



RESEARCH ARTICLE

# Production trends and export performance analysis of Indian fresh mangoes and mango pulp: A two-decade assessment (2004-2024)

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## Abstract

India is the largest producer and consumer of mangoes, accounting for approximately 45 % of the world's production. Mangoes and mango pulp export holds a significant position in Indian agricultural trade. The secondary data obtained from Indiastat and Agricultural and Processed Food Products Export Development Authority (APEDA) were examined using Compound Annual Growth Rate (CAGR), instability indices and the Markov chain to assess production performance, instability in production and exporting countries and trade directions. The analysis demonstrates an in-depth analysis of production trends & performance and export directions of mangoes and mango pulp over the last two decades, as they significantly contribute to export. The findings revealed an overall increase in the area, production and productivity of mango with low instability, indicating low fluctuations. The UAE exhibited low instability with 29.5 % of fresh mango export, whereas Saudi Arabia (20.5 %) and the USA (17.4 %) showed low instability in mango pulp export. The UAE remains the stable importers of fresh mangoes with 66 % retention potential, while Saudi Arabia and UAE were the stable importers of mango pulp with the retention potential about 97 % and 67 % respectively. The forecasted export up to 2028-29 revealed that the UAE and UK continued to be the promising markets of Indian mangoes, while Saudi Arabia and USA for Indian mango pulp. The study emphasizes the significance of improving trade infrastructure, raising quality standards and promoting policy support to boost India's export competitiveness for mango and mango pulp in the global market.

**Keywords:** CAGR; fresh mango; future predictions; growth rate; instability index; mango pulp; Markov chain; production; trend

## Introduction

India is the world's largest producer of fruits, contributing approximately 95 million metric tons annually, followed by China. Mango (*Mangifera indica*) of the Anacardiaceae family is the second largest produced fruit (22.40 million metric tons) in India after banana (37.61 million metric tons) (1). Mango is frequently referred to as the king of fruits among South Asian countries and it is considered the national fruit of India. Mangoes constitute 50 % of all tropical fruits produced globally and it is highly valued with their increased demand and significant economic impact in the international market (2, 3). Mangoes are rich in Vitamin A and C renowned globally for their sweetness containing 20 % of Total Soluble Solids (TSS) (4). In addition to their nutritional content, mangoes possess fattening, diuretic and laxative properties, which aid in enhancing digestive capacity (5). Nearly 1000 mango varieties exist out of which 20 varieties are grown commercially in India (6). Total mango production worldwide is about 59.15 million metric tons and India is the largest producer with 22.4 million metric tons, which contributes

about 45 % of total world's total production, followed by Indonesia (4.1 million) and China (3.8 million) metric tons. Deep, aerated, well-drained, loamy, alluvial soils that are high in organic matter with a pH range of 5.5 to 7.5 are ideal for mango cultivation (National Horticultural Board). The favourable soil and climatic conditions and diversified varieties result in the increased production and supply of mangoes throughout the year (7). Because of its extensive cultivation, economic significance and cultural value in tropical and subtropical regions, Uttar Pradesh ranks first in the production of mango and producing about 5.99 million tons followed by Andhra Pradesh with 4.98 million tons and during the year 2023-24. Bihar, Karnataka, Madhya Pradesh, Gujarat, Tamil Nadu and West Bengal are the other leading producers of mango in India (8). Alphonso (king of mangoes), totapuri, kesar, badami and banganapalli are the major mango varieties produced and exported from India with the high demand and significantly generate foreign exchange along with the use of unique geographical indication tags in the international markets (9). Mexico is the world's largest

exporter of mangoes and India holds the fourth rank in global exports. The various factors such as domestic consumption, restrictions to trade, post-harvest losses at the point of storage and handling and ensuring the overall quality, influences the export performance (10). Indian mangoes are mainly exported to UAE, Nepal, the UK, the USA, Kuwait and Saudi Arabia.

Mango pulp is a processed form produced by extracting the inner flesh of mature mangoes and separating the skin and seed. It was followed by pasteurization based on the methods such as low temperature long time (85 °C), high temperature short time (95 °C) or ultra-high temperature (120 °C) and packaging using various methods like modified atmospheric packaging, biodegradable packaging, smart packaging and vacuum packaging (11). It can be packed using aseptic packaging and canned to store for a period up to 24 months, or it can be kept frozen at a temperature of -18 °C and stored in bulk quantities without any preservation. Alphonso, totapuri and kesar are the major mango varieties preferred for mango pulp processing with a high level of pulp content, aroma and sweetness. Among the varieties, totapuri has the high pulp content of nearly 70 %, alphonso has the higher protein and mineral content and significantly higher dietary fibre and totapuri has the higher fat content (12). Chittoor in Andhra Pradesh and Krishnagiri in Tamil Nadu are the two major mango pulp clusters in India, comprising around 65 processing units (13). Mangoes are processed and consumed in various forms such as juices, nectars, pickles, jam, jelly and chutneys (14). Depending on the varieties, mango pulp consists of non-edible peels about 20 %, non-edible kernels up to 40 % and edible pulp up to 85 %. India's largest fruit export continues to be the mango, which is primarily shipped as pulp (15). India exports about 60900.23 metric tons mango pulp with a value of 75.95 US Million Dollars / 64618 lakhs INR. India is the largest exporter of mango pulp in the world, dominating about 83 % of the global export (16). Peru, Vietnam & Bangladesh are the other major mango pulp exporters. Saudi Arabia, USA, UAE, UK and Netherlands are the major importers of mango pulp in the world. Saudi Arabia, the USA and the UK contribute more than 50 % of total imports. India acts as a primary supplier of mango pulp to the USA.

