

India's Spice Export Evolution Through a Data-Driven Analysis of Trends and Growth from 2020 to 2025

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Abstract - India ranks among the major spice exporters in the world; however, there are changes in the quantity of exports, market demands, pricing trends, and competition, among others, making it difficult to get an overview of the whole development in the spice export industry. Previous works mostly cover a single spice or a limited aspect of export development, which calls for a comprehensive analysis of export trends, growth rates, commodity performance, destinations, and future prospects during 2020–25. This study is focused on analyzing the development of India's spice exports by examining trends, growth rates, spice-wise performance, destinations, and future growth prospects during the financial years 2020–25. A quantitative approach is used in this study, in which export data is gathered from secondary sources of information, including spice-wise export quantities and values. The collected data are analyzed through descriptive statistics, trend analysis, year-on-year growth rate, CAGR analysis, ranking analysis, profitability and ARIMA forecast modeling. There is a trend towards positive growth in the exports of Indian spices, with an increase in the value of exports of spices from 3,032,432.44 lakhs in 2020–21 to 3,914,011 lakhs in 2024–25, and it has achieved a CAGR of 6.59%. Chilies have proved to be the main contributor to exports through their high export value, and processed spices and high-end varieties have been more profitable. Correlation analysis found a very strong positive correlation between the export quantity and value of exports having a coefficient of 0.82. The future projections also suggest that there is scope for further growth, with a projected export value of 4,850,000 lakhs by 2028–29.

Keywords: Indian Spice Exports, Data-Driven Analysis, Growth Trends, Export Forecasting, CAGR, Market Competitiveness

I. INTRODUCTION

Exports of spices from India have attracted a considerable amount of attention through studies that deal with production trends, export trends, price changes, competitiveness, and export opportunities. Previous studies have considered historical export trends and price changes of spices from India and the need for a time-series approach to study market behavior and export trends (Anusha et al., 2020). Production, productivity, and export performance of Indian spices have been studied with an emphasis on the significance of increased efficiency of cultivation for improving export

performance (Priya & Thyagarajan, 2020). The development trends of production area, productivity, and exports of important spices have been examined in order to analyze long-term development trends and problems facing export promotion (Sengupta, 2025). The trade potential of India has been studied in terms of export opportunities and competitiveness of Indian spices (Singh et al., 2014). Earlier studies about spice exports have shed light on export trends, export development, and the contribution of spice trade to agricultural trade (Thomas et al., 2023). The recent research studies have also included the application of machine learning-based forecast techniques to determine spice prices and macroeconomic factors affecting the commodity market, establishing the significance of data-driven techniques in making decisions about agriculture (Vaishnavi et al., 2026). The export performance analysis of different types of spices like chili has emphasized differences in the international demand, competitiveness, and growth potential (Bansal et al., 2022). Economic analysis of major spices in India has focused on determining export efficiency and market performance to know the reasons behind their export growth (Kumar & Muraleedharan, 2007). Competitiveness in the export trade of spices has been studied in order to identify the problems faced by the country in its export activities due to the issue of market accessibility, quality, and international competition (Idris et al., 2015). Recent works that have used data visualization and analysis techniques have demonstrated the importance of using graphical and computational techniques to interpret the trends in agricultural production and transformation in the value chain in India (Lemenkova, 2025). These studies provide a solid basis for conducting a data-driven study of the spice export evolution of India with an emphasis on historical trends, growth, price dynamics, competitiveness, and forecasting techniques.

Key Contribution

- The paper provides an evidence-based analysis of the progress of India's exports of spices, examining annual exports, variations in growth rates, and market trends during 2020–21 to 2024–25.

- Analysis methods such as quantitative analysis are used in this study to examine the growth rates, fluctuations, and trends exhibited by major Indian spices in terms of their exports.
- The paper formulates graphs and interpretations that help in presenting the export paths, commodity-specific contributions, and time-related changes of India's spice trade.
- Through analysis of past export records and future trends, this research identifies growth opportunities, market threats, and ways to improve India's competitiveness in spice exports internationally.

The rest of this essay is structured as follows. Section II is devoted to a literature review, which covers existing studies on agricultural data analysis, export trend analysis, forecasting methods, and digital analysis in the spice trade. Section III presents the framework of the methodology used in this research, which includes objectives, hypotheses, secondary data acquisition and pre-processing, exploratory data analysis, performance analysis, market analysis, analysis of statistical relationships, and forecasting methods. In Section IV, the research methodology is explained in detail, which includes the research design, data sources, duration of the study, data processing steps, analytical methods, and sampling. Section V includes the results and analysis, which involves descriptive statistics, export trends analysis, growth rate analysis, CAGR analysis, spice-wise ranking, destination markets analysis, profitability analysis, correlation analysis, forecasting outcomes, hypothesis testing, discussion, and limitations. Finally, Section VI concludes the research, where the main findings of the research are discussed and future recommendations should be made.

II. LITERATURE REVIEW

The development of agricultural data analysis, there is an improvement in production trends, market trends, forecasts, and quality management in Indian agricultural exports. Time series-based studies show that statistical methods can effectively analyze growth trends and forecast future trends in agricultural production systems, which can be used to analyze export development (Vanitha et al., 2021). Recent studies on horticulture in India have used trend analysis and forecasting methodologies to analyze future growth and production trends useful for planning agricultural exports (Kumar et al., 2026). Machine learning-based systems for price forecasting of spices have demonstrated the use of predictive analytics for helping spice traders in the market (Basavannappagowda et al., 2025). The studies on agriculture in India have focused on agricultural diversification and consumption trends, thereby emphasizing the importance of sustainable production systems and their impact on food security and the commodity chain (Ray & Ray, 2022). The statistical studies of Indian organic farming have focused on sustainable agriculture and its impact on value-added agricultural exports (Manavalan, 2022).

Digital transformation research has emphasized the role of technology and data availability in enhancing agricultural information systems and trade analytics (Pattnaik, 2018). Modern analytical approaches, including spectroscopy and chemometrics, have been used in spice authentication and quality analysis, which contributes to the provision of quality assurance and marketability in the international market (Pacholczyk-Sienicka et al., 2021). The use of intelligent systems and predictive analytics has also been instrumental in ensuring food safety and contamination prediction, thus enhancing the reliability of agricultural supply chain operations (Lebelo et al., 2022; Swathi et al., 2025). Statistical analysis of agricultural price patterns has revealed the importance of data-based methodologies in explaining price volatility and market behavior in India (Rajeswari et al., 2024). Geospatial and machine learning predictive approaches have proved the importance of computational methodologies in pattern recognition and decision-making in agricultural and environmental settings (Sindhu, 2025). All these studies show that statistical modeling, machine learning, digital technologies, quality assessment, and predictive analytics have become increasingly important in studying the dynamics of agricultural markets. These methodologies are useful in the analysis of India's spice export evolution from 2020 - 2025.

