeric and ginger which account for over 75% of exports (Fig. 1). As of 2023-24, India exported spices to more than 180 destinations, with China, the USA, Bangladesh, the UAE, Thailand, Malaysia, Indonesia, the UK and Sri Lanka accounting for over 70% of the total export earnings (Spices Board, 2024).The Spices Board is targeting an export realization of 206 thousand crores (US$ 25 billion US$) from annual export

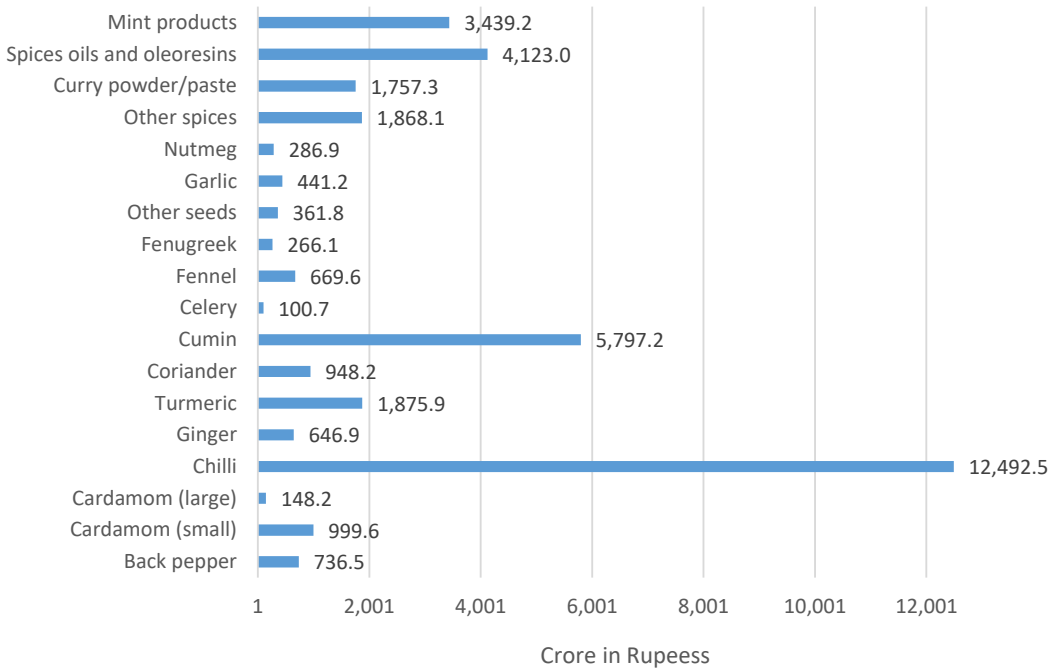

Fig. 1. Export value of spice crops from India during the fiscal year 2023-2024, highlighting the total value of spice exports across various categories (Source: Spices Board India,Government of India 2024).

Spices: History, Commerce and Global Value Chains

India has earned the sobriquet, 'The land of spices' by virtue of its historical dominance in spice production and trade. Spices form an important constituent of the agri export basket of the country. They are one of the most traded agricultural commodities across the globe. The non-perishable nature, global demand and geographical concentration in production has led to the establishment of intricate global value chains in spices. India can leverage its unique position in the global spice economy to translate efficiency gains in production and processing to positive and sustainable changes in the livelihoods of millions of spice primary producers in the country. In this context, concerted efforts are required for designing an effective roadmap for achieving the targets set for the spices sector.

of spices and spice-based products by 2047. In his address during the 14th World Spice Congress in 2023, The Union Minister for Commerce and Industry, Sri. Piyush Goyal, has set a target of 87.3 thousand crores (10 billion US$) from spice exports by 2030. The spice crops have a high degree of export orientation when compared to other horticultural crops like fruits, vegetables etc (Fig. 2).

Being the world's largest spice producer and exporter, the global spice market is highly responsive to changes in Indian production and export strategies. The spices sector in India faces several technical, technological, institutional and policy challenges in emerging as an efficient and market responsive sector capable of meeting the aspirations of a multitude of stakeholders including consumers, primary

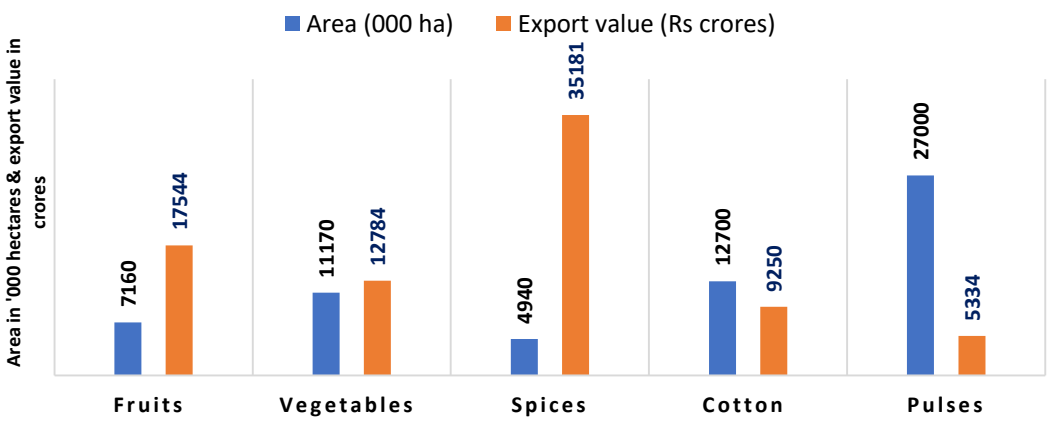

Fig. 2. Export orientation of spice crops compared to other major horticultural crops, cotton and pulses (Source: Ministry of Commerce & Industry, Government of India, 2024)