The Pradhan Mantri Kisan Sampada Yojana (PMKSY) launched by the Ministry of Food Processing Industries (MoFPI) offers financial support to implement food processing units, cold storage units and packaging units by providing credit up to 35 % (17). PM Formalisation of Micro Food Processing Enterprises (PMFME) Scheme provides business guidance and financial support to micro processing enterprises (18). Export Promotion Capital Goods (EPCG) helps in importing advanced processing, grading and sorting equipments for export-oriented products at zero customs duty for mango pulp manufacturers. This helps in reducing the overall cost of production and helps to meet the international standards (19). Therefore, these schemes lead to the increased export of mango pulp by the nation.

The objectives of the study are to estimate the long-term trends and instability in area, production and productivity of mango. To assess the country-wise volatility of mango and mango pulp export from India. To analyse the

trade directions, market retention potential and future directions of fresh mangoes and mango pulp export. Most literature focussed on short term patterns, lacking long-term trends on area, production and productivity of mango and noticeable lack on comprehensive study analysing both the production trends and export performance over decades. India currently existing the largest exporter of mango pulp, majority of studies were focused on fresh mango export, resulting lack of research on trade directions, future predictions and implications of mango pulp export. The period from (2003-04 to 2023-24) where chosen to ensure consistent pattern, reliable assessment and accuracy of results. The study categorised the years into decades and patterns of each decade were analysed to obtain optimum results.

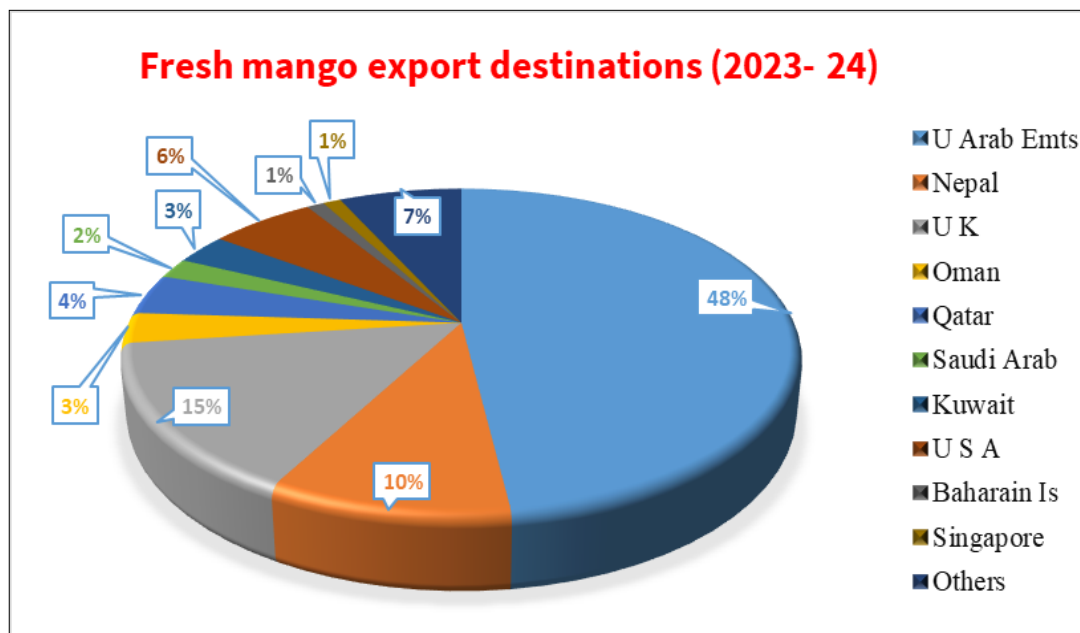
### Global scenario of Indian fresh mangoes and mango pulp

Mexico is the world's largest exporter of mangoes, holding global share of 36 % with export value of \$576 million in 2024. It accounts for 85 % of total US mango exports with the North American Free Trade Agreement (NAFTA), which helps reduced tariffs and trade barriers between the nations. Brazil being one of the major exporters of fresh mangoes holding share about 25 % with export value of 345 million dollar, primarily focussed on Netherlands, UK and Spain. The top fresh mango importing countries from India during the year (2023-24) were categorized as follows in Fig. 1. With 15336 metric tons of total exports, the UAE is the largest importer, making up about 48 % of the total. The UK follows with 15 % of imports with 4706 metric tons and Nepal accounts for 10 % with 3106 metric tons. Fig. 2 highlights the top importers of mango pulp from India during the year (2023-24). With 15388 metric tons of total exports, Saudi Arabia holds the largest importer with about 25 % of the total exports from India. Followed by it, Yemen Republic accounts for 10 % of imports with 6211 metric tons and the USA accounts for 8 % with 5090 metric tons. There are more than 480 mango exporting companies in India in 2017 and with more than 6000 exporters at 2024 (2).

