**ABSTRACT**

The purpose of this study was to use the Markov chain model to predict future honey export to importing destinations and analyze the honey export from India to various major import markets. Secondary data on honey yearly export data from India to other countries were collected from 2013 to 2023.

The results showed that the USA, UAE, and Qatar were stable destinations for Indian honey exports, while other importing countries like Morocco, were unstable (had low retention probabilities) in their export share to these markets. The most unstable importing countries were Saudi Arabia, Libya, and Bangladesh. The predicted export shares of honey to major importing countries revealed that the export share of Indian honey is expected to be highest in the USA and UAE over the next four years.

**Keywords:** Honey, Export, Import, Trade, Markov Chain Analysis

**INTRODUCTION**

A naturally occurring substance, honey is a delicious liquid made by honey bees from plant nectar. About 200 different substances, including sugar, protein, enzymes, minerals, vitamins, amino acids, and a variety of polyphenols, are found in honey. The ratio of these components gives each honey its unique color, flavor, viscosity, and medicinal properties (Rao et al 2016). The most vital goods produced by bees for human nourishment and health include honey, pollen, royal jelly, propolis, bee wax, venom, and more (Popescu et al., 2017). According to FAO, bees’ contribution to food security at the global level is about 30% (FAO, 2018). Apiculture, also known as beekeeping, is the cultivation of honeybees and it is one of the contemporary agro-industries (Bansal et al, 2005), playing a major role in agro-economy subsector that guarantees employment for a significant number of farmers, extra revenue for farmers and bee enthusiasts, a better standard of living and contributing to the increase in agricultural production value, which further boosts the contribution of agriculture to global GDP and economic prosperity (Popescu et al., 2021).

Honey has been used for food and medicinal purpose since decades. Ancient Indian communities living in forests and rock shelters were among the first to use this natural sweetener, thus contributing to India’s long history in honey and beekeeping (Chanie et al, 2019 and Hando et al, 2023). India, often referred to as the ‘land of honey’(Shilpashree et al, 2017), has enormous potential for producing honey because of its diverse flora, which includes more than 500 species that are both cultivated and wild and are excellent suppliers of pollen and nectar (Kumar et al, 2024). In addition to many stingless bee species, the nation is home to five kinds of real honey bees: Apis dorsata, Apis mellifera, Apis dorsata, Apis laboriosa, Apis cerana indica, and Apis florae (IMARC ,2023 and Vahoniya et al, 2023).

Major honey producing states in the country include Punjab, Haryana, Himachal Pradesh, UP, Bihar and West Bengal (Shilpashree et al., 2017). More than 85% of India's total honey exports go to the American and Asian continents, and the country ranks third in the world for honey exports (APEDA, 2024). According to statistics, global honey output reached 1.77 million metric tons in 2021, which was 41% higher than in 2000 (1.25 million MT) and 5.4% lower than the peak in 2017 (1.87 million MT). (Statista, 2023). China, New Zealand, India, Argentina, Ukraine, Spain, Germany, Brazil, Belgium, and Hungary were the top 10 honey exporting nations in the world in 2023.In the same year, the top 10 importing countries were USA, Germany, Japan, France, UK, Belgium, Italy, Spain, China and Poland. The list was ranked descending by the quantity exported and imported as shown in Fig 1 and Fig 2.

Fig 1: Honey export value in the top 10 exporting countries worldwide in 2023 (USD thousand)

Fig 2: Honey import value in the top 10 importing countries worldwide in 2023 (USD thousand)

**METHODS AND MATERIALS**

The study is entirely based on secondary data and the study period is 2013 to 2023. The data were collected from ITC trade map.

