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The Economic Dimension of Saudi Arabia's Strategy to Minimize the Value of Honey Imports

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Abstract:

Given the high average import price of honey, which reached 4.13 thousand USD per ton during the period 2019–2023, this study aims to develop a strategy for reducing the value of Saudi Arabia's honey imports using linear programming. The results indicate that global honey exports amounted to 998.94 thousand tons, valued at 2,541.6 million USD, while global imports reached 823.41 thousand tons, valued at 2,354.2 million USD in 2024. By calculating the geographical concentration coefficient for both the quantity and value of honey imports, the coefficients were estimated at 31.34% and 30.76%, respectively, over the

study period, indicating a high degree of diversification in honey import sources during 2019–2023.

Under the objective of importing the same quantity of honey 19.71 thousand tons at a lower cost, four alternative models were developed to reduce the value of Saudi Arabia's honey imports. A comparison of the proposed models reveals that the first model is associated with higher risk due to its reliance on imports from only China and Thailand. In contrast, the remaining models (the second, third, and fourth) achieve reductions in import value of 24.96%, 32.78%, and 32.87%, respectively.

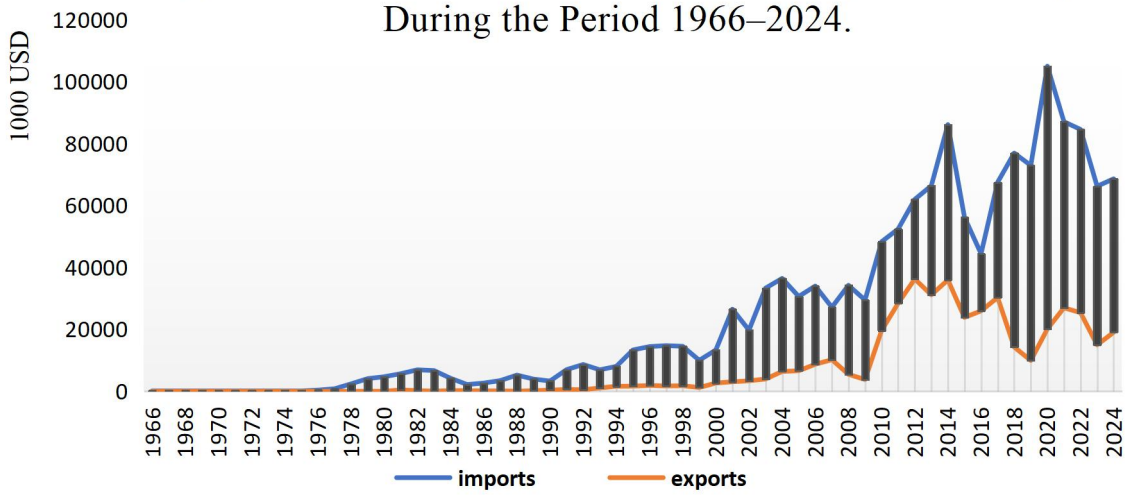
The study ultimately recommends that the Ministry of Commerce restructure the geographical distribution of honey imports to reduce the overall value of Saudi imports and consequently lower the average import price of honey from 4.13 thousand USD per ton to 2.77 thousand USD per ton. Such a reduction in import prices would be reflected in retail prices, thereby making honey more affordable for low-income consumers.

Keywords: Honey; Linear Programming; Import Value Reduction; Geographical Distribution; Exports and Imports.

1- Introduction

Saudi Arabia engages in both the importation and re-exportation of honey. The volume of honey imports increased from 50.0 tons, with a value of 100 thousand USD in 1966, to 23.52 thousand tons, valued at 105.07 million USD in 2020, before declining to 18.51 thousand tons, valued at 68.66 million USD in 2024. Similarly, Saudi honey exports rose from 11.0 tons, valued at 2.0 thousand USD in 1972, to 5,646.0 tons, valued at 36.27 million USD in 2012, and subsequently decreased to 2,364.8 tons, valued at 19.04 million USD in 2024. As the value of imports consistently exceeded that of exports, the honey trade balance recorded a persistent deficit, which expanded from 100.0 thousand USD in 1966 to 84.95 million USD in 2020, before contracting to 49.62 million USD in 2024 (Figure 1).