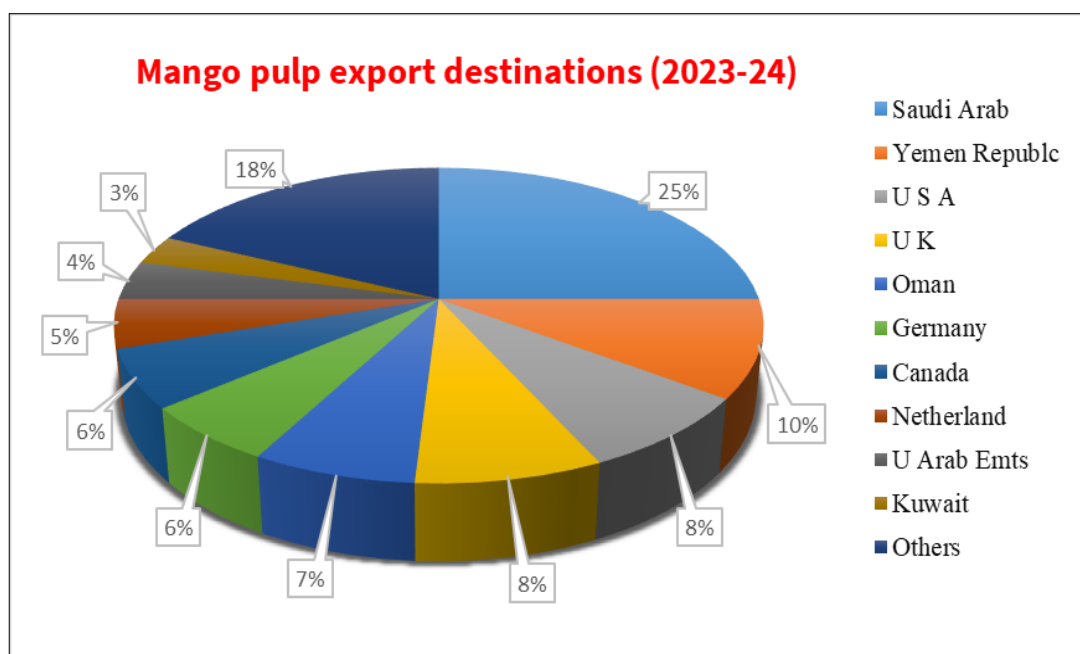
### State-wise export performance

Fig. 3 shows that Maharashtra is the largest exporter of fresh mangoes, with an export volume of 25203 metric tons accounting for 79 % of the nation's total export volume and earning a value of about 41 lakhs, representing 84 % of total export value. As it produces premium varieties such as Alphonso and Kesar, which are highly demanded globally and with the presence of good infrastructure facilities such as packaging houses and export hubs. The presence of Jawaharlal Nehru Port (JNPT) shares the largest part of exports of the nation, results MH as top exporter among the states (2). With the Himsagar and Lakshman Bhog varieties accounting for 1658 metric tons of exports, representing 5.2 % of total volume, worth 746 Lakhs, West Bengal is the second largest exporter. In addition, Bihar, with its well-known Bhagalpur GI-tagged Zardalu variety, accounts for 308 metric tons of exports, representing 4 % of the country's total exports (20).

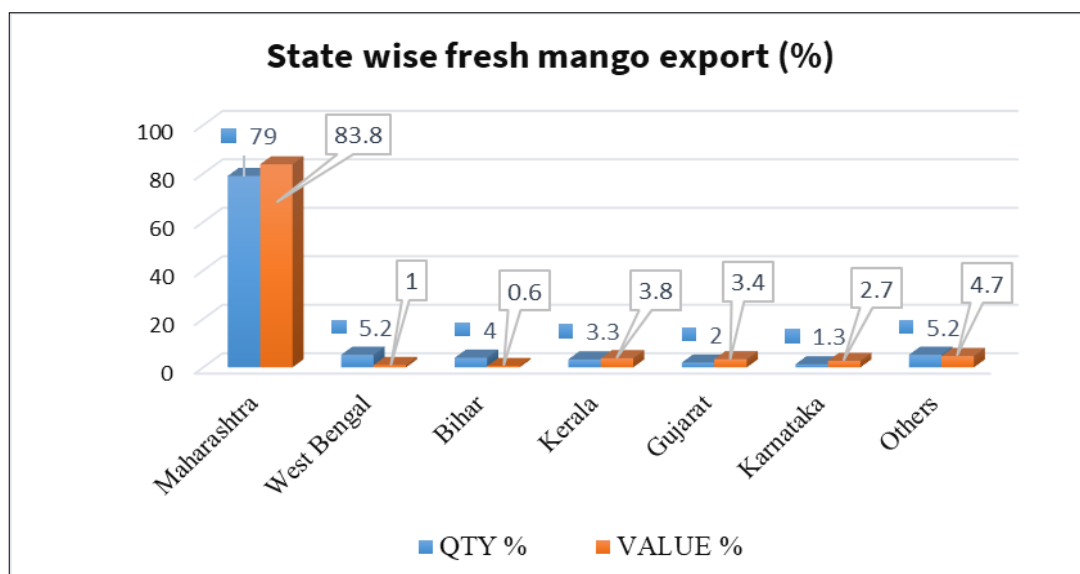
Fig. 4 illustrates that Gujarat is the leading exporter of mango pulp in India with export volume of 22234 metric tons accounting for 37 % of total export with their Kesar and Alphonso mangoes which is highly suited for pulp because of



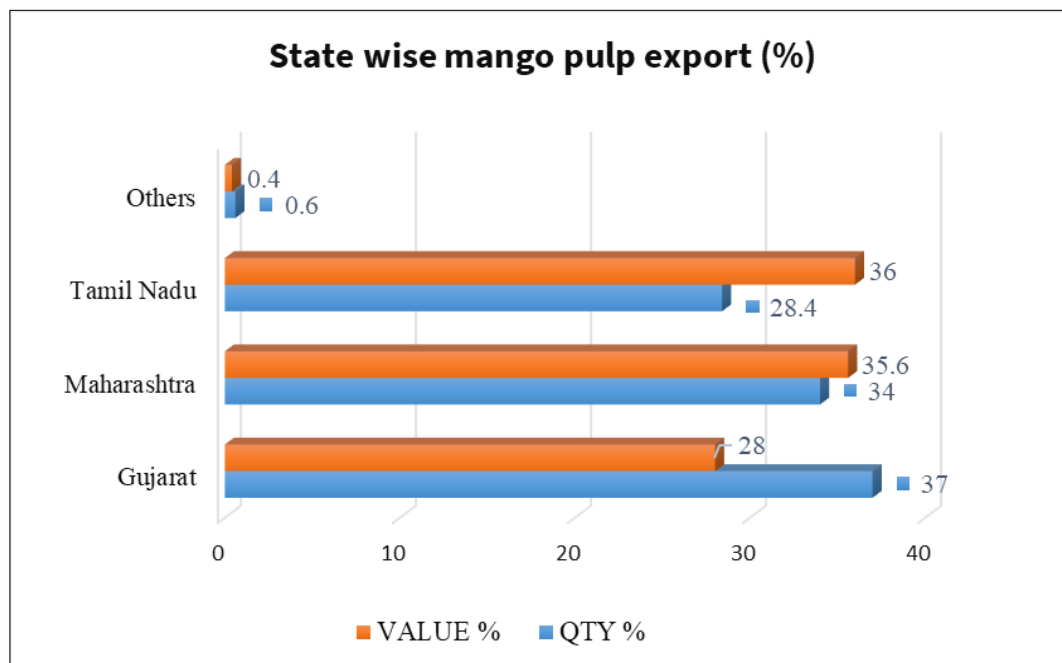
**Fig. 1.** Fresh mango export destinations.