producers, processors and exporters (Ravindran *et al.*, 2024). The spice market is characterized by evolving consumer preferences, technological advancements and regulatory challenges. Additionally, geopolitical factors and trade policies, such as tariffs and non-tariff barriers, affect market access and competitiveness. According to the current trends, the spice market is likely to see demand for value-added products such as blended spices, spice extracts, essential oils and oleoresins. The markets for premium, certified products including organic spices have also shown steady growth during the last decade. Diversifying into these segments can help Indian producers reduce their dependency on raw spice exports and tap into high-value markets.

India's population is projected to reach 1.619 billion by 2050, accompanied by rising GDP and higher per capita food expenditures (Alexandratos and Bruinsma, 2012). As a result, per capita demand for spices is anticipated to grow significantly. Globally, the spices and seasoning market is expected to expand due to the growing popularity of oriental and ethnic cuisines, the rise of vegan and vegetarian lifestyles, increased investment in digitalizing the spice supply chain, and the heightened demand for immunity-boosting products. To adapt to the projected trends in the spices sector, Indian spice stakeholder community must focus on identifying critical drivers of sustainable growth and ensuring an enabling policy environment for implementation of key elements of strategic interventions.

2. GLOBAL TRENDS AND CONSUMPTION PATTERNS

The spice sector has witnessed several transformative trends in recent years, driven by evolving consumer preferences, technological advancements, and a growing emphasis on sustainability and quality. Value addition has been gaining prominence, with producers investing in advanced processing techniques, products and packaging solutions to enhance the quality and shelf life of spices. Ready-to-use spice mixes, spice-infused oils, and other innovative products in this category offer greater convenience to consumers and open new market segments.

Specialty spices with unique quality attributes, such as specific geographical indications, heirloom varieties, and rare spices, are increasingly sought after. Consumers are willing to pay a premium for these high-quality products, which often claim superior flavor profiles and intrinsic quality and are associated with specific cultural or regional identities. Organic spice production is another growing trend, reflecting the broader movement towards organic and sustainable agriculture. Projections for 2050 estimate per capita demands for black pepper, cardamom, ginger, and turmeric at 148 g, 53 g, 1.22 kg, and 1.63 kg, respectively (ICAR-IISR, 2013). The ICAR-National Research Centre on Seed Spices (NRCSS) has also targeted substantial productivity gains by 2050 across major seed spices like cumin (2.6 q), fennel (7.1 q), fenugreek (6.1 q) and coriander (2.7 q). To meet these future demands, significant improvements in productivity are essential, as current levels are below the optimal threshold (ICAR-NRCSS, 2011).

This would also imply that the domestic market will remain a major driver of growth of the spice economy.

Food safety aspects are receiving heightened attention, with stricter regulations and standards being implemented globally. Producers are adopting better practices in cultivation, harvesting, and processing to minimize contamination risks and ensure the safety of their products. This includes measures to prevent adulteration, control microbial contamination, and reduce pesticide residues. Increased global consumer awareness is driving these trends, as more consumers seek out high-quality, safe, and ethically produced spices. Access to information through digital platforms and social media has made consumers more knowledgeable about the health benefits, sourcing practices, and environmental impact of the spices they purchase. This awareness is influencing purchasing decisions and encouraging the spice industry to adopt more transparent and sustainable practices. Overall, these trends indicate a dynamic and evolving spice sector that is increasingly aligned with the demands for quality, safety, and sustainability (Sharangi and Pandit, 2018).

3. SELF-SUFFICIENCY IN SPICES

Spice crops from a distinct sector within agriculture. They yield high value low volume commodities with significant export orientation. Presently, India commands approximately 20% of the global market share in spice trade. With the domestic demand for spices rising continually, more than 85% of the spices produced in India are consumed within the country.

Area under spice cultivation expanded by 10.2%, increasing from while the spice output increased by 14.0%, indicating a rise in productivity of the crops. The increase in output and the availability of domestic surplus supported the growing export demand for the crops. The export quantity of spices rose by 52.6%, during the last five years. This data underscores the robust expansion and increasing global demand for Indian spices over the period. However, India continues to import considerable quantity of spices. In value terms, it is about one third of the total value of spice exports (Table 1). The major import sources and the potential areas for expanding domestic production of these spices are listed in Table 2.