Figure 1: The Value of Saudi Exports and Imports of Honey During the Period 1966–2024.



Source: Author's compilation based on published Food and Agriculture Organization (FAO) data, 1966–2024.

Given the weak level of domestic honey production, Saudi Arabia relies heavily on imports to meet local consumption requirements. Naturally, wholesale and retail honey prices in the domestic market are closely linked to import prices, which increased from 2.0 thousand USD per ton in 1966 to 4.54 thousand USD per ton in 2018, before declining to 3.71 thousand USD per ton in 2024. Undoubtedly, reducing retail prices through lowering honey import prices would make honey more affordable for low-income consumers. In this context, the present study raises several key questions, most notably: (1) Is it possible to import the same quantity while reducing its total value? and (2) Is it feasible to reduce the average import price, thereby lowering wholesale and retail honey prices?

Some studies have addressed the minimization of import costs, in addition to examining the patterns of international honey trade. Seale, Sparks, and Buxton (1992) employ the Rotterdam model to analyze international honey trade, examining how import quantities respond to changes in relative prices and total consumer expenditure. Utilizing data from major honey-importing countries, the study estimates demand elasticities and evaluates the impact of economic factors on the volume of honey imports. The analysis underscores the influence of price and income variations on trade patterns and the competitive position of exporters in global markets. The findings provide valuable insights into the sensitivity of honey imports to market fluctuations and offer guidance for the formulation of agricultural trade policies and strategies aimed at enhancing international market efficiency.

Abdel-Sayed and Abdel-Mohsen (2012) examined the optimal geographical allocation of Egypt's local fava bean imports and found that the same quantity of 201.2 thousand tons could be procured at approximately EGP 718.3 million, yielding savings of nearly 21 million EGP, or 2.8% of the total import value of 739.3 million EGP during 2006–2010. Popp et al. (2018) indicate that honey, a relatively homogeneous and hard-to-trace product, is prone to economically motivated adulteration due to significant international price disparities and high tariff barriers. Such adulteration can compromise consumer confidence and pose public health risks. This study demonstrates the use of network-based stochastic simulation methods to assess the spread of contaminated food products, using the international honey trade as a case study, based on FAO data. Network analysis reveals a scale-free structure of the global honey trade. By focusing on backbone states and major product flows, the geographical distribution of contaminated honey can be traced according to its source. These insights are crucial for designing effective international trade control systems. Furthermore, the "polluted product transfer capacity" and state-level exposure can be efficiently predicted through the combined application of centrality measures and network indicators.

Alnafissa and Alderiny (2020) analyzed Saudi demand for natural honey imported from six countries, representing 73.7% of total imports during 1991–2017. Using the AIDS model, they found most own-price elasticities to be negative and significant, except for honey from Pakistan, while Yemeni honey demand was inelastic. Cross-price elasticities indicated substitution patterns among imported products. The study recommended boosting domestic production and diversifying import sources to meet growing demand. Abdel-Mawgoud et al. (2021) investigated the optimal geographical allocation of Egypt's chicken meat imports. Their proposed models successfully reduced the value of imports, resulting in trade balance savings ranging from 2.67% to 23.73%.

Osaili et al. (2023) evaluated the physicochemical quality of honey imported into the UAE through Dubai ports between 2017 and 2021. A total of 1,330 samples were analyzed for sugar composition, moisture content, HMF levels, free acidity, and diastase activity. Among these, 1,054 samples complied with UAE standards, whereas 276 samples (20.8%) did not, suggesting potential adulteration, improper storage, or inadequate heat treatment. Non-compliant samples were highest from India (32.5%) and lowest from Germany (4.5%). The study emphasized the importance of physicochemical testing in international honey inspections to minimize the importation of adulterated products.

Ghanem et al. (2024) reported that Saudi red meat imports exceeded exports, increasing the trade deficit at an average annual growth rate of 7.4% during 2000–2021. Exports to nine countries accounted for 85.94% of total exports, while imports from seven countries represented 92.91% of total imports (2017–2021). Optimizing exports and minimizing imports could reduce the trade deficit from 653.76 million USD to 597.52 million USD, an 8.60% decrease. The study recommended restructuring the geographical distribution of Saudi red meat trade to achieve this reduction.