**Fig. 2.** Mango pulp export destinations.



**Fig. 3.** State-wise export performance of fresh mango.



**Fig. 4.** State-wise export performance of mango pulp.

its rich aroma, colour and taste. 70 % of Gujarat's processed mango pulp are exported to global markets (21). With its high-quality Alphonso variety and well-developed infrastructure, Maharashtra accounts for 34 % of all exports with 21266 metric tons. Tamil Nadu remains one of the major exporters with 17567 metric tons accounting for 28.4 % of the total export, with the presence of nearly 46 mango processing units in Krishnagiri district, where 90 % of the processed pulp is exported (13). Gujarat, Maharashtra and Tamil Nadu are the major exporters of mango pulp from India, accounting for 99 % of the total export.

#### Method of study

The study was conducted based on the secondary data from the APEDA Agri Exchange and Indiatat.com (22, 23). To ensure accuracy and reliability, secondary data from widely recognized and government authorized database were used in the study. The export data were cross-checked with searxim solutions data. To obtain the trend and CAGR, area, production and productivity data during the period of twenty years from 2004-05 to 2023-24 were obtained from the Indiatat portal which were also cross-checked and validated with Ministry of Commerce and Industry Report. Area, production, productivity data and country wise export data were used to estimate the instability index. To estimate trade directions and the probability of export, the top eight major importing countries were selected and the country wise annual data for the period from 2008-09 to 2023-24 were selected and used for the study.

#### Tools involved for analysis

##### Compound Annual Growth Rate (CAGR)

The growth performance of mango total cropped area, production and productivity using time series data obtained from IndiaStat from 2004-05 to 2023-2024 was calculated using the CAGR by the exponential form,

$$Y = ab^t \quad (\text{Eqn. 1})$$

where,

Y = Dependent variable i.e., area, production, productivity

a = Intercept of the equation

b = Regression coefficient

t = time period (2004-05 to 2023-24)

The growth rate was derived using the logarithmic form of the equation expressed as:

$$\ln(Y) = \ln(a) + t \times \ln(b) \quad (\text{Eqn. 2})$$

Where  $\ln(Y)$ ,  $\ln(a)$  and  $\ln(b)$  represent the natural logarithms of Y, a and b respectively.

The CAGR was calculated using the formula:

$$\text{CAGR} = [\text{antilog}(b) - 1] \times 100 \quad (\text{Eqn. 3})$$

**Hypothesis (H<sub>1</sub>):** There is a statistically significant positive growth trend in area, production and productivity during 2004-05 to 2023-24.

**Null hypothesis (H<sub>0</sub>):** There is no statistically significant growth in area, production and productivity during 2004-05 to 2023-24.

The statistical significance for coefficient (b) were tested using t-test. Growth rates are statistically significant at 1 %, 5 % and 10 % levels with 95 % confidence intervals.

##### Instability Index (I)

The instability index was used to determine the significant fluctuations in mango cropped area, production, productivity and the fluctuations in the import of the countries over the study period. The Cuddy-Della Valle index has been employed to measure the relative instability index, it corrects the coefficient of variation, while the simple coefficient of variation overestimates the level of volatility in time series data with a long-term trend (24). The following formula may be used to calculate the coefficient of variation.

$$I = CV * \sqrt{1 - R^2} \quad (\text{Eqn. 4})$$

where,

I = Instability index

CV = Coefficient of variation

R = Regression value

Coefficient of variation is calculated by the formula,

$$CV = \frac{\sigma}{\bar{x}} \times 100 \quad (\text{Eqn. 5})$$

$\sigma$  = Standard deviation

$\bar{x}$  = Arithmetic mean

CDVI value <15 % indicates low instability, 15-30 % indicates medium instability, >30 % indicates high instability.

#### Markov chain analysis - Transitional probability matrix

It is a process of events to measure the trade patterns and directions of the fresh mango and mango pulp export from India over the years. Here, 8 major exporting countries were taken for the years (2008-09 to 2023-24) to analyze the retention probability and change in the trade patterns of the countries are predicted based on the previous series of events. It is expressed using,

$$E_{jt} = \sum_{i=1}^r E_{it-1} \times P_{ij} + e_{jt} \quad (\text{Eqn. 6})$$

$E_{jt}$  = Export of Indian mangoes over the years from (t) to  $j^{\text{th}}$  country

$E_{it-1}$  = Export of mango from India to  $i^{\text{th}}$  country from the year t-1

$P_{ij}$  = Probability of mango export shift from  $i^{\text{th}}$  to  $j^{\text{th}}$  country

$e_{jt}$  = The error term independent of  $e_{it-1}$

r = Number of importing countries

The transition probability matrix is arranged in a (c x r) matrix form with the following properties. The diagonal matrix indicates the probability of export share of the country during the period (t-1).

$$\sum P_{ij} = 1 \text{ for all } i \quad (\text{Eqn. 7})$$

The export share of the country during the period t, obtained by multiplying the actual exports with the previous period (t-1) to obtain the export shares of the countries at the period t. The transitional probability matrix was estimated in the Linear Programming matrix (LP) framework by minimization of Mean Absolute Deviation (MAD), which is presented as,

$$\text{Min } OP^* + Ie \quad (\text{Eqn. 8})$$

Subject to,

$$X P^* + V = Y$$

$$G P^* = 1$$

$$P \geq 0$$

Where,

P = Vector of the probabilities  $P_{ij}$

O = Vector of zero

I = dimensional vector of area

e = vector of absolute errors

Y = proportion of exports of each country

X = Black diagonal matrix of lagged values of Y

V = vector of error

G = grouping matrix to add new row elements of probability arranged in  $P^*$  to unity

The trade patterns and export shares from one country to another over the period of 16 years were calculated using the first order Markov chain model. To identify significant relationships among importing nations, trade matrices were estimated. Markov chain analysis was used to analyze systemic changes in any structure whose improvements over time can be measured in terms of a single outcome variable (15). In the transition matrix, values in the rows indicate losses to other countries, while values in the columns represent gain from other countries. The future predictions for the next five years up to 2028-29 were done using the transitional probability matrix and the last year's export data using the matrix multiplication method. Analyses were done using LP Solve software (Version 5.5.2.11).