Problem Statement

India is one of the world's largest spice exporters; however, the industry faces constant challenges from fluctuating demand, changing prices, supply-chain disruptions, shifting trading patterns, and growing competition from other exporting countries. While Indian spice exports have shown progress over the past few years, changing trends in export quantities, export value, contributions by different spice types, and export destination markets make it challenging to understand overall export growth and competitiveness. Current research mainly focuses on either a specific spice or particular aspects of export performance. Limited comprehensive work has analyzed export trends, growth rates, profitability, market distribution, and future potential during 2020-2025. Therefore, this research attempts to fill this gap through a data-driven approach to understanding the evolution of India's spice exports and associated growth trends.

Research Objective

1. An analysis of trends and growth rates for India's spice exports during the years 2020 - 2025 based on export volumes and values.
2. An assessment of the performance of different spices through analyzing their export contribution, rankings, and values earned in the international market.
3. The identification of the major destination markets for Indian spices along with analysis of the export demand distribution in different countries.

4. A forecast of future export growth potentials and creation of strategic opportunities for Indian spice export business.

Research Hypothesis

H1: There is a significant positive trend in India's spice export value during the period 2020–21 to 2024–25.

H2: Export quantity has a significant relationship with export value of Indian spices during the study period.

H3: There is a significant difference in export performance among different spice categories based on export value and profitability.

H4: Destination markets have a significant influence on the growth and competitiveness of India's spice exports.

III. PROPOSED METHODOLOGY

3.1 Overall Conceptual Framework for Proposed Methodology

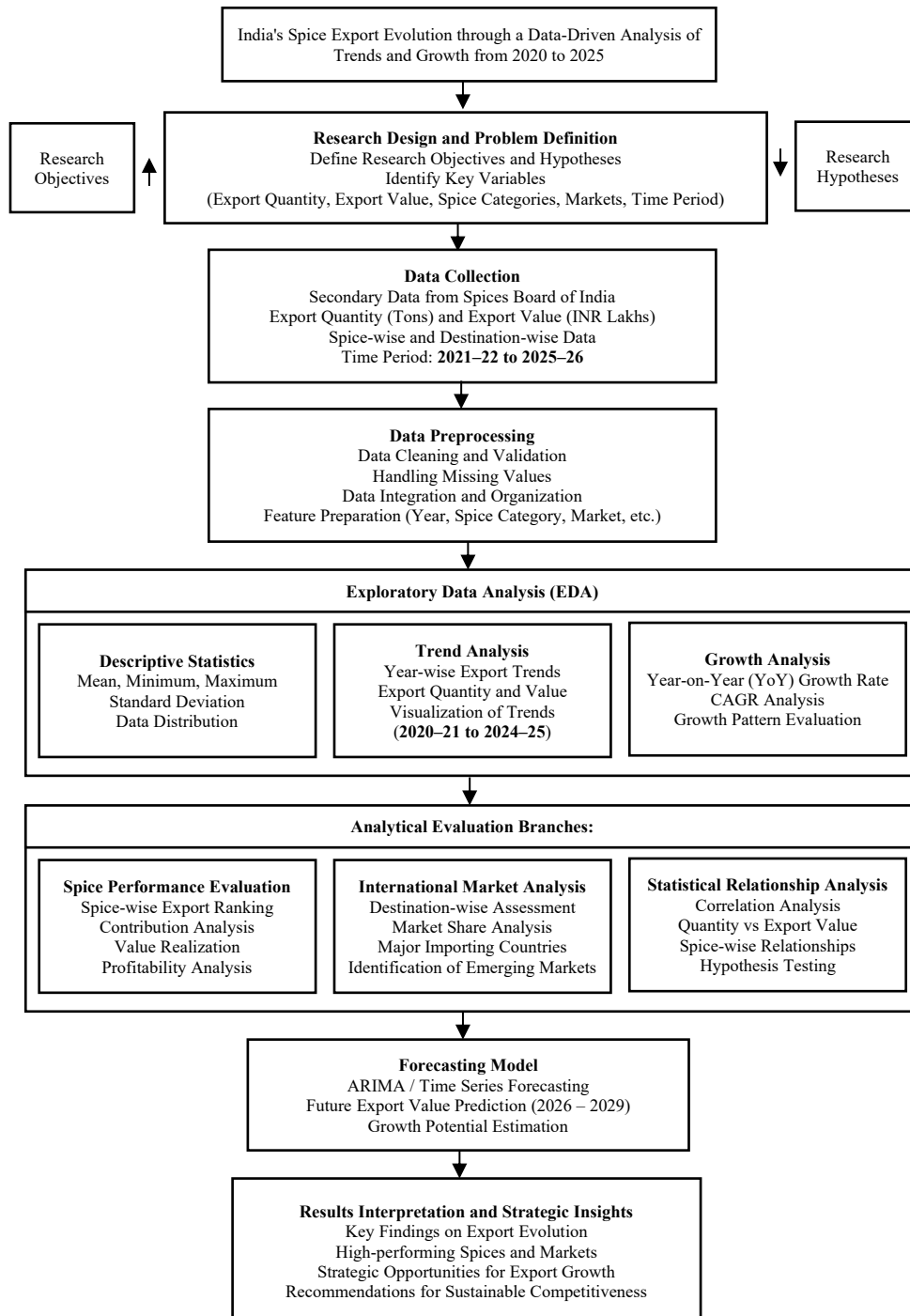


Fig. 1 Overall Conceptual Framework for Proposed Methodology

Fig. 1 describes the proposed methodology framework, which presents a systematic, data-driven approach for analyzing the evolution of India's spice exports from 2020–21 to 2024–25. The framework begins with research design, problem identification, objectives, and hypothesis formulation, followed by secondary data collection from reliable export sources. The collected data undergoes preprocessing to ensure consistency, accuracy, and suitability for analysis. Exploratory Data Analysis (EDA) then uses descriptive statistics, trend analysis, and growth analysis to evaluate export patterns, variations, and long-term growth. Further, spice performance evaluation identifies high-contributing spice categories through ranking, contribution, value realization, and profitability analysis. International market analysis examines destination-wise export distribution and market opportunities, while statistical relationship analysis evaluates the association between export quantity, export value, and other influencing factors. Finally, forecasting models such as ARIMA and time-series approaches are applied to predict future export potential and growth trends. The outcomes of this framework provide strategic insights into major export drivers, high-performing spices, emerging markets, and opportunities for enhancing India's global spice export competitiveness and sustainable growth.