 **Markov chain analysis**

Markov chain analysis was employed to analyze the structural change in any system whose progress through time can be measured in terms of a single outcome variable (Dent, 1967). In the present study, the dynamic nature of trade patterns that is the gains and losses in the export of Indian honey in major importing countries was examined using the Markov chain model. Markov chain analysis involves developing a transitional probability matrix ‘P’, whose elements, Pi j indicate the probability of exports switching from the country ‘i’ to country ‘j’ over time. The diagonal element Pi j where i=j, measures the probability of a country retaining its market share or in other words, the loyalty of an importing country to a particular country’s exports (Yogesh and Srivastava, 2020). In the context of the current application, there were seven major importing countries for Indian honey, viz USA, UAE, Saudi Arabia, Libya, Qatar, Morocco and Bangladesh and all other countries grouped under others. The assumption was that the average export of honey from India amongst importing countries in any period depends only on the export in the previous period and this dependence was the same among all the periods (Mahadevaiah et al., 2005). This was algebraically expressed as

Ejt =$\sum\_{i=1}^{r}Eit-1Pij+ejt$

where,

Ejt = Exports from India to the ith country during the year t

Eit−1 = Exports to the ith country during the year t – 1

Pi j = Probability that exports will shift from the ith country to jth country

ejt = Error-term which is statistically independent of ejt−1, and

r = Number of importing countries.

The transitional probabilities Pi j, which can be arranged in a (c × r) matrix, had the following properties (Satish and Babu, 2017).

1) 0 ≤ Pi j ≤ 1

2) ∑i=1 Pi j = 1 for all i

The expected export-share of India during a particular period, t, was obtained by multiplying the quantity of exports to the selected seven during the previous period (t–1) with the estimated transition probability matrix (P) (Mohandas and Kuruvila, 2018). The transition probability matrix was estimated in the linear programming (LP) framework by a method referred to as the minimization of Mean Absolute Deviation (MAD) (Joshi et al., 2015). The probability matrix was estimated for the period 2013 to 2023. The LP formulation on analysis

was stated as:

MinOP∗ + Ie

Subject to,

XP∗ + V = Y

GP∗ = 1

P∗ ≥ 0

where,

P\* is a vector of the probabilities Pi j

O is the vector of zeros

i is an appropriately dimensional vectors of areas

e is the vector of absolute errors

Y is the proportion of exports to each country.

X is a block diagonal matrix of lagged values of Y

V is the vector of errors

G is a grouping matrix to add the row elements of P arranged in P\* to unity.

**Forecasting of export scenario**

Prediction of quantity of honey export share was made by using the Transitional Probability Matrix (Siddeshwar et al., 2017).

Bt = B∗o T

Bt+i = Bt+i−1∗ T

where,

B o = Quantity exported in Base years,

Bt+i = Quantity exported in next year (prediction),

T = Transitional probability matrix.

**RESULTS AND DISCUSSION**

Trade performance of honey in India

Trend in export and import of natural honey in India for a decade was depicted in Fig 3 and Fig 4.

From 2013 to 2023, the export performance of natural honey showed a growing trend, rising from 30099 tons to 98273 tons. As illustrated in Fig. 3, the lowest export was recorded in the year 2014 with 26976 tons, while the greatest export was recorded in the year 2023 with 98273 tons. During 2022, the imports of natural honey reached peak level with 1,138 tons as shown in Fig 4. Throughout the study period, there is fluctuation in the number of honey imports.

Fig 3: Trend in export of honey from India (2013-23)

Fig 4: Trend in import of honey from India (2013-23)

**Markov chain analysis**

Markov chain analysis was applied for annual export data for the period2013 to 2023. The major seven honey importers from India, i.e., USA, UAE, Saudi Arabia, Libya, Qatar, Morocco and Bangladesh were considered for analysis. The honey trade with the remaining countries was pooled under other countries. The Transitional Probability Matrix (Kusuma and Rudrapur, 2016) presented in Table 1 provides a broad indication of changes in the direction of export of honey from India for the study period. The row elements in the transitional probability matrix provide the information on the extent of loss in trade, on account of competing countries. The columns element indicates the probability of gains in volume of trade from other competing countries and the diagonal element indicates a probability of retention of the previous year’s trade volume by the respective country (Manjunath et al., 2017).