## Results and Discussion

### Growth rate of mango

#### Area

It is evident from Table 1, that CAGR increased by 2.7 % during the first decade (2004-05 to 2013-14) and by 0.18 % during the second decade (2014-15 to 2023-24). The overall 20 years land area resulted in lower growth of 0.6 %. Increased urbanization, lack of available land for cultivation and farmers switching to other crops resulted in the lower growth of production area.

#### Production

Production increased at a stronger rate of 4.5 % during the first decade (2004-05 to 2013-14) and the rate remains comparatively low with the rate of 1.5 % in the second decade (2014-15 to 2023-24). Despite challenges, mango production has remained steadily increasing over the years at the rate of 3.5 % with rising demand for Alphonso, bangnapalli and other such varieties and the presence of a suitable climate

**Table 1.** CAGR of area, production and productivity of mango

Particulars	Sub-periods (%)		
	I	II	Overall (%)
	(2004-05 to 2013-14)	(2014-15 to 2023-24)	(2004-05 to 2023-24)
Area	2.77	0.18	0.66*
Production	4.5	1.5*	3.5*
Productivity	1.7**	1.4***	2.8

Source: Indiatat

Note: \*indicates level of significance at 1 %, \*\*indicates level of significance at 5 %, \*\*\*indicates level of significance at 10 %



and well-drained alluvial and red soil conditions in the country. The government's development of agri export zones and the formation of cooperatives in the main mango-producing states may be the factor behind the rise in mango production (25). In partnership with the Ministry of Commerce, Export Promotion Board, NHB, APEDA and the Government of India, the Indian government has also implemented several initiatives to increase mango production and exports (26).

### Productivity

Productivity growth has been moderate over the last two decades, at 1.7 % and 1.4 %, respectively, resulting in a continuous increase of 2.8 % (2004-05 to 2023-24). The increase is influenced by an increase in the number of plantings per unit area as maximum density planting and usage of high-yielding varieties such as hapus, neelum, banganapalli (27). The grafted mango varieties Alphonso, dashehari, langra and hybrid such as mallika, amarapalli also results in increased productivity.

From Fig. 5 it is observed that the highest productivity was recorded during the year 2017-18 and followed by 2023-24 over the study period with 9.7 and 9.35 respectively. The highest production recorded as 22.39 million metric tons during 2023-24 and production nearly doubled from 11.49 million metric tons during 2004-05, which results in the increasing trend. Strict non-tariff measures adopted by developed nations and a significant decline in Indian exports to Bangladesh are the main reasons for the decline of the trend during 2018-20 (26).

### Instability Index

#### Area

It is evident from Table 2, that first decade had extremely low instability with 1.9 % suggesting a consistent area of mango cultivation with increased land availability. The second decade with comparatively more instability with 4.28 % was reflected by farmers' shift to high-value crops and with increased unavailability of land due to urbanization. The overall instability of cropped area was significantly low with 5.5 % (2004-05 to 2023-24).

#### Production

The production was relatively stable over both decades with

4.8 % & 4.1 % respectively. The overall low instability of 6.04 % (2004-05 to 2023-24) was influenced by the usage of high-yielding varieties and use of resistant varieties for pest attacks including fruit fly and hoppers infestation and diseases including Powdery mildew and Anthracnose.

### Productivity

The lower instability in area & production results in lower instability in productivity during the total study period (2004-05 to 2023-24) with 7 % (<15 % - low instability value) which is sensitive to factors such as climatic conditions, pest and disease outbreaks. The use of good agricultural practices, particularly high-density planting results in stable productivity (8).

### Country wise instability of fresh mango export

As shown in Table 3, among the major mango importing countries, Kuwait has the highest instability value with 82.18 % followed by Oman at 66.68 %. These countries lack consistent imports from India as they also import mango from other countries such as Pakistan & Mexico and with increased checks in fruit fly infestation lead to rejections & delays in clearance. Their fluctuating economic conditions also lead to high instability. It is followed by Nepal with 62.7 % being a neighbour of India they rely on road transport which may lead to border closures during various periods in the nation leads to inconsistent exports. The countries such as Singapore (42 %), Qatar (39.5 %) and Canada (41.8 %), have moderate instability. UAE holds the lowest instability value 29.5% over all the other countries resulting in the consistent and stable importer of Mango from India. It is due to various reasons such as high demand for Indian mango varieties with the presence of the Indian expatriate population. The presence of Jebel Ali Port with 134.68 sq. km in UAE plays as a major hub for Arab countries from which the mangoes are reshipped to other nations, with the increased infrastructure and cold storage facilities making consistent exports (28). The CEPA between India and UAE reduces tariffs and export procedures, making increased and consistent imports from India.