It is important to take a closer look at the import profile to design strategies aimed at enhancing self-sufficiency in spices and to sever the dependence on imports. A few salient features of the spice import of the country needs to be noted. Clove is one of the major constituents of imports in value terms (11.2%, worth Rs. 1352 crores). Even though India is known as a traditional grower of black pepper, the country has become a major importer of black pepper in the recent years (11.3% of spice imports in value terms, worth Rs. 1360 crores). A confluence of several factors like yield stagnation in the crop, limited geographic spread, increased domestic demand from households and industry, robust re-export opportunities etc. have led to the increase in imports of the commodity (Thomas *et al*., 2021). The tree spices together (clove, cinnamon,

Table 1. Import and export value of spices

Spices	Export value (Rs crores)	Import value (Rs crores)
Black pepper	737	1360
Clove	100	1352
Asafoetida	90	1240
Cardamom	1148	665
Cinnamon/Cassia	102	863
Nutmeg/Mace	287	326
Star Anise	Negligible	439
Cumin	5797	792
Coriander	948	157
Ginger	647	276
Turmeric	1876	150
Mint and Mint Products	3439	1156
Spice Oils/Oleoresins	4123	1182
Total	**36959**	**12015**

Source: Ministry of Commerce & Industry, Government of India (2024)

Table 2. Major import sources and the potential areas for expanding domestic production of spices in India

Spices	Major import sources	Potential areas of expansion
Black pepper	Brazil, Indonesia, Sri Lanka, Vietnam	Assam, Meghalaya, Nagaland, Odisha, Andhra Pradesh, Chhattisgarh
Clove	Indonesia, Madagascar, Tanzania, Sri Lanka	Andaman, Selected areas of Eastern Ghats, Maharashtra, Karnataka
Asafoetida	Afghanistan, Uzbekistan, Iran	Himachal Pradesh, Ladakh, Uttarakhand
Large cardamom	Nepal	Arunachal Pradesh, Nagaland, Meghalaya
Cinnamon/ Cassia	Indonesia, China, Sri Lanka, Vietnam	Odisha, Chhattisgarh, Madhya Pradesh, NEH states, Karnataka, Tamil Nadu, Maharashtra
Nutmeg/Mace	Grenada, Indonesia, Sri Lanka	Assam, Andhra Pradesh, Telangana
Star Anise	Vietnam	Arunachal Pradesh, Assam
Coriander	Russia	Madhya Pradesh, Telangana, Tamil Nadu, Andhra Pradesh, Karnataka

nutmeg & mace and cassia) constitute 21% of the total value of spice imports. When we consider the share of oils and oleoresins derived from these tree spices in our imports, the self-sufficiency in tree spices shall deteriorate further. Another significant contributor to the spice import bill with a share of 10.3% (unport worth Rs 1240 Crores) is asafoetida (Ministry of Commerce, GoI, 2024), which is not commercially produced in the country at present. The major items in our spice export and import basket is provided in Table 1.

3.1 Crop Specific Strategies to Reduce Import Dependency

The discussion on the structural composition of spice imports and their underlying features warrants that crop specific strategies would be required to be deployed along with generic measures to reduce import dependency in spices sector. Key elements of crop specific strategies are outlined below for four crops/commodities which constitute nearly 50 per cent of spice import in value terms:

3.1.1 Asafoetida

- The crop is non-traditional in India and farmers might require constant handholding and technical guidance for taking up cultivation of the crop. The crop spread should be concurrently supported with facilities for post-harvest processing and marketing facilitation.
- The potential climate analogous regions for crop spread should be mapped for targeted promotion of asafoetida cultivation.
- Intensive investment should be made to hasten research on developing scientific crop management practices.
- The processing industry needs to follow good manufacturing practices to overcome inconsistency in product quality. This along with establishment of state-of-the-art common facilitation centres in public-private partnership need to be considered for promoting asafoetida industry.
- There is significant scope for improvement of the production process at various stages like selection of raw material combination, mixing, drying and powdering.
- New product development, and innovative applications of extracts across food, nutraceutical, pharmaceutical and wellness industries can enhance the depth of asafoetida markets while providing commercial opportunities.

3.1.2 Clove

- The perennial tree crop is an introduced crop. One of the major technical constraints is the shyness in flowering in non-ideal climatic conditions. The long gestation period before economic viability of clove plantation is also a deterrent for the farming community in cultivating clove.

- The tree spice may be given the status of plantation crop and special incentives may be provided for identified regions to enhance area under the crop.
- Crop prospect map needs to be prepared identifying and delineating potential areas for cultivation of clove.
- Research efforts to identify and develop clove varieties which can yield outside traditional clove growing regions.
- A special programme for revival of old clove plantations and targeted area expansion in traditional areas like Kanyakumari (Tamil Nadu) and niche areas like Idukki (Kerala).

3.1.3 Black pepper

- A significant share of area under black pepper is planted with local cultivars. This scenario needs to be addressed with a special focus on genetic improvement.
- The planting material production and supply network need a complete overhaul with focus on varietal replacement and enhanced access to accredited nurseries.
- Light pepper is substantially imported for extraction purpose as Indian farmers harvest the pepper only at full maturity. By creating special farmer groups or regions for ensuring availability of light pepper, this issue can be addressed.
- Promote INDGAP (India Good Agricultural Practices) in spices in coordination with Spices Board for addressing production constraints along with biotic and abiotic challenges.

3.1.4 Cinnamon and Cassia

- The factors which hold back the widespread adoption of the crop include the labour-intensive nature of processing and competition from its close substitute, cassia, which is cheaper.
- The cassia variety (Konkan cassia) released under the ICAR-All India Coordinated Research Project (AICRP) on Spices network holds promise as a means to initiate cultivation of cassia in the country.
- Advances in mechanization of processing of cinnamon need to adopted. For this international cooperation from other producing countries need to be explored.
- A disaggregated household processing system of cinnamon, as practiced in Sri Lanka can be deployed.
- ICAR should enter into active consultation and collaboration with Rubber Board to promote cinnamon in rubber plantations. Exclusive cinnamon producer societies can also be promoted, where sufficient potential warrants it.