IV. RESEARCH METHODOLOGY

4.1 Research Design

The current research study uses a quantitative research design to study the development and growth trends, performance variations, and future prospects of India's spice exports during the years 2020–2025. The research process is data-driven and involves collecting data from reliable sources like export data from the Spices Board of India. The data include export quantity (in tons), export value (INR lakhs) by spice type, annual export performance, and market details. The data were processed and arranged in a suitable manner, considering key factors such as spice category, export quantity, export value, and annual export trends, to make them useful for statistical analysis. Data analysis was done using MS Excel, IBM SPSS Statistics, and analytical tools for statistical models. Descriptive statistical analysis, such as mean, minimum, maximum, and standard deviation, was used to assess the variations in performance of exports of each type of spice, whereas trend analysis, year-on-year growth rate, and CAGR analysis were used for analysis of export growth patterns. Moreover, test was carried out to examine the association between the quantity of exports and export value, while ranking and contribution analysis of spices, along with unit value profitability analysis, helped in determining the superior-performing and valuable spices. Lastly, time series forecasting using an ARIMA model was done to forecast the future export prospects and growth trends of the spice export industry of India.

4.2 Data Source and Period of the Study

The research is based on secondary data obtained from reliable export databases to examine the changing trends in India's spice exports in the study period. The data includes the item-wise quantity (tons) and export value (in INR lakhs) of spice exports. The collected data includes spice-wise export data with annual quantity and value of different spices in the period 2020–21 to 2024–25 for use in trend analysis, growth assessment, ranking, profitability calculation, and prediction. The major source of primary data in the research is the Spices Board of India export statistics, which include extensive details regarding the performance of spice-wise exports and market trends. The study period covers the financial years 2020–21 to 2024–25 for examining historical trends in India's spice exports, as presented in table I.

4.3 Data Processing and Analytical Techniques

The collected secondary export data were cleaned, organized, and prepared to ensure consistency and suitability for statistical analysis. The data set was constructed on the basis of several key variables, which included spice type, export quantity (in Tons), export value (INR Lakhs), and yearly export performance. The data set was analyzed by means of several quantitative methods, such as descriptive statistics (determination of mean, minimum, maximum, and standard deviation values); trend analysis (investigation of year-wise differences in export quantity and value); and growth analysis by means of Year-on-Year (YoY) growth rate and CAGR analysis. Moreover, the analysis of ranking of spices, contribution, value realization, profitability, destination market, and correlation was conducted in order to determine the competitiveness of exports and relationships between key variables. Lastly, forecasting models, including ARIMA and time-series models, were used to predict export potential in the future. Lastly, forecasting models, including ARIMA and time-series models, were used to predict export potential in the future.

The ARIMA forecasting model was evaluated using statistical validation measures to ensure the reliability and accuracy of future export predictions. The optimal ARIMA configuration was selected based on the minimum Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values, where lower values indicate better model efficiency and reduced complexity. Forecast accuracy was assessed using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE), which measure the difference between observed and predicted export values. Furthermore, residual diagnostic analysis was performed using residual plots and autocorrelation tests to verify that residual errors were randomly distributed without significant temporal patterns. These validation procedures ensure that the selected ARIMA model provides an appropriate representation of historical export trends and supports reliable forecasting of future spice export values.

4.4 Sample Data Collection

TABLE I SAMPLE DATA COLLECTION

Item	2020–21 Qty (Tons)	2020–21 Value (Lakhs)	2021–22 Qty (Tons)	2021– 22Value (Lakhs)	2022– 23Qty (Tons)	2022–23 Value (Lakhs)	2023– 24Qty (Tons)	2023–24 Value (Lakhs)	2024–25 Qty (Tons)	2024– 25Value (Lakhs)
Pepper	21,863	75,331.23	17,958	72,686.41	17,890	73,648.88	20,830	105,500	19,806	121,712
Cardamom (S)	10,571	137,566.95	7,352	87,514.87	6,168	99,959.85	6,728	156,682	15,050	367,198
Cardamom (L)	1,981	15,448.21	1,883	13,720.19	1,281	14,815.41	1,368	22,944	1,753	31,592
Chilli	557,144	858,458.36	516,177	1,044,412.31	601,084	1,249,248.45	715,506	1,140,490	683,681	1,039,559
Ginger	147,677	83,651.76	50,885	43,246.06	60,833	64,688.57	131,360	106,240	146,257	126,098
Turmeric	152,758	153,442.05	170,085	166,699.49	162,019	187,586.79	176,325	288,539	175,896	288,718
Coriander	48,656	48,247.51	54,481	66,501.19	108,624	94,820.97	60,323	63,320	60,211	67,970
Cumin	216,971	334,367.40	186,509	419,359.76	165,269	579,723.43	229,881	617,886	196,800	461,115
Celery	7,579	9,854.19	5,248	7,755.76	6,599	10,074.33	8,473	11,879	5,900	10,629
Fennel	40,139	41,197.20	21,201	31,437.42	39,565	66,960.91	76,586	76,544	33,038	42,122
Fenugreek	32,402	26,285.83	35,055	26,680.17	30,855	26,612.76	44,516	36,589	47,069	35,716
Other Seeds	47,167	40,445.48	57,431	48,089.08	39,438	36,177.50	35,109	34,959	46,141	42,288
Garlic	22,135	18,575.04	57,346	24,579.64	73,950	44,118.84	43,959	53,838	43,240	52,804
Nutmeg & Mace	3,597	21,798.86	3,447	22,127.57	5,143	28,687.69	4,756	25,192	4,608	27,117
Other Spices	109,369	159,957.89	116,269	193,701.29	102,133	186,808.08	118,171	242,447	105,673	189,157
Curry Powder/Paste	52,479	115,836.50	57,924	141,689.27	72,421	175,727.66	77,151	209,499	104,765	229,605
Spice Oils & Oleoresins	21,920	447,823.73	18,398	408,551.25	18,762	412,300.59	20,940	453,324	20,730	467,081
Mint Products	36,254	444,144.18	26,708	357,386.49	27,659	343,919.81	27,283	353,576	23,944	313,530
Total	1,530,661	3,032,432.44	1,404,357	3,176,138.22	1,539,692	3,695,880.50	1,799,267	3,999,448	1,734,562	3,914,011

(Source: <https://www.indianspices.com/sites/default/files/major%20itemwise%20export%202025%20web.pdf>)

V. RESULTS ANALYSIS AND INTERPRETATION

5.1 Descriptive Statistical Analysis of Export Quantity (Tons)

TABLE II DESCRIPTIVE STATISTICAL ANALYSIS OF EXPORT QUANTITY (TONS)