### Country wise instability of mango pulp export

As shown in Table 4, Germany has a very high instability index of about 128 %, resulting in high inconsistency in imports from India due to their strong European Union sanitary and

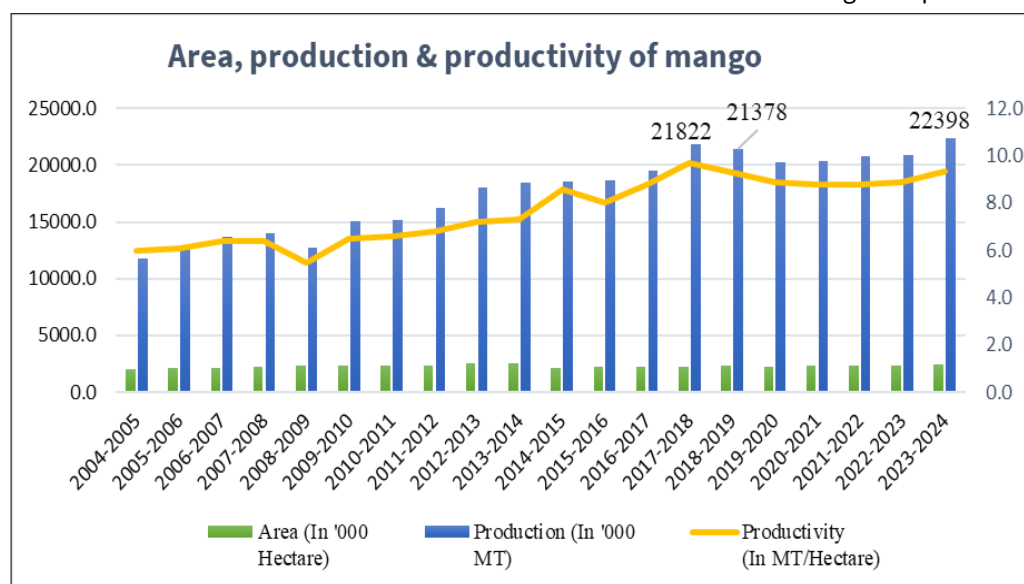


Fig. 5. Trend in area, production and productivity of mango, 2004-05 to 2023-24.

**Table 2.** Instability indices of area, production and productivity

Particulars	CV (%)	Instability index (CDVI) (%)		
		I	II	Overall
		(2004-05 to 2013-14)	(2014-15 to 2023-24)	(2004-05 to 2023-24)
Area	6.7	1.97	4.28	5.509
Production	20.36	4.8	4.13	6.04
Productivity	17.72	5.49	6.27	7.07

Source: Indiatat

Note: CV- Coefficient of Variance; CDVI- Cuddy-Della Valle Instability

**Table 3.** Country wise instability indices of fresh mango export (2004-05 to 2023-24)

Countries	CV (%)	CDVI (%)
UAE	32.15	29.51
U K	41.62	37.65
Nepal	63.97	62.71
Qatar	77.44	39.55
Kuwait	97.85	82.18
Oman	115.42	66.68
Canada	50.49	41.87
Baharain Is	42.21	38.97
Singapore	49.04	42.27
Saudi Arabia	51.47	33.51

**Source:** Author's calculation based on the data from APEDA

phytosanitary regulations. Oman has a high instability value of 68 % after Germany. Saudi Arabia, Canada has comparatively low instability with 20 % and 22 % respectively, resulting in consistent import of Indian mangoes. With the presence of large processing industries and an increased preference for mango-based beverages, makes consistent imports by Saudi Arabia. Canada has a larger South Asian diaspora which results high preference for mango-based products and the bilateral trade agreements with India have increased imports of mango pulp from India. The USA is the most stable and consistent importer of Indian mangoes having a low instability value of 17 % despite having Mexico as the primary exporter of mango, their varieties are suited for fresh consumption and India serves as a primary importer of mango pulp to USA which prefers Alphonso and Totapuri mango varieties with high pulp content of about 75 %. Along with the high consumption of mango-based products, it remains the stable importer.

### Markov chain - Transitional probability matrix

#### Fresh mango

A transitional probability matrix using Markov chain analysis was used to study the direction of trade of mangoes from India to major destinations. The matrix Table 5. shows that the UAE remains a robust market for Indian mangoes among major importing countries, with the highest retention probability of 0.66 or 66.4 %. It had lost its market share of

**Table 4.** Country wise instability indices of mango pulp export (2004-05 to 2023-24)

Countries	CV (%)	CDVI (%)
Saudi Arabia	33.4	20.52
Yemen Republic	39.6	34.24
U S	21.5	17.49
U K	43.2	42.96
Oman	72.5	68.078
Germany	137.5	128.62
Canada	23.3	22.69
Netherland	35.7	31.87
UAE	51.2	32.43
Kuwait	30.7	30.48

**Source:** Author's calculation based on the data from APEDA

about 34.4 % to Nepal, whereas it has gained a market share of 69 % from Kuwait 63.3 % from Nepal, 30.6 % from Qatar and 16 % from other countries. Indian mango exports have been subjected to vapour heat treatment, which improved the quality of fruits by eradicating the maggots present in the fruits, which makes UAE a reliable market (16). They signed the CEPA a free trade agreement with India to boost trade by reducing tariffs making Indian mangoes cheaper and more competitive than other countries. Saudi Arabia remains a stable market followed by UAE with a probability of retention of 0.58 i.e. the probability of retention of export share of 58 % by Saudi Arabia over this period. It had lost its market share of about 37 % to Kuwait and 5.4 % to Qatar whereas it has gained a market share of 2 % from Kuwait. Saudi Arabia also have a high demand for Indian mango varieties such as Kesar and Banganapalli and the presence of ports such as Jeddah facilitates smooth trade. Followed by its Singapore has a retention probability of 52 %, Qatar has a retention of share of 39 % and Oman with 27 %. From the transition probability matrix, UAE, Saudi Arabia and Singapore remain the stable importers, Qatar and Oman remain moderate importers of mango from India as UAE sometimes acts as a re-export hub for Indian mangoes to these countries resulting in varying consistency in export over the study period. Nepal, Kuwait & UK remain unstable markets over the study period. Indian mango and some vegetables are prohibited by the European