3.2 Export Competitiveness

In this era of globally integrated trade networks and value chains, the spices from India face strong competition from other producing countries (Table 3). However, for most of the spice commodities, only a few countries have exportable surplus. Most of the countries exporting spices can be categorized as developing countries and the major import destinations are in general spread over North America and Europe. This creates a possibility for the producing countries to form inter-governmental commodity regulation boards to provide fair price for the primary producers of the commodity, while providing a stable market, conducive for sustainable growth and development.

Apart from market competition, there is another factor that needs to be given importance in planned export development of spices. This would be the tendency of performance of spice exports to be dependent on a few destinations, or a high degree of concentration in export destinations. This invokes the risk of a major export destination country, opting to source its spice requirement from a competing country, due to economic or geopolitical reasons. A deliberate exercise aimed at diversification of export sources has to be pursued to avoid such risk elements.

The export competitiveness of spice is not often a simple function of productivity or cost factor alone. The price discovery for specialty products like spices often depends on factors like perceived quality, geographic origin, intrinsic quality profile and uniqueness of the product and marketing strategies adopted by the firms and producers, either individually or as a group. The trade competitiveness (TC) is one of the indices (Long, 2021) and it varies from -1.0 to +1.0. An index value between -1.0 to -0.5 indicates

Table 3. India's competitors in global spice export markets

Commodity	India's competitors for export market
Black pepper	Vietnam, Sri Lanka, Brazil, Indonesia
Ginger	China, Nepal, Nigeria
Turmeric	Bangladesh
Asafoetida	Iran, Afghanistan,
Chillies	Vietnam, Thailand
Cardamom	Guatemala
Nutmeg	Indonesia, Vietnam
Spice Extracts	China
Cumin	China, turkey, Syria
Coriander	Russia, Italy, Morrocco, Bulgaria
Fenugreek	Pakistan, Egypt, China

very poor export competitiveness while a value between -0.5 and 0.0 indicates poor competitiveness. Similarly, TC index value between 0.0 and 0.5 indicates strong export competitiveness while values above 0.5 is indicative of a very strong export competitiveness in the commodity.

Among the major components of spice exports, chillies (0.99) cumin (0.98), mint products (0.97), turmeric (0.81), coriander (0.64) and ginger (0.56) were found to have very strong export competitiveness during 2022-23 while cardamom had a strong export competitiveness with a trade competitiveness index value of 0.36. The export competitiveness of black pepper, once a major item of the spice export basket was found to be poor (-0.30). Nutmeg and mace, as an export item had very poor competitiveness during 2022-23. The analysis of trade competitiveness indicates the urgent need to improve efficiency of the production ecosystem in crops like black pepper and nutmeg. It also points out the need to consolidate gains in crops like coriander, ginger and cardamom, where there is considerable scope for improving export competitiveness. However, it should be borne in mind that the calculation depicted above is for a particular year alone. A comprehensive picture of trade competitiveness needs to be constructed based on price, trade volume and other non-price factors.

4. REGULATORY ENVIRONMENT AND TRADE

The share of spices in the total agricultural exports of India has been steadily rising over the past four decades. In 1980-81, spices accounted for only 0.5% of the total export value of agricultural and allied products exports, by 1990-91, this share had increased significantly to 3.8%, and further to 5.7% by 2000-01. In 2010-11, the share of spices rose to 7.2%, By 2022-23, the share of spices in total agricultural exports had climbed to 9.6%. Both domestic and export markets are equally important in a commodity group like spices, where nearly 15 per cent of the domestic output is destined for exports. The institutional and regulatory environment with respect to external trade and domestic marketing gains prominence in this context. As noted earlier, the changing market preference and consumer sentiments have necessitated increased regulatory systems in spices.

Apart from pricing of the commodity, concerns about food safety and sustainability of production process employed have also become important in determining market preference for spices (Kumar *et al*., 2024). Market dynamics and the nature of global value chains significantly influence spice farming, impacting cropping patterns, cultivation practices, and the adoption of plant protection measures. The implementation of traceability systems has gained traction, driven by the need to ensure transparency and build consumer trust, providing detailed information about the origin, processing, and handling of the products. This is particularly important in addressing concerns related to food safety and authenticity. All these aspects of spice production ecosystem have attendant regulatory concerns also.

Key Issues in Regulatory Environment and Trade of Spices

- Issues to reduce the export rejections in spices without compromising the product quality and food safety
- Differences in quality standards across nations and strive for common standards in spices
- Strong, flexible and nimble mechanism to coordinate our responses to new threats in trade disruptions and food safety of spices
- Periodic review of Free Trade Agreements (FTA's) and Regional Trade Agreements (RTA's) regarding spices taking inputs from spice stakeholders
- Deploying a cost-effective traceability system from farm to fork for internationally traded spice commodities
- Rationalization of harmonised system of nomenclature (HSN) codes.

Though the spices from India reach more than 180 countries, the trade lacks sufficient resilience owing high concentration in trade, with a few countries accounting for bulk of the spice imports. There is an urgent need to tap into underexploited markets in Africa, Central Asia, and the Middle East, through strategic trade agreements, enhancing marketing efforts and handholding private sector initiatives in accessing new markets. The spices export units often have unique policy support requirements to enable them to remain competitive in the international market. Several firms involved in spices export have faced challenges in remaining economically viable in a highly competitive global market.