The study by Powrel and Sharma (2024) explained that honey is a globally important food commodity with deep cultural significance and extensive international trade. The study analyzed global honey trade over the period 1961–2022, aiming to examine the socio-economic, environmental, and geopolitical factors influencing its movement from production centers to consumer markets. It highlighted the roles of ecological conditions, technological advancements, trade regulations, and consumer preferences in shaping global honey trade dynamics. The results indicated sustained growth in honey trade across all continents, accompanied by notable regional disparities in trade volumes and values. Spearman's rho test revealed varying degrees of monotonic growth trends among regions, while instability and trade balance dynamics were assessed through longitudinal analysis. Overall, the study provided valuable insights into global honey trade patterns and their implications for scholars, industry stakeholders, and policymakers

Osman et al. (2025) Imported honey in Saudi Arabia was evaluated for physicochemical, antimicrobial, heavy metal, and pesticide properties. Some samples violated national and international standards, showing high moisture (22.93–23.73%) and variable antimicrobial activity (42–100% growth inhibition). Pb and Cd levels were below detection limits, while Zn and Ni exceeded guideline values in some samples, with Ni from Germany, Turkey, France, and India presenting a hazard index (HI) > 1. Pesticide residues exceeding MRLs were detected, although their HI values remained below 1. These findings underscore the need for continuous monitoring to ensure honey safety and protect consumers.

Based on the findings of previous studies, particularly those concerning honey, it is evident that they focused on demand, the quality of imported honey, and the associated risks related to honey properties and consumer protection. Accordingly, this study addresses a strategy to reduce the value of Saudi imports of natural honey, aiming to lower its price and make it more accessible to low-income consumers.

2- Research Objectives

This study aims to develop a strategy for reducing the value of Saudi Arabia's honey imports by addressing the following specific objectives:

1- Examining the current status of global honey production and trade (exports and imports) in 2024.

2- Analyzing the existing geographical distribution pattern of the quantity and value of Saudi Arabia's honey imports during the period 2019–2023.

3- Identifying the optimal geographical distribution pattern for honey imports into the Kingdom of Saudi Arabia.

3- Research Methodology

This study relies on secondary data to achieve its objectives, primarily obtained from international organizations, most notably the Food and Agriculture Organization (FAO). In addition, the study employs quantitative economic analysis using the following models:

1- Geographical Concentration Coefficient, which is measured using several indicators, the most important of which is the Hirschman Index (Hirschman, 1964; Lapteacru, 2012).

$$C_{jx}=100\times\sqrt{\sum(\frac{X_{sj}}{X_i})^2}$$

Where:

- C_{jx} : Geographical concentration coefficient,
- X_{sj} : Quantity and value of honey exports and imports to or from a specific country,
- X_i :Total quantity and value of Saudi Arabia's honey exports and imports.

The value of the geographical concentration coefficient ranges between 0 and 1. The closer the coefficient is to 1, the more concentrated the exports and imports are in a small number of international markets. Conversely, if the coefficient is close to 0, this indicates a broad diversification across international markets.

2- The linear programming (LP) model used to reduce the value of Saudi Arabia's honey imports can be formulated as follows (Bector and Chandra, 2005):

Objective Function:

$$Min\ Z = C\ X:$$

Subject to:

$A\ X \leq b$

$X \geq 0$

Whereas:

Z represents the objective function to be minimized, specifically the minimization of Saudi Arabia's honey import costs, given the export capacity constraints of the countries from which imports were made during the period 2019–2023. C denotes an (n×1) vector of the average honey prices for the Kingdom in thousand USD per ton, while X represents an (n×1) vector corresponding to the countries from which imports were sourced. A denotes the technical coefficients matrix of dimensions (m × n).

Explanation:

The objective of the LP model is to minimize the total import value while ensuring that the total import quantity remains constant. The constraints guarantee that imports from each country stay within allowable limits and that the overall import target is met. By solving this model, optimal import quantities from different countries are determined, which reduces the total import cost while maintaining the same total quantity of honey imports.

4. Research Results