**Table 5.** Transitional probability matrix of fresh mango export, 2008-09 to 2023-24

Countries	UAE	Nepal	U K	Oman	Qatar	Saudi Arabia	Kuwait	Singapore	Others
UAE	0.66	0.34	0	0	0	0	0	0	0
Nepal	0.63	0	0.21	0.16	0	0	0	0	0
U K	0	0.34	0	0.09	0	0	0.02	0	0.55
Oman	0	0	0.73	0.27	0	0	0	0	0
Qatar	0.31	0	0	0.02	0.39	0	0.28	0	0
Saudi Arabia	0	0	0	0	0.05	0.58	0.37	0	0
Kuwait	0.69	0	0	0	0.11	0.2	0	0	0
Singapore	0.46	0	0.02	0	0	0	0	0.52	0
Others	0.16	0	0	0	0.01	0	0	0.01	0.82

Source: Author's calculation based on the data from APEDA

Union's Standing Committee on Plant Health to avoid the introduction of viruses and pests (29). As Kuwait has a smaller population result in seasonal imports lacking continuous imports. Nepal imports mangoes from nations like India, Pakistan and Bangladesh based on local mango seasons since they provide better pricing during specific periods and they do not have any special trade agreements with India. Adopting organic fertilizers significantly enhance fruit quality and lower chemical residues which results in meeting out EU residual levels, reduce rejections and increase the export to these nations (30).

#### Future predictions of fresh mango export

The projected export quantity of fresh mangoes from India for the next five years from 2024-25 to 2028-29 was estimated in Table 6, Fig. 6. It is evident from the table that UAE continued to be the top and stable importer of fresh mango from India. UK and Nepal shows a strong growth and remains the emerging future market of Indian mangoes. Saudi Arabia, Qatar and Kuwait remain as saturated markets in future.

#### Mango pulp

From the transitional probability matrix Table 7, it is obtained that Saudi Arabia has the highest probability of retention of 0.97 or 97 % over the period resulting as the stable importer of Indian mango pulp. It has lost only about 3 % of its shares to UAE and has gained 57 % of shares from the USA, 90 % of shares from the Netherland, 20 % from the UK and 28 % from other remaining countries. UAE remains the next stable importer of Indian mango pulp with a retention probability of 0.67 or 67 %. It has lost 29 % of its shares to Netherland, 4 % of shares to Germany whereas it gained 29 % of shares from Oman, 3 % from Saudi and 2 % from Germany. As mango pulp being the key raw material for mango juices, ice creams, smoothies and other desserts, which are highly consumed among these country people and the trade agreements with

zero percentage tariff results to remain stable importers of mango pulp from India. Following these countries, the United States is the steady importer, with India acting as the primary supplier of mango pulp, with a retention probability of 43 %. It has lost 57 % of shares to Saudi Arabia and gained 39 % of shares from the UK and 10 % from the Netherlands. It has India as the primary supplier of mango pulp because of significant Indian varieties which are rich in aroma, flavour and pulp content resulting in stable imports. Following it, UK remains stable in imports with a retention probability of 41 % and Germany with 5 %. Oman and Netherlands are the unstable markets for mango pulp exports from India.

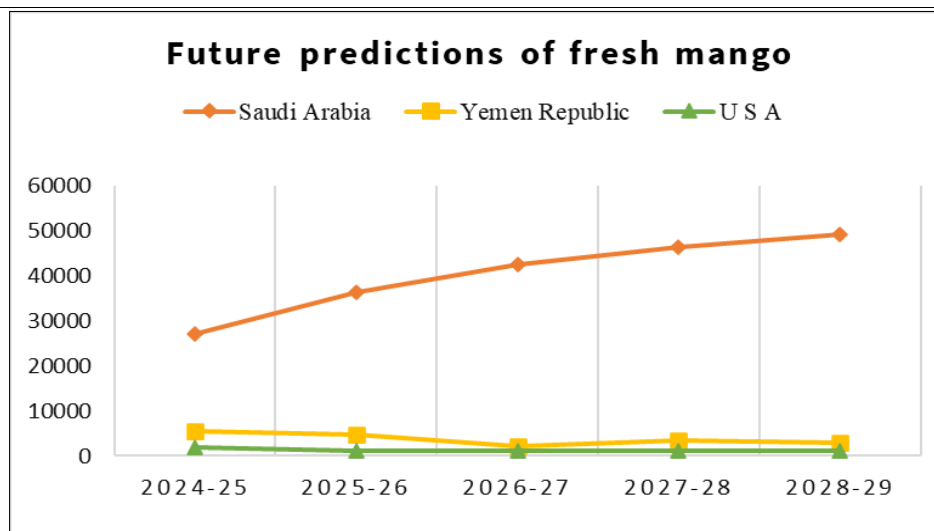
#### Future predictions of mango pulp export

The projected export quantity of mango pulp from India for the next five years from 2024-25 to 2028-29 was estimated in Table 8. It is evident that Saudi Arabia remains the promising importer with the increased demand of Mango pulp from India resulting in increase in imports to 49162.8 metric tons of mango pulp during 2028-29. USA, UAE, Yemen Republic, remains moderately stable markets. Expanding the market access to these countries results in increased exports in the future period (Fig. 7).