Spice	Mean Quantity (Tons)	Minimum	Maximum	Standard Deviation (SD)
Pepper	19,669.40	17,890	21,863	1,522.35
Cardamom (S)	9,173.80	6,168	15,050	3,812.48
Cardamom (L)	1,653.20	1,281	1,981	286.41
Chilli	614,718.40	516,177	715,506	78,871.52
Ginger	107,402.40	50,885	147,677	42,223.77
Turmeric	167,416.60	152,758	176,325	9,734.19
Coriander	74,459.00	48,656	108,624	24,906.47
Cumin	199,086.00	165,269	229,881	24,963.41
Celery	6,759.80	5,248	8,473	1,265.45
Fennel	42,105.80	21,201	76,586	21,377.38
Fenugreek	37,139.40	30,855	47,069	6,982.55
Other Seeds	45,057.20	35,109	57,431	8,950.61
Garlic	59,934.00	22,135	73,950	20,640.17
Nutmeg & Mace	4,310.20	3,447	5,143	727.73
Other Spices	110,323.00	102,133	118,171	6,530.82
Curry Powder/Paste	72,948.00	52,479	104,765	20,025.61
Spice Oils & Oleoresins	20,150.00	18,398	21,920	1,282.79
Mint Products	28,369.60	23,944	36,254	4,806.98

Table II shows the descriptive statistical analysis of export quantities of various spices. It provides differences in the averages of export quantities, the range between the minimum and the maximum export quantities, and the consistency of the export quantity levels. The largest average

export quantity is seen in the case of Chili (614,718.40 tons). This means that the spice has great export importance, followed by Cumin (199,086 tons), Turmeric (167,416.60 tons), and Ginger (107,402.40 tons). Other spices such as Nutmeg & Mace, Cardamom (L), and Celery have a smaller

export importance due to the niche nature of their markets. Standard deviation shows how much the quantity of the exports of the commodity differs from the average export quantity. The highest standard deviations (SD = 78,871.52 tons) are associated with the biggest changes between the maximum and minimum export quantities in the case of Chili. In turn, Nutmeg & Mace (SD = 727.73 tons) and

Cardamom (L) (SD = 286.41 tons) have the most consistent export volumes, which differ little from each other. Other spices such as Ginger, Coriander, Cumin, Garlic, and Curry Powder/Paste have moderate standard deviations that show the changing market conditions. Descriptive Statistical Analysis of Export Value (INR Lakhs)

TABLE III DESCRIPTIVE STATISTICAL ANALYSIS OF EXPORT VALUE (INR LAKHS)

Spice	Mean Export Value (Lakhs)	Minimum	Maximum	Standard Deviation (SD)
Pepper	89,775.90	72,686.41	121,712	20,823.74
Cardamom (S)	169,784.30	87,514.87	367,198	113,662.61
Cardamom (L)	19,704.24	13,720.19	31,592	7,220.34
Chilli	1,066,433.51	858,458.36	1,249,248.45	151,648.28
Ginger	84,784.96	43,246.06	126,098	32,515.96
Turmeric	216,997.82	153,442.05	288,718	58,765.31
Coriander	68,172.53	48,247.51	94,820.97	18,364.32
Cumin	482,490.40	334,367.40	617,886	116,034.72
Celery	10,038.49	7,755.76	11,879	1,688.63
Fennel	51,652.34	31,437.42	76,544	18,543.23
Fenugreek	30,376.30	26,285.83	36,589	4,267.51
Other Seeds	40,811.47	34,959	48,089.08	5,696.16
Garlic	38,039.68	18,575.04	53,838	14,970.91
Nutmeg & Mace	25,044.36	21,798.86	28,687.69	2,823.54
Other Spices	194,414.07	159,957.89	242,447	31,760.38
Curry Powder/Paste	174,471.22	115,836.50	229,605	46,020.52
Spice Oils & Oleoresins	437,816.28	408,551.25	467,081	24,254.67
Mint Products	362,510.46	313,530	444,144.18	51,444.38

Table III demonstrates the descriptive statistics of export values from different spice categories, which depicts their economic significance and variance in export performance. In all spice categories, Chilli has the highest mean export value, being INR 1,066,433.51 lakhs, and hence it signifies that this spice is economically very important for India's export revenue, followed by Cumin (INR 482,490.40 lakhs), Spice Oils & Oleoresins (INR 437,816.28 lakhs), and Mint Products (INR 362,510.46 lakhs). High-priced spices like Turmeric, Other Spices, Curry Powder/Paste, and Cardamom (S) also have good export income, showing high international demand for them. Standard deviations demonstrate the fluctuation in export value over the time under consideration. The highest standard deviations can be seen for Chili (SD = 151,648.28 lakhs), Cardamom (S) (SD = 113,662.61 lakhs), and Cumin (SD = 116,034.72 lakhs). On the other hand, spice categories like Nutmeg & Mace, Fenugreek, Celery, and Other Seeds recorded smaller variations, which showed the stability of their export earnings. In general, it can

be seen from the above discussion that the Indian spice export earnings are mainly influenced by important spices like Chili, Cumin, Spice Oils & Oleoresins, and Mint Products, whereas specialty spices make steady contributions to economic income. The changes recorded here clearly show the effects of global market trends, availability, prices, and international demand on the earnings of spice exports.

5.2 Year-wise Export Trend Analysis

TABLE IV YEAR-WISE EXPORT TREND ANALYSIS

Year	Total Export Quantity (Tons)	Total Export Value (INR Lakhs)
2020–21	1,530,661	3,032,432.44
2021–22	1,404,357	3,176,138.22
2022–23	1,539,692	3,695,880.50
2023–24	1,799,267	3,999,448.00
2024–25	1,734,562	3,914,011.00