The export rejections of Indian spices have shown a declining trend in the recent years. However, the number of export rejections are still at an unacceptable level. Export rejections hurt the image of the Indian spices and act as a barrier for export market consolidation (Eapen *et al*., 2022). A catalogue of prioritized issues related to export rejections of spices need to be developed. Some of the trade related issues in spices need to be taken up at the government level or at multilateral level. The spice export sector is mainly dependent on numerous individual export firms, who constantly innovate and adapt to the changing market requirements. Over the years, this vibrant sector has served the spice sector with distinction. However, there are some pertinent challenges in the sector, which needs to be addressed on a priority basis. These include:

✦ The high cost of aggregation of the produce from small and marginal operational holdings of spice primary producers.

- ✦ The increasing stringency in trade standards including demand for traceability, unreasonable demands regarding microbial/chemical residues etc.
- ✦ The fast escalation in cost of transportation without commensurate increase in price realization.
- ✦ The need to adopt Good Manufacturing Practices (GMP) across the sector along with Food Safety Management Protocols to enhance the general image of the Indian spice processing and trading sector.
- ✦ Increasing trend of processing operations and value addition shifting outside the country due to economic and regulatory reasons.
- ✦ The low level of adoption of Hazard Analysis and Critical Control Points (HACCP) standards in spice value chain.
- ✦ High cost of compliance and lack of strong financial incentives for innovation and product development.
- ✦ Lack of streamlined external market intelligence etc.

5. SHAPING THE RESEARCH LANDSCAPE IN SPICES

The research on spice crops is mainly undertaken in the public sector spearheaded by the National Agricultural Research System. The research efforts from the private sector on these crops have traditionally focused on product development and processing rather than varietal development, crop agronomic management etc. The research allocation for spices sector has remained under whelming over the years. In case of ICAR, the major public funded institution shaping agricultural research, the research allocation for horticultural crops was barely nine per cent (revised estimates of government grants for 2020-21). Out of this, the direct allocation for spices sector was less than two per cent. There is an urgent need to highlight the importance of the spices sector (potential for employment generation, multiple linkages through vertical and horizontal integration, value addition etc.) and ensure research funding allocation congruent to its relevance.

The spice productivity in the country is well below the expected levels. The attainable yield gap in several spice crops is substantial. For example, in turmeric, a 22% increase in yield compared to the extant farmers practice has been reported by adoption of standard cultivation practices. Similarly, a yield improvement of nearly 40 per cent could be demonstrated in cumin by adoption of advanced crop management practices (Meena and Singh, 2011). The yield gap is significant in other spice crops also. The domestic output of spices needs to increase rapidly to ensure exportable surplus. A technology driven approach starting with advanced cultivation techniques and precision farming to post-harvest management, value addition and marketing practices can ensure competitiveness and sustainability of spices sector. Developing climate resilient varieties with embedded pest and disease resistance traits shall form

A Unique Segment in Indian Agricultural Economy

The spices economy of the country is unique in several ways. The spice crops belong to several botanical families and includes annuals, perennials, tree crops, perennial climbers, rhizomatous crops etc. The economic product varies from dried forms of fruits, flowers, rhizomes, leaves, buds, seeds, aril etc. The diversity in crop habitats and specificity in agro-climatic suitability presents another set of challenges. This diversity needs to be taken into consideration while contemplating the research investment needs for the sector.

The spice commodities are high value low volume commodities. While food security should rightly require primacy in research allocations of a nation, it would be prudent to consider farm income generation potential of the spice crops, which can deliver a higher value of output per unit area, impacting farm business income. This higher income can translate into higher investment in agriculture and subsequently better adoption of technologies, transforming the agricultural production system.

cornerstone of our efforts in increasing productivity, ensuring sustainability and assuring profitability for the farmers. Enhancing the bioactive compound content in spices can increase their market value by catering to the growing demand for nutraceutical and pharmaceutical applications.

A policy change is also needed to promote research on chilies, focusing on their use as a spice. Currently, most research programs are concentrated on the vegetable aspect of chilies.

Smart biocontrol strategies offering eco-friendly solutions to combat various biotic stress factors can lead to reduced reliance on chemical-based approaches. Developing protocols for regenerative agricultural practices in spices, which are critical for improving the soil microbial community and conserving biodiversity, also require focused research efforts.

Circular agricultural economy practices provide opportunities for sustainable agricultural practices. Precision Farming technologies like usage of drones, soil sensors and satellite imaging assist in monitoring crop health, soil conditions and pest infestations. Technologies like blockchain and AI-driven sensors in supply chains help trace the quality of spices from farm to consumer.

Given the magnitude of challenges across the primary production and processing of spices, continuous innovations and adoption of smart technologies is imperative. Both the innovation ecosystem and the research investments are crucial drivers of

growth, profitability, and sustainability in the spice sector. Research should focus on enabling growers to adopt innovative practices and technologies that reduce production costs. Cost reduction can be achieved through the deployment of novel technologies that optimize the use of inputs, including water, nutrients, energy, and labour. A coordinated strategic approach that balances short- and long-term goals is necessary to maximize the impact of investments in research and innovation.