The findings of the study imply to increase the investments on cold storage, transportation and modern packaging facilities at major export areas such as Maharashtra, Gujarat and Tamil Nadu. Under the scheme one district one product programme focuses export on UAE and Saudi Arabia which possess low instability and high retention potential. India being the dominant exporter of mango pulp the implication of schemes such as PMKSY, PMFME facilitates financial assistance and subsidies for new establishments and modernizations of processing units. Bilateral trade agreements such as CEPA should be preserved to increase the export process by lowering tariffs. India should also focus on

**Table 6.** Future projections of top countries' fresh mango exports from 2024-25 to 2028-29

Year	UAE	Nepal	U K	Oman	Qatar	Saudi Arabia	Kuwait	Singapore	Others
2024-25	13652	6888.4	1343.9	1193	666.5	436.7	620.7	200.6	4517.7
2025-26	14795.6	5159.8	2289	1545.7	400	376	374	114	4462
2026-27	14145	5876.4	2187	1446	263.8	292.5	298.9	69	4937.8
2027-28	14137.6	5617.6	2261.5	1519.9	302	229	228	46.6	5274
2028-29	13944.8	5640.4	2261.3	1504.4	270	258	320	86	5592.6



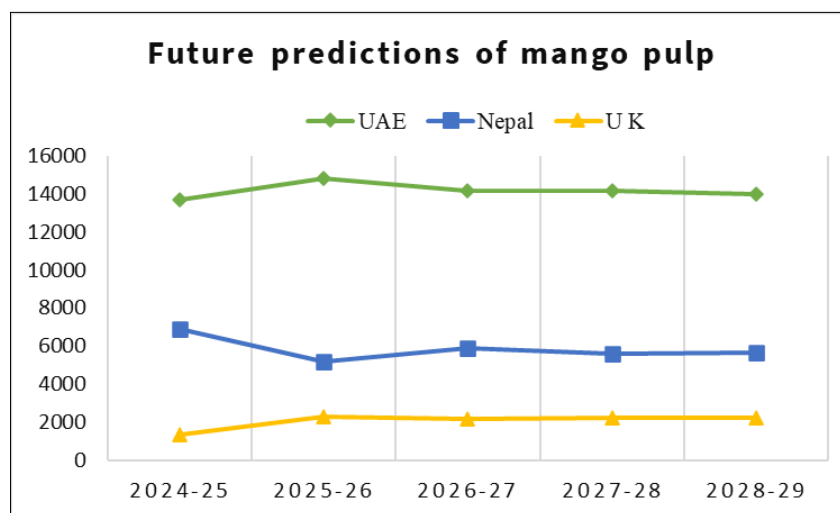
**Fig. 6.** Future projections of top countries' fresh mango exports from 2024-25 to 2028-29.



**Table 7.** Transitional probability matrix of mango pulp export, 2008-09 to 2023-24

Countries	Saudi Arabia	Yemen Republic	U S A	U K	Oman	Netherland	UAE	Germany	Others
Saudi Arabia	0.97	0	0	0	0	0	0.03	0	0
Yemen Republic	0	0	0	0	0	0	0	0	1
U S A	0.57	0	0.43	0	0	0	0	0	0
U K	0.2	0	0.39	0.41	0	0	0	0	0
Oman	0	0	0	0	0	0.24	0.29	0.47	0
Netherland	0.9	0	0.1	0	0	0	0	0	0
UAE	0	0	0	0	0	0.29	0.67	0.04	0
Germany	0	0.1	0	0.16	0.05	0.44	0.2	0.05	0
Others	0.28	0	0	0	0	0	0	0	0.72

Source: Author's calculation based on the data from APEDA

**Fig. 7.** Future projections of top countries' mango pulp exports from 2024-25 to 2028-29.**Table 8.** Future projections of top countries' mango pulp exports from 2024-25 to 2028-29

Year	Saudi Arabia	Yemen Republic	U S A	U K	Oman	Netherland	UAE	Germany	Others
2024-25	27137	5388	1773.2	2856	660.7	3118.4	3357	2043	14417.7
2025-26	36416	4694	1065.5	1710.7	500	1910.6	2710.4	663	10784.9
2026-27	42613.5	2253.6	1242	878.5	464.6	942.8	1919.8	264	8013
2027-28	46531.7	3493.5	1153	1289	289	628.8	1332.5	446	5833
2028-29	49162.8	2873	1076.75	997	217	877	1024	317	4239.8

developing trade agreements with promising nations to retain and expand the access to these markets. The government should support exporters in adopting to meet the international quality standards for export and forecast export data and update in the APEDA portal which would help exporters to plan according to the demand to the countries.

## Conclusion

As the largest producer of mango, India holds a significant position in the export of fresh mango and mango pulp. With the introduction of various schemes and subsidies on food processing, the mango pulp export has shown a consistent increase and India holds the largest exporter of mango pulp in the world. From the results, it is evident that gulf countries were the top and stable importers. It is evident from the transitional probability matrix that UAE being the top importer of Indian fresh mangoes and India being the primary exporter of mango pulp to Saudi Arabia and USA, they act as a significant and promising market in the future. Kuwait, Oman were not stable importers of fresh mangoes, Germany and Oman were not stable importers of mango pulp. Addressing physiological disorders in premium varieties like alphonso is crucial for maintaining quality and preferences in international market (31). To maintain the export share,

suitable policies and promotion techniques should be implemented (32). Indian export prices must be competitive in addition to meeting quality, sanitary and phytosanitary standards to remain a major leader in the global market (33).

## Limitations and future directions

As the study focussed on secondary data on yearly basis, it may subject to time lags, seasonal variations and lack of micro level information from producers, exporters and logistics. The direction of future trade is dependent on past export performance and shifts, which lacks consideration of dynamic interventions, policies and agreements of government. Seasonal price fluctuations may also results shift in patterns of export. Future studies can focus on study on mango producers and exporters to examine the entire value chain, including post-harvest losses at different stages and develop quality enhancement measures to meet out various international standards. The focus on assessing the performance and effectiveness of existing government schemes for enhancing mango processing facilities and increase in overall export value of mango pulp by the nation.

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## Authors' contributions

Conceptualization, methodology and data collection was done by ANT and KD. Resources were collected by STBS, KU and RP. Investigation and formal analysis were performed by ANT, KD and STBS. ANT, KD and KU prepared the original draft. Visualization was done by ANT, KD and RP. KD, STBS, KU and RP supervised the whole work. All authors read and approved the final paper.

## Compliance with ethical standards

**Conflict of interest:** The authors declare no Conflicts of interest.

**Ethical issues:** None

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