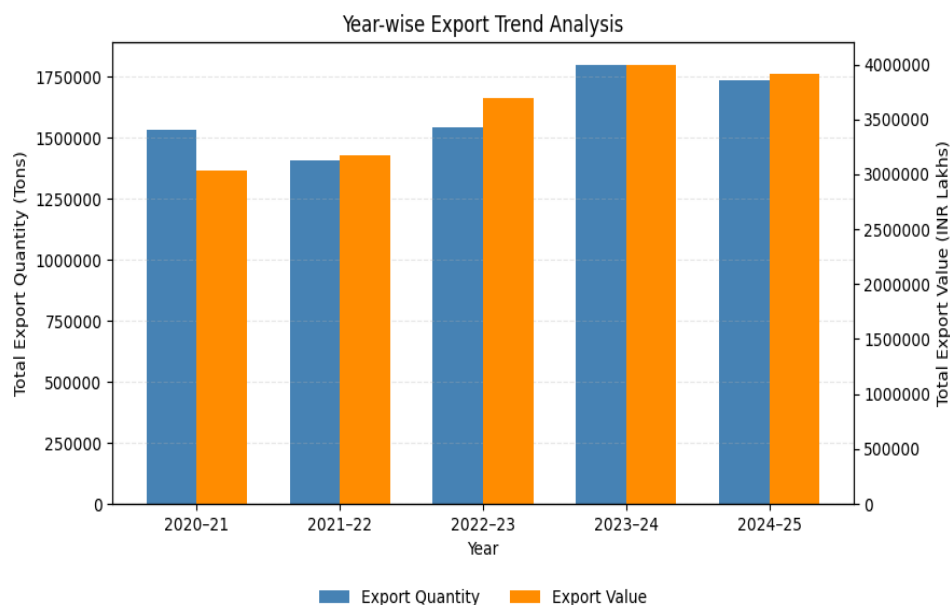


Fig. 2 Year-Wise Export Trend Analysis of Indian Spices (2020-2025)

Year-wise analysis of the trend in spice exports of India from 2020-21 to 2024-25 is provided in table IV and fig. 2, which captures the change in export quantity as well as export value. It is clear that the trend in the performance of spice exports from India is an increasing one, as the total quantity exported from India rose from 1,530,661 tons in 2021-22 to 1,734,562 tons in 2024-25, even after taking into consideration the decline experienced in 2022-23. The maximum quantity of exports in terms of value was observed in 2023-24 (1,799,267 tons), showcasing the strong production and demand for the spice exports at this time. As regards the export value, there was an increase from INR 3,032,432.44 lakhs in 2020-21 to INR 3,914,011 lakhs in 2024-25, with the maximum value observed in 2023-24 (INR 3,999,448 lakhs). The increase in the export value was comparatively more than the increase in

quantity. This indicates the impact of good pricing, value-added products, as well as market conditions abroad. However, there was a marginal decline in the quantity and value of exports in 2024-25 relative to 2023-24.

5.3 Year-on-Year (YoY) Growth Rate Analysis

TABLE V YEAR-ON-YEAR (YOY) GROWTH RATE ANALYSIS

Year	Quantity Growth (%)	Value Growth (%)
2020-21	+26.67	+37.45
2021-22	-8.25	+4.74
2022-23	+9.63	+16.36
2023-24	+16.86	+8.22
2024-25	-3.60	-2.14

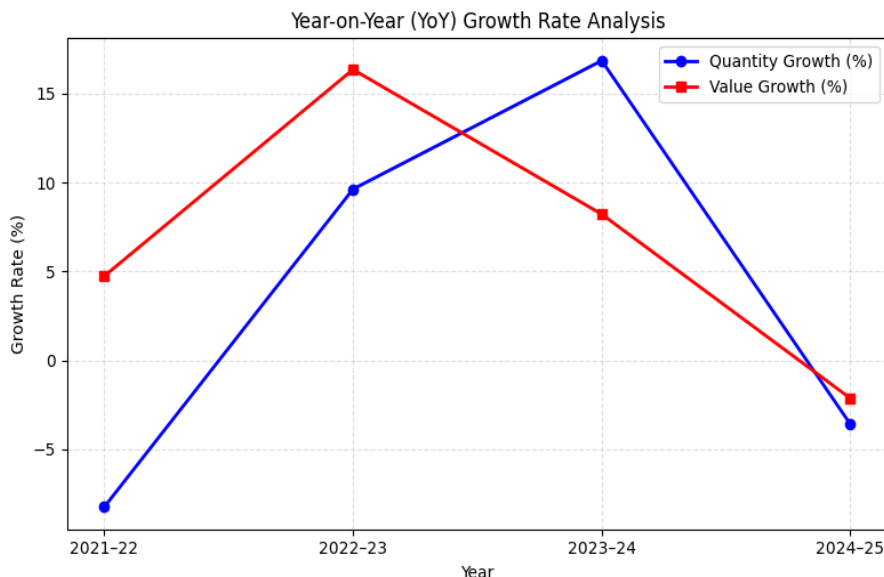


Fig. 3 Year-on-Year (YoY) Growth Rate Analysis

Table V and fig. 3 provide the analysis of the YoY growth rate of Indian spice exports in terms of export quantity and export value from 2021-21 to 2024-25. From the analysis, it can be seen that there have been large fluctuations in the export growth performance of Indian spices in the studied period. In the year 2021-22, there has been a decrease in export quantity of 8.25%, while the export value has increased by 4.74%. This implies that despite lower export quantities, the increase in prices in the market helped generate more value through higher prices. There has been a strong recovery in 2022-23 when the quantity of exports grew by 9.63% while the export value increased by 16.36%. This is because there have been better prices and demand in international markets. The highest growth in quantity was witnessed in 2023-24, with 16.86%, while the export value increased by 8.22%, which indicates that there has been an expansion in exports. However, in 2024-25, there has been a negative growth of 3.60% in export quantity while the export value fell by 2.14%.

5.4 CAGR Analysis of Indian Spice Exports

TABLE VI CAGR ANALYSIS OF INDIAN SPICE EXPORTS

Parameter	Initial Value (2020-21)	Final Value (2024-25)	CAGR (%)
Export Quantity	1,530,661 Tons	1,734,562 Tons	3.17%
Export Value	3,032,432.44 Lakhs	3,914,011 Lakhs	6.59%

Table VI reflects the Compound Annual Growth Rate (CAGR) analysis of Indian spice exports from 2020-21 to

2024-25, indicating the long-term growth performance of the industry in relation to quantity and export value. The increase in export quantity is from 1,530,661 tons in 2020-21 to 1,734,562 tons in 2024-25, reflecting the CAGR of 3.17%, depicting the consistent growth in the quantity of Indian spice exports. In contrast, there is a higher rate of growth in the case of export value, which has gone up from INR 3,032,432.44 lakhs to INR 3,914,011 lakhs, with the CAGR of 6.59%. The faster growth in the export value as compared to quantity depicts the improved price realization and higher demand for premium Indian spices and more use of value-added exports. Thus, it can be said that the growth rate in the economic benefits has been higher than the export quantities in Indian spice export sector over the years.