6. NEW PRODUCT DEVELOPMENT AND ALTERNATE USES

A significant trend is the increasing product diversification, with manufacturers expanding their portfolios to include a wide range of spice blends, extracts, and value-added products that cater to diverse culinary traditions, applications and consumer segments. This shift while meeting the demand for convenience by the consumers, also plays a vital role in strengthening derived demand for spices. The alternate use of spices usually focuses on any of its functional properties. Increasing instances of the use of spice extracts as natural colourants and as a source of specific and unique compounds augurs well for the spices sector. The immense significance of colour in multiple industry segments has necessitates more efficient technologies for extraction and quality evaluation methods.

Focused efforts are also needed for documenting the presence, relevance and implication of nutritional and anti-nutritional compounds in spices, which can enhance their use in nutraceutical and wellness applications (Prasath *et al*., 2025).

Along with new product development, one area where India has substantial scope for improvement is in product design and packing. Attractive product design and packing has become an invaluable asset in developing markets for new products including those in the spices sector. The post-harvest handling and processing following internationally accepted standards of safety and hygiene is another area for improvement in the case of spices.

7. NETWORKS AND PARTNERSHIPS FOR PROSPERITY

As a large nation, balancing the interests of primary producers, constituents of spice industry, traders,exporters, importers, and the consumers is always a difficult proposition. There is no straightforward solution or a right answer. The nuances of the national policies for spices and the trade policies must be understood and analysed in this context. Another aspect of the spice economy is that, as we move vertically along the value chain starting from primary production, the concentration of the segment increases. That is, at higher reaches of the value chain, we have fewer players. This has implications for relative bargaining power, ease of organized action etc. In this context one of the key concerns of the policy makers would be to ensure development of strong synergies between industry and primary production (or between various stakeholder categories along the spice value chain).

Farmers are increasingly aware of the benefits that advanced technologies can bring. However, technologies are not free from various kinds of risks. The predominance of small holder production systems and low investment capacity of farm households makes it important to supplement technology dissemination efforts with suitable risk mitigation strategies (Kirpalani, 2024). This could be by way of financial support, production incentives, Output price assurance systems etc.

The aggregation of uniform quality spice raw materials has remained a critical challenge in spice processing and extraction industry. We need to quantify the demand and supply gap of the industry for spice raw materials and ensure sustained availability of raw materials requiring crop planning across regions and in choice of varieties. The enhanced role of farmer collectives in spices production and aggregation is seen as a viable option to address the existing challenges. The presence of multiple public funded institutions, parastatals and industry collectives with fragmented and partial mandate, makes it imperative to find areas of convergence and consensus among the institutional stakeholder community. Efforts must also be taken to enhance the stake of private sector entities in research outcomes and development initiatives in the spices sector.

8. IT-BASED INNOVATIONS FOR TRANSFORMING VALUE CHAINS

Advances in Information technology and associated innovations have the potential to revolutionize the spice value chain in India, right from production to consumption. These technologies can facilitate each aspect of the value chain starting from primary production to consumption and marketing. India has made tremendous strides in the field of information technology encompassing software development, communication technologies and electronic systems in the recent decades. Given these capabilities and the huge pool of skilled human resources, the country is ideally positioned to harness them for developing technologies, innovations and digital interventions in the spices sector. The innovations need to target enhancing efficiency of production, improving product quality and safety and to increase the transparency and sustainability of the spice value chains. While these innovations and solutions offer increased value proposition, they also come with a cost. The cost aspect of digital innovations can be critical in determining their acceptance and adoption in spices sector, where small holder producers constitute more than 80 per cent of the operational holdings. To address the low investment capacity of small holder producers, it is important to focus on development of low-cost smartphone applications that can be deployed effectively to address the most pertinent issued faced by the value chain actors.

There are several areas across the spice value chain where digital innovations can make significant changes. Precise methods can be employed for application of fertilizers, water and plant protection chemicals, enhancing their use efficiency while reducing the quantity applied by using real-time data from sensors to guide the input application. The widespread adoption of mobile communication technology can be leveraged to

offer crop advisory services and decision support systems, that can help farmers in deciding planting time, crop protection decisions and timing of harvest.

The blockchain technology is increasingly being used to reduce the costs of intermediaries, allowing better control over the quality and efficiency of the value chain for each stakeholder in the supply chain (Kamble *et al*., 2020). Presently, blockchain technology is being used to encrypt important documentation regarding quantity, price etc. The same technology can be used to provide end-to-end traceability of spice commodities. Recently, the Indian Spice Board has signed a memorandum of understanding with the United Nations Development Programme (UNDP) Accelerator Labs to build a blockchain-based traceability, quality assurance and trading system for Indian spices. The pilot project is set to be implemented with more than three thousand chilli and turmeric farmers in Andhra Pradesh. One of the most important challenges in the spice value chain is to ensure food safety. This would require quick and efficient detection of parameters, critical for food safety and quality. Use of drones for crop health monitoring, development of precise crop output estimates, AI powered algorithms for input management, sensor-based quality monitoring systems, digital technologies for grading and sorting of produce, assistance for standardization and certification process etc are a few of the potential areas for digital innovations in the spices sector.