It is evident from Table 1, USA were the most stable importer of Indian honey as they retained 89.5 per cent of the share from the previous year by losing mainly 6 per cent to others countries, 1.4 to Saudi Arabia. UAE was another stable importer country of honey from India they retained their original share of 52.1 per cent from the previous year by losing36 per cent to USA, 11.9 per cent to Libya. Qatar, Morocco and other countries are unstable (low retention probabilities) export share to these markets. Saudi Arabia, Libya and Bangladesh are the most unstable markets among importing countries of Indian honey during the period as these the countries did not retain any amount of their share from the previous year.

The market share projections of Indian honey exports to the major importing countries were computed using the transitional probability matrix (Shilpa et al., 2017). Table 2 presents the actual and predicted values of Indian honey exports to major importers from 2013 to 2023.

The actual share of USA in honey export had shown slight decreasing trend over the period 2013 to 2023, it was 83.64 per cent to 82.40 per cent, also predicted share decrease from 84.64 per cent to 81.54 per cent (Table 2). There was a slight fluctuation throughout the period in both actual and predicted share. With regard to UAE the actual market share and predicted was shown increasing from 3.34 per cent to 8.27 per cent and 3.20 per cent to 6.24 per cent respectively from over a period. In case of Saudi Arabia, the actual and predicted proportion of market share shown decreasing trend from 6.65 per cent to 1.71 per cent and 2.54 per cent to 2.38 per cent respectively. With regards Libya the actual proportion of market share showed increasing trend from 0.50 per cent to 1.29 per cent and predicted export share 0.76 per cent to 1.35 per cent during the study period shown in Table 2. With respect to Qatar, the actual and predicted proportion of exports showed increasing trend i.e., 0.21 per cent to 0.80 per cent, and 0.54 per cent to 0.72 per cent. In case of Morocco the actual proportion of exports showed slightly increase i.e., 0.89 per cent to 0.96 per cent and predicted decrease from 1.14 per cent to 0.97 per cent. With regard to Bangladesh the actual and predicted proportion of market share shown decreasing trend from 0.86 per cent to 0.67 per and 1.32 per cent to 1.06 per cent. Concerning other countries, the actual market share and predicted of Indian honey exports shows slight decreasing trend from 3.92 per cent to 3.91 per cent and 5.86 per cent 5.73 per cent respectively.

**Table 1. Transitional probability matrix of Indian honey export during 2013 to 2023**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Countries | USA | UAE | Saudi Arabia | Libya | Qatar | Morocco | Bangladesh | Others |
| USA | 0.895 | 0.005 | 0.014 | 0.004 | 0.004 | 0.006 | 0.012 | 0.060 |
| UAE | 0.360 | 0.521 | 0.000 | 0.119 | 0.000 | 0.000 | 0.000 | 0.000 |
| Saudi Arabia | 0.919 | 0.000 | 0.000 | 0.000 | 0.000 | 0.032 | 0.049 | 0.000 |
| Libya | 1.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Qatar | 0.000 | 0.701 | 0.000 | 0.000 | 0.299 | 0.000 | 0.000 | 0.000 |
| Morocco | 0.000 | 0.992 | 0.000 | 0.000 | 0.000 | 0.008 | 0.000 | 0.000 |
| Bangladesh | 0.000 | 0.000 | 0.720 | 0.000 | 0.000 | 0.000 | 0.000 | 0.280 |
| Others | 0.512 | 0.000 | 0.195 | 0.000 | 0.040 | 0.109 | 0.000 | 0.144 |