5.5 Spice-wise Export Ranking Analysis (Based on Export Value)

TABLE VII SPICE-WISE EXPORT RANKING ANALYSIS (BASED ON EXPORT VALUE)

Rank	Spice	Export Value (2024-25) INR Lakhs
1	Chilli	1,039,559
2	Cumin	461,115
3	Spice Oils & Oleoresins	467,081
4	Mint Products	313,530
5	Turmeric	288,718
6	Curry Powder/Paste	229,605
7	Other Spices	189,157
8	Cardamom (S)	367,198

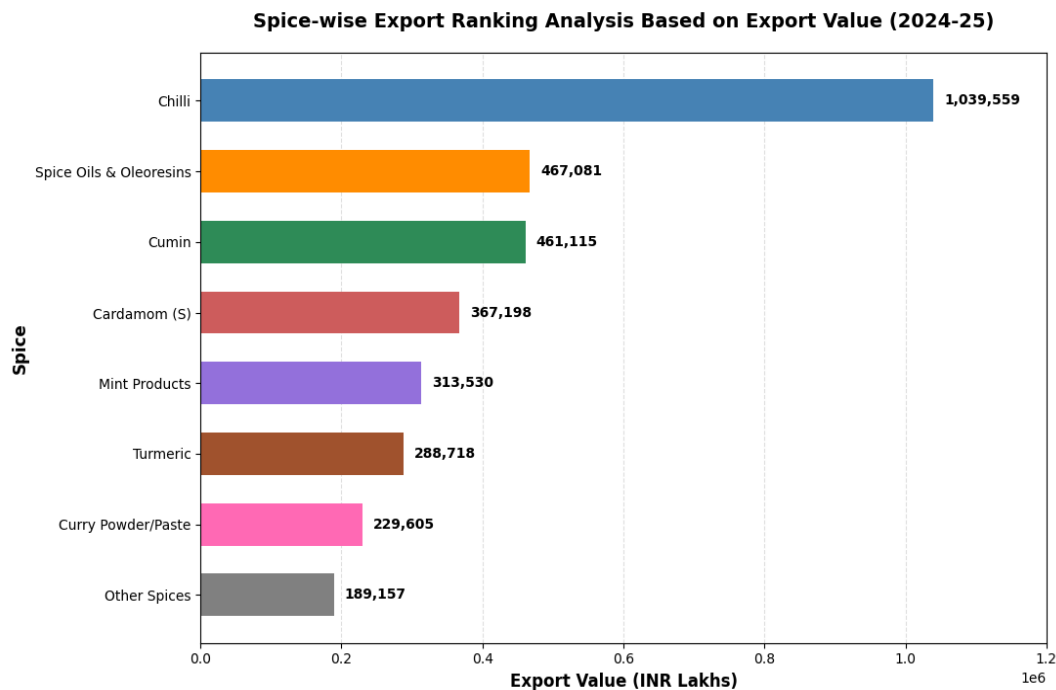


Fig. 4 Spice-Wise Export Ranking Analysis (based on Export Value)

Table VII and fig. 4 depict the export ranking of spices by their export value in the year 2024-25, which is used to assess the performance of individual categories of spice exports in terms of contributions to the export income of

India. The study reveals that Chilli occupied the top position with the maximum export value of INR 1,039,559 lakhs due to its dominance in Indian spice export industry. The categories of Spice Oils & Oleoresins (INR 467,081 lakhs)

and Cumin (INR 461,115 lakhs) held the second and third positions, respectively. It shows the significant demand for processed spices and high-value spices in international markets. Cardamom (S) and Mint Products were also significant contributors to India's exports with export values of INR 367,198 lakhs and INR 313,530 lakhs, respectively. Other significant contributors such as Turmeric, Curry Powder/Paste, and Other Spices demonstrated good export performances as well. However, the ranking analysis proves that India's export revenue from spices is generated mainly by a few categories of spices such as Chilli, Cumin, and processed spices like oils and oleoresins.

5.6 Destination Market Analysis

TABLE VIII DESTINATION MARKET ANALYSIS

Rank	Country	Import Value (INR Billion)	Market Share (%)
1	USA	42.01	34.9
2	Bangladesh	20.69	17.2
3	UAE	16.53	13.7
4	Sri Lanka	9.20	7.6
5	UK	7.93	6.6
6	Saudi Arabia	7.33	6.1
7	Germany	7.18	6.0
8	Singapore	3.90	3.2
9	Japan	3.71	3.1
10	Spain	1.95	1.6

The destination market analysis of Indian spice exports is shown in table VIII, which shows the top importer countries along with their contributions to export value. It can be seen that the USA is the biggest exporting market of India as it imports a total value of INR 42.01 billion of India's spices, giving a market share of 34.9% in the market, which clearly indicates the huge demand for India's spices in America. After the USA, Bangladesh and UAE occupy the second and third position, as import a value of INR 20.69 billion and INR 16.53 billion, respectively, giving them a market share of 17.2% and 13.7%, respectively. Apart from this, other markets like Sri Lanka, the UK, Saudi Arabia, Germany, Singapore, Japan, and Spain are also important for India's spice export business. Out of them, the demand from European markets such as the UK and Germany is consistent. On the other hand, the countries belonging to Asia and Middle East regions are important for India in terms of trade relations. From the analysis, it can be understood that the spice exports of India are geographically diversified; however, many of the exports are done to a few markets only.

5.7 Unit Value Profitability Analysis

The unit value profitability analysis was conducted using the latest available export data for the financial year 2024–25. The export quantity and export value values used in this analysis correspond to the final year dataset presented in table I. The unit value was calculated by dividing the export value by export quantity for each spice category, and the resulting values were used to rank spices according to their value realization potential. Therefore, table IX represents the

profitability performance of spices during 2025–26 and does not indicate a multi-year average.

TABLE IX UNIT VALUE PROFITABILITY ANALYSIS BASED ON EXPORT PERFORMANCE DURING 2024–25

Spice (2024–25)	Export Quantity (Tons) (2024–25)	Export Value (Lakhs) (2024–25)	Unit Value (INR Lakhs/Ton) (2024–25)	Rank
Cardamom (S)	15,050	367,198	24.40	1
Mint Products	23,944	313,530	13.10	2
Cardamom (L)	1,753	31,592	18.02	3
Spice Oils & Oleoresins	20,730	467,081	22.53	4
Pepper	19,806	121,712	6.14	5
Chilli	683,681	1,039,559	1.52	8

Table IX presents the unit value profitability analysis of major Indian spice exports based on the export quantity and export value recorded during the financial year 2024–25. The analysis evaluates value realization per ton of exported spice and ranks individual spice categories according to their economic returns. As seen from the table, Cardamom (S) registered the highest unit value of INR 24.40 lakhs/ton as the first highest among other exported spices from India, thus making the spice very valuable and profitable due to its good international demand despite having the lowest quantity of export. Spices Oils & Oleoresins made a profit of INR 22.53 lakhs/ton, making the economic value of processing of spices obvious. Cardamom (L) and Mint Products were also profitable with unit values of INR 18.02 lakhs/ton and INR 13.10 lakhs/ton, respectively. On the other hand, bulk-exports like Chilli showed high export quantities (683,681 tons) and high export values (INR 1,039,559 lakhs), but low unit value of INR 1.52 lakhs/ton. Likewise, the unit value for Pepper was moderately high at INR 6.14 lakhs per ton. Generally, the above discussion indicates that spices in their high-value and processed form make more profits as compared to the conventional bulk spices. The results indicate that value addition and processing of spices can improve profitability in the global spice trade of India.