9. MAINSTREAMING NICHE PRODUCTION SYSTEMS

Spices have been cultivated in the country for centuries and they have acquired unique cultural significance in the country. This has also resulted in an accumulated stock of indigenous knowledge and availability of many traditional varieties developed and conserved through indigenous seed systems over generations. The cultivation of spice crops across diverse production systems with unique agro-climatic features has also influenced the intrinsic qualities of several spice products, which are linked to their geography. Such features of the Indian spice production ecosystem have occasioned several niche production systems in spice farming in India. They are marked by specialized farming practices that focus on producing specific commodities with unique quality profile and often target specific market segments, such as organic, gourmet, or specialty food markets. These niche production systems offer opportunities for farmers to differentiate their products, increase profitability, and contribute to sustainable agriculture. In the emerging competitive agricultural landscape, these niche production in India have an increasingly important role to play, especially in gaining markets and reaping premium price for products. Certain varieties and geographic origins within India are regarded as among the best in the world. The Geographical Indication (GI), an official mechanism to link a produce quality with a particular region can be considered as a niche production certification platform (Saikia and Bhagaboty, 2024). There are around 30 GI tagged spices in India, to name a few, Malabar pepper, Lakadong turmeric, Assam Karbi Anglong ginger, Ramnathapuram Mundu chilli, and Hathras hing. There

is a need to create awareness through consumer campaigns about GI spices and the implications of GI protection. This awareness should help build brand equity and help the broader audience understand the consequences of violating regulations (Fig. 3). Promoting GI spices not only protects local heritage but also boosts the global recognition and export potential of these unique products (Prasath *et al*., 2020).

Fig. 3. The way forward for Geographical Indication (GI) Spices

Similarly organic farming, certified sustainable farming, permaculture and ethnobotanical farming are some of the other areas that can be exploited in case of spices. India, alongside China and Vietnam, is a leading exporter of organic spices. While spices constitute a small fraction of the overall food market, demand for organic spices is on the rise, particularly among food processors in the USA and EU. Additionally, the growing recognition of the medicinal properties of spices and its use in nutraceutical and pharmaceutical preparations has further boosted the demand for spices grown under organic production systems (Babu *et al*., 2019). Several spices have a variety of cultural connotations associated with its use. The medicinal and traditional uses of spices also have immense diversity and specificity. Catering to these requirements offer market opportunities while contributing to preservation of traditional knowledge and sustainable livelihoods. Combining ITKs with modern science, these spices and products derived from them, hold considerable promise and prospects for high-value products.

Vertical farming, hydroponics, permaculture, aeroponics and production of specialty spices can also be considered as niche production system with considerable latent potential, especially in the back drop rapid urbanization and associated space constraints. Future spice production and consumption will increasingly rely on such niche production systems to meet the changing needs of consumers. Reduced environmental impact, cropping system resilience, carbon sequestration, climate proof output etc are some of the other desirable outcomes that can be targeted from niche production systems. The most effective way to utilize the niche production systems in spices is to integrate it into a sustainable framework encompassing certification, authenticity and quality assurance, resulting in premium prices for producers.

Spices play a crucial role in the economic, cultural, and environmental landscape of Northeast India. With its diverse climate and fertile soils, the region produces unique and

Organic Spices

The global organic spice market is valued between Rs. 6200 Crores (750 million US$) and Rs. 8250 Crores (1 billion US$), which is less than one per cent of the total organic market. However, this also presents a latent opportunity for India for enhancing its footprint in the global organic spice market.

Organic spices typically command a retail premium of 30% to 40%, and in some cases, even up to 100%. The premium depends on various factors like product type, transaction partners, and market linkages. In some geographically challenged regions, for example, the Northeastern Region (NER), the weak Institutional mechanisms for marketing could lead to market failures in price discovery (NEDFi, 2021). Middlemen-driven value chains often do not offer any premium for organic products. The authentication and certification mechanisms in vogue for organic products has failed to generate producer participation in large numbers. A critical rethinking focused on improving efficiency of certification systems is urgently required.

high-quality spices such as large cardamom, ginger, turmeric, and black pepper, which are integral to both local cuisine and traditional practices. These spices hold significant export potential, contributing to the livelihood of farmers and offering opportunities for rural development. Furthermore, the organic and sustainable farming methods employed in the region align with global market trends, making Northeast India a key player in the spice industry. By promoting research, improving infrastructure, and strengthening market linkages, the spice sector can drive economic growth, preserve biodiversity, and elevate the global recognition of Northeast Indian spices.

10. RECOMMENDATIONS

1. Promote sustainable and safe production practices to align with global concerns for food safety, traceability, and sustainable agriculture.

Action Plan:

- ✦ Develop and disseminate guidelines for Good Agricultural Practices (GAP) in spice cultivation and incentivize their adoption.
- ✦ Promote adoption of integrated pest management (IPM) to minimize pesticide residues.
- ✦ Strengthen traceability systems in spice value chains through planned aggregation mediated by farmer collectives to assure buyers of safety and sustainability.

Measurable Indicator:

- ✦ Certification of One million spice farmers under GAP by 2030.
- ✦ Adoption of IPM by 50% of spice farmers by 2030.
- ✦ Adoption of blockchain systems by at least 20% of exporters by 2028

2. Address the limited plant protection choice scenario in spices by rationalizing the insecticides registration and regulation system and promoting safe pesticide use in spice cultivation.