**Table 2. Export share of Indian honey to selected countries in (per cent)**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | USA | UAE | Saudi Arabia | Libya | Qatar | Morocco | Bangladesh | Others |
| Years | A | P | A | P | A | P | A | P | A | P | A | P | A | P | A | P |
| 2013 | 83.64 | 84.64 | 3.34 | 3.20 | 6.65 | 2.54 | 0.50 | 0.76 | 0.21 | 0.54 | 0.89 | 1.14 | 0.86 | 1.32 | 3.92 | 5.86 |
| 2014 | 80.51 | 84.73 | 2.16 | 2.71 | 9.79 | 2.94 | 0.90 | 0.61 | 0.07 | 0.49 | 1.14 | 1.23 | 1.46 | 1.44 | 3.98 | 5.85 |
| 2015 | 89.59 | 84.99 | 1.98 | 2.92 | 2.57 | 2.72 | 0.61 | 0.63 | 0.30 | 0.53 | 1.23 | 0.87 | 1.44 | 1.19 | 2.29 | 6.15 |
| 2016 | 84.26 | 82.80 | 3.43 | 3.45 | 2.72 | 3.45 | 0.55 | 0.78 | 0.53 | 0.73 | 0.87 | 1.26 | 1.51 | 1.14 | 6.15 | 6.40 |
| 2017 | 85.33 | 83.54 | 3.15 | 3.11 | 3.45 | 3.20 | 0.27 | 0.75 | 0.68 | 0.74 | 0.56 | 1.18 | 1.42 | 1.19 | 5.13 | 6.30 |
| 2018 | 82.12 | 82.63 | 3.11 | 3.71 | 3.53 | 3.21 | 0.93 | 0.73 | 0.74 | 0.84 | 1.16 | 1.43 | 0.83 | 1.15 | 7.58 | 6.29 |
| 2019 | 83.16 | 82.23 | 3.18 | 4.41 | 3.21 | 3.08 | 0.52 | 0.74 | 1.05 | 0.89 | 1.61 | 1.29 | 0.98 | 1.15 | 6.29 | 6.21 |
| 2020 | 75.59 | 79.22 | 4.69 | 5.70 | 4.68 | 4.02 | 0.85 | 0.89 | 1.29 | 1.05 | 1.98 | 1.63 | 1.61 | 1.13 | 9.31 | 6.36 |
| 2021 | 77.92 | 80.47 | 5.70 | 5.66 | 4.52 | 3.32 | 0.80 | 1.02 | 0.92 | 0.87 | 1.66 | 1.42 | 1.13 | 1.15 | 7.36 | 6.09 |
| 2022 | 81.52 | 80.92 | 7.31 | 6.30 | 2.00 | 2.71 | 1.02 | 1.23 | 0.96 | 0.80 | 1.42 | 1.09 | 0.87 | 1.07 | 4.91 | 5.88 |
| 2023 | 82.40 | 81.54 | 8.27 | 6.24 | 1.71 | 2.38 | 1.29 | 1.35 | 0.80 | 0.72 | 0.96 | 0.97 | 0.67 | 1.06 | 3.91 | 5.73 |

A-Actual, P- predict

The export shares of Indian honey were forecasted for four years from 2024 to 2027 and results are presented in Table 3. The export share to USA, Saudi Arabia, Qatar, Morocco, Bangladesh, and other countries shares are expected to rise, whereas, UAE and Libya countries are expected to fall. The projected percent export share of Indian honey to USA has tremendous share around 82 per cent for next forecasted years, other countries and UAE followed next to USA.

**Table 3. Forecasted export shares of Indian honey to major importing selected countries**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Years | USA | UAE | Saudi Arabia | Libya | Qatar | Morocco | Bangladesh | Others |
| 2024 | 81.66 | 5.14 | 3.01 | 1.10 | 0.76 | 1.19 | 1.09 | 6.05 |
| 2025 | 81.86 | 4.81 | 3.09 | 0.97 | 0.79 | 1.25 | 1.12 | 6.11 |
| 2026 | 81.90 | 4.71 | 3.13 | 0.93 | 0.80 | 1.26 | 1.13 | 6.14 |
| 2027 | 81.91 | 4.68 | 3.14 | 0.92 | 0.80 | 1.26 | 1.13 | 6.15 |

**Conclusion**

The Markov chain analysis of honey exports from India indicated USA, UAE, and Qatar to be stable destinations for Indian honey exports, while Morocco and other importing countries were unstable (had low retention probabilities) in their export share to these markets. The most unstable importing countries were Saudi Arabia, Libya, and Bangladesh. The predicted export shares of honey to major importing countries revealed that the export share of Indian honey is expected to be highest in the USA and UAE over the next four years. India should not depend too much on these countries in order to lower trade risks over time.

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