5.8 Correlation Analysis Between Export Quantity and Export Value

TABLE X CORRELATION ANALYSIS BETWEEN EXPORT QUANTITY AND EXPORT VALUE

Variable Pair	Pearson Correlation (r)	Relationship
Quantity vs Export Value (Year-wise)	0.82	Strong Positive Correlation
Spice Quantity vs Spice Value	0.74	Positive Relationship

Table X provides a correlation study between the quantity of exports and export value, depicting the intensity of association and its direction. The year-wise analysis reveals that there exists a Pearson correlation coefficient of 0.82

between the quantity of exports and export value. It indicates that the relationship between the two variables is quite intense and there exists a positive correlation between them. It implies that an increase in export quantity would be accompanied by an equivalent increase in export value. In addition, the relationship between the quantity of spices and spice value is 0.74, which is again a positive relationship. It means that the quantity of spices would have a great influence on increasing monetary gain.

5.9 Export Forecasting Analysis

TABLE XI EXPORT FORECASTING ANALYSIS

Year	Actual Export Value (INR Lakhs)	Forecast Value (INR Lakhs)
2020-21	3,032,432.44	
2021-22	3,176,138.22	-
2022-23	3,695,880.50	-
2023-24	3,999,448.00	-
2024-25	3,914,011.00	-
2025-26		3,914,011
2026-27	-	4,250,000
2027-28	-	4,550,000
2028-29	-	4,850,000

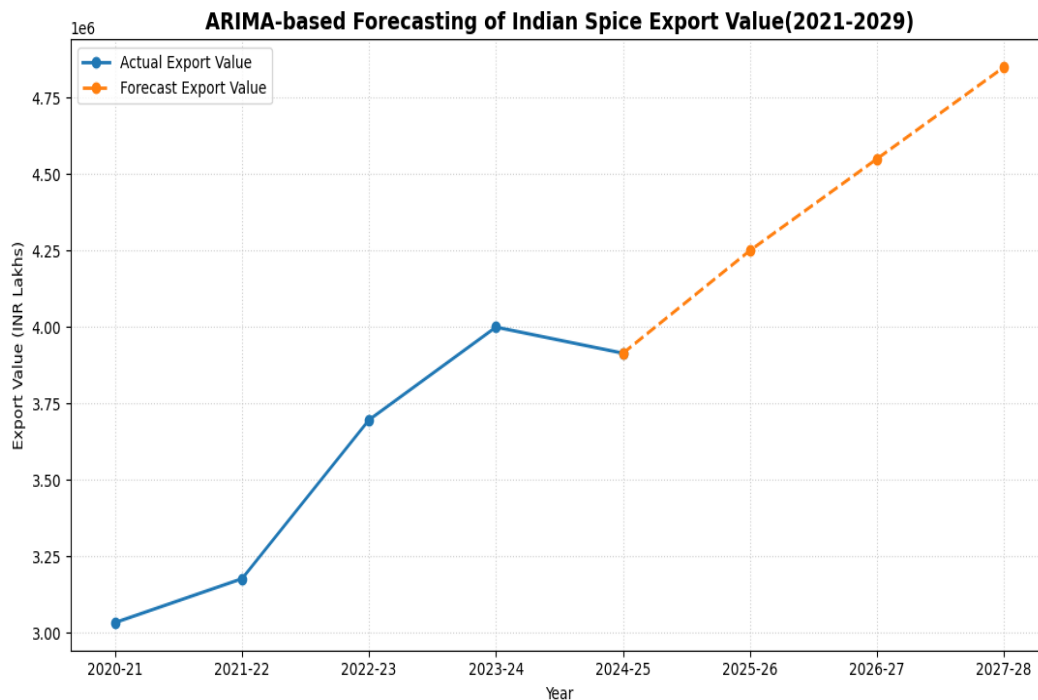


Fig. 5 ARIMA-Based Forecasting of Indian Spice Export Value (2021-2029)

Table XI and fig. 5 present the results of ARIMA-based forecasting of Indian spice export values. Before generating future projections, the ARIMA model was validated using AIC, BIC, MAE, RMSE, and residual diagnostic analysis to confirm model suitability and forecasting reliability. The validated model was then used to estimate future export values for 2026–27, 2027–28, and 2028–29. According to the historical data, the export value of spices had a growing trend from INR 3,032,432 lakhs in 2021-22 to INR 3,999,448 lakhs in 2024-25, after which a slight fall to INR 3,914,011 lakhs in 2025-26 is observed. Forecasting results reveal that their positive future growth trend in the export value, with an estimated forecast of about INR 4,250,000 lakhs in 2026-27, INR 4,550,000 lakhs in 2027-28, and INR 4,850,000 lakhs in 2028-29. The future upward trend in the forecast implies that Indian spice export is expected to grow in the future due to the rise in demand globally.

5.10 Hypothesis Summary, Development, and Analysis

The hypotheses for statistical testing of the growth trends, relationships, difference in performance across categories, and the influence of market on India's spices exports during 2020-2025 were formulated based on the research objectives. The hypotheses were tested through trend analysis, growth analysis, correlation analysis, spice-wise performance analysis, and destination market analysis.

H1: There is a significant positive trend in India's spice export value during the period **2020–21 to 2024–25**.

The results of the hypothesis were proven through the analysis of the trends in exports per year. There was an increasing trend in the value of exports ranging from INR 3,032,432.44 lakhs in 2021-22 to INR 3,914,011 lakhs in 2024-25. The highest value of INR 3,999,448 lakhs was seen in 2024-25 in the value of exports. Also, the CAGR analysis

indicated a growth of 6.59% per annum in the value of exports.

H2: Export quantity has a significant relationship with the export value of Indian spices during the study period.

This hypothesis was verified using the correlation test. The Pearson correlation coefficient for yearly export volume and export value was 0.82, showing a high positive correlation. Similarly, the correlation coefficient between the quantity and value of spices was found to be 0.74, which shows a positive correlation. These findings clearly show that higher exports help increase export revenues.