Action Plan:

- ✦ Strengthen the Central Insecticides Board & Registration Committee's (CIBRC) and include spices in priority categories for reviewing new and safer agrochemicals.
- ✦ Implement crop grouping approaches to streamline pesticide residue testing and harmonize Maximum Residue Limits (MRLs)
- ✦ Increase funding for research on spice-specific pest control solutions.
- ✦ Create interface for communicating market specific pesticide residue requirement and other quality parameters to producers and other value chain actors.

Measurable Indicator:

- ✦ Faster approval process for bio-pesticides and new generation safer molecules used in spice cultivation (target: under six months).
- ✦ Annual reports showing increased compliance with safety standards.

3. Encourage domestic cultivation of high-demand imported spices like cloves, asafoetida, cinnamon and black pepper through focused production programs.

Action Plan:

- ✦ Identify and promote agro-climatically suitable regions for these crops, especially in NEH and other non-traditional regions using geo-spatial technologies.
- ✦ Provide market support and production-based incentives for targeted spice commodities through FPOs and offer technical training for farmers (Spices Board).

Measurable Indicator:

- ✦ Reduction in the import bill of targeted spices by 50% by 2035.
- ✦ Increase in the area under cultivation of these spices by 30% by 2030.

4. Focus on the development of high-value nutraceuticals and cosmeceuticals derived from spices

Action Plan:

- Create a National Spice innovation hub to drive research, product development, and market strategies in collaboration with industry stakeholders and academic institutions
- Promote the development of spice extracts and essential oils tailored to global flavour and fragrance markets.
- Organize industry-academia workshops to develop innovative uses of spice-based flavours in beverages and processed foods.

Measurable Indicator:

- Launch of 10 new patented spice-based products by 2030.
- Increase in export value of spice-based flavour products by 25% within five years

5. Develop state-of-the-art processing and storage facilities in major spice-producing regions to reduce post-harvest losses and improve quality.

Action Plan:

- Establish 50 state of the art integrated spice processing units equipped with drying, cleaning, and packaging technology.
- Introduce subsidized cold storage facilities in high-production zones to maintain product quality and extend shelf life, especially for export-oriented spices.

Measurable Indicator:

- Reduction in post-harvest losses by 30% by 2030.
- Increase in processed spice exports by 20% by 2028.

6. Leverage the market potential of GI-tagged spices like Malabar pepper, Alleppey green cardamom,Byadagi chilli, Naga chilli, Waigaon turmeric and Lakadong turmeric to create premium niche markets.

Action Plan:

- Establish a mechanism to protect supply chain integrity to determine the authenticity of spices sold as GI spices
- Provide financial and technical support to producer groups for GI branding and marketing.

- Facilitate international trade shows and promotional campaigns for GI-tagged spices.
- Use storytelling to showcase the heritage and GI-tagged origins of Indian spices through digital platforms.

Measurable Indicator:

- Annual growth in exports of GI-tagged spices by 15%.
- Increase in registered GI-tagged spice producer groups by 20% by 2030.
- Growth in demand for premium and GI-tagged spices by 25% by 2030.

7. Reduce dependency on a few countries for spice exports by targeting underexplored regions such as Africa, Central Asia, and Latin America.

Action Plan:

- Conduct market studies to identify demand patterns in under explored market regions.
- Develop trade agreements to address tariff and non-tariff barriers.
- Organize international trade fairs in emerging markets to showcase Indian spices.

Measurable Indicator:

- Reduce C10 export market concentration ratio by at least 30% by 2030
- Increase in export revenue from non-traditional markets by 15% in five years.

8. Enhance support for spice cultivation in the North-East Hill (NEH) region, focusing on niche spices like turmeric and ginger.

Action Plan:

- Launch a regional mission for spices with dedicated funding for capacity building and market linkages. These efforts could help integrate smallholder farmers into high-value global markets while promoting sustainable agricultural practices.
- Train farmers in organic cultivation and provide certification assistance.

Measurable Indicator:

- Increase in area under spice cultivation in NEH region by 25% by 2030.
- Number of NEH farmers obtaining organic certification

9. Develop climate-resilient spice varieties and farming practices to address the challenges posed by climate change.

Action Plan:

- ✦ Invest in research programs for drought-tolerant and pest-resistant varieties and technologies.
- ✦ Promote water-efficient irrigation systems and RCTs in spice cultivation.

Measurable Indicator:

- ✦ Introduction of five climate-resilient spice varieties by 2030.

10. Enhance the role of Farmer Producer Organizations (FPOs) in spice aggregation, quality improvement, and direct marketing.

Action Plan:

- ✦ Provide funding and capacity-building support to FPOs for post-harvest processing and branding.
- ✦ Encourage FPOs to engage in direct exports, bypassing intermediaries.

Measurable Indicator:

- ✦ Increase in the number of FPOs engaged in spice export (target: 50 FPOs by 2030).
- ✦ Growth in FPO-led exports to 10 % of total spice exports by 2035.

11. Strengthen functional collaboration between key institutional stakeholders in the spices research and development sector for specific targets.

Action Plan:

- ✦ Establish a community of practice of institutions involved in spices research
- ✦ Develop a platform for knowledge exchange between institutions like IISc, NIFTEM, ICAR-IISR, ICAR-NRCSS, and Private labs etc.

Measurable Indicator:

- ✦ Increase in number on Inter institutional collaborative projects

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