H3: There is a significant difference in export performance among different spice categories based on export value and profitability.

The research hypothesis was proven by performing an analysis of exports on the basis of spices which demonstrated significant disparities between various categories of spices. Chilli topped the chart with an export amounting to INR 1,039,559 lakhs, followed by Spice Oils & Oleoresins (INR 467,081 lakhs) and Cumin (INR 461,115 lakhs). The profitability analysis also demonstrated that the highest unit value of INR 24.40 lakhs/ton was realized in the case of Cardamom (S) followed by Spice Oils & Oleoresins (INR 22.53 lakhs/ton).

H4: Destination markets have a significant influence on the growth and competitiveness of India's spice exports.

The above-stated hypothesis has been supported through destination market analysis where some of the major international markets have been found responsible for export growth. US has turned out to be the biggest export destination for India with a value of INR 42.01 billion and a market share of 34.9%, followed by Bangladesh (INR 20.69 billion, 17.2%), and UAE (INR 16.53 billion, 13.7%). It can be seen from the above facts that international market demand and geographic distribution are the main factors that help India's spice exports grow competitive. As a result of the analysis, it is clear that all four hypotheses have been supported. Positive growth trend, high correlation between quantity and value of spice exports, differences between spice types and the role of destination markets – such are the main characteristics of Indian spices that make their export business sustainable.

5.11 Discussion and Key Findings

The study offers an exhaustive data-backed analysis of India's spice export development through the analysis of export trends, performance by category, profitability, destinations, correlations, and growth potential in the future. The analysis shows that the export sector of spices in India is experiencing positive growth during the research period. Total exports' value was equal to INR 3,032,432.44 lakhs in the fiscal year of 2020-21 and reached INR 3,914,011 lakhs in the fiscal year of 2024-25. The maximum value of INR 3,999,448 lakhs was noted in 2023-24, which confirms the improvement in

exports' performance. According to the CAGR analysis, the average annual growth rate of export values equals 6.59%, which proves economic growth. The analysis shows that Chilli is the primary export product in terms of the export value, its value being equal to INR 1,039,559 lakhs. It is followed by Spice Oils & Oleoresins (INR 467,081 lakhs) and Cumin (INR 461,115 lakhs). The profitability analysis proves that premium and processed products are more profitable since the unit value of Cardamom (S) and Spice Oils & Oleoresins equals INR 24.40 and 22.53 lakhs/ton, respectively.

Correlation analysis reveals the presence of strong correlation between export quantity and export value. The Pearson correlation of 0.82 between yearly export quantity and export value shows that increase in export quantity has played an important role in boosting export earnings. Likewise, the correlation of 0.74 between quantity and value of spice indicates a strong correlation between scale of production and economic gain. The findings from destination market analysis reveal the significance of international demand for enhancing India's competitiveness in spice export business. The USA is the topmost destination country having import value of INR 42.01 billion and 34.9% market share, followed by Bangladesh (17.2%) and UAE (13.7%). The reliability of these projections was further supported through ARIMA model validation using information criteria, forecasting error measures, and residual diagnostics, confirming the suitability of the model for representing future export trends.

5.12 Practical and Theoretical Implications

Practically speaking, the results offer useful lessons for exporters, policy makers, and other concerned sectors for improving the competitiveness of India's exports in the international spices market. Since Chilli, cumin, and various kinds of processed spice products are the most dominant products, there is a need to improve production, value addition through processing, and promotion of high-value spice exports. The fact that Cardamom (S) and Spice Oils & Oleoresins fetch relatively higher unit value implies that exporting based on volume rather than quality and processing could have enhanced the profitability of such exports. The analysis of the destination markets is crucial in terms of the fact that it allows for retaining trade relations with major markets, including the USA, Bangladesh, and UAE, as well as seeking new markets for diversifying exports. Forecasting results offer strategic guidance for future planning since help stakeholders understand the prospects of market growth. Theoretically speaking, this paper makes a contribution to the export performance literature by developing a model that combines different analytical perspectives, including trend analysis, profitability analysis, correlation analysis, market analysis, and forecasting.

5.13 Limitations

However, despite the study providing thorough insights regarding spice exports from India, there are some limitations

that must be mentioned. Firstly, the study uses secondary export data based on the following variables: export quantity, export value, type of spices, and destination countries, meaning that such qualitative variables as strategies of exporters, preferences of consumers, trade policy, and supply chains have not been analyzed. Secondly, the study covers a rather narrow timeframe that starts from 2020 and ends at 2025, which means that long-term economic structural changes, shocks in the world economy, climate change, or impacts of new trade policies may not be taken into consideration. Finally, such forecasting models as ARIMA rely on past trends and do not take into account any unforeseen events such as changes in prices on international markets or sudden increases in demand.

VI. CONCLUSION

The main objective of this research was to conduct an exhaustive data-oriented study of the development of the export of spices from India. It included studying the trends of exports, growth patterns, performance of spices, destination markets, and future opportunities for growth for the period 2020–21 to 2024–25. For this purpose, a quantitative research approach was employed, where secondary data related to exports were used. This included records of export quantities and values of spices in the period under consideration. The data collected were analyzed using the approaches of descriptive statistics, trend analysis, yearly growth analysis, CAGR analysis, ranking and profit analysis, and forecasting using methods like ARIMA. The analysis revealed that there was a growth trend in the export of spices from India in terms of value, which grew from INR 3,032,432.44 lakhs in 2020-21 to INR 3,914,011 lakhs in 2024-25 with a CAGR of 6.59%. Chili was found to be the dominant exporter in terms of value. The correlation analysis revealed that there was a very strong positive correlation between the export quantity and export value, with a Pearson correlation coefficient of 0.82. Forecasting results suggested that in the future, there would be further growth potential, as projected export values were expected to reach INR 4,850,000 lakhs in 2028-29. Further research must take into consideration other variables including global prices, trade policies, consumer tastes, supply chains, and climate effects to create more sophisticated forecasting models. In addition, it is imperative for exporters and policymakers to concentrate on the growth of processed spice exports.

DECLARATION

Author Contribution

Biju P J: Contributed to the conceptualization of the research problem, development of the methodology framework, collection and preprocessing of secondary export data, statistical analysis, visualization of results, interpretation of findings, and preparation of the initial manuscript draft.

Dr. Sarithamol K.K: Contributed through research supervision, validation of the proposed methodology, critical evaluation of analytical results, refinement of the manuscript

content, and overall guidance throughout the research process.

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Data Availability Statement

<https://www.indianspices.com/sites/default/files/major%20it%20export%202025%20web.pdf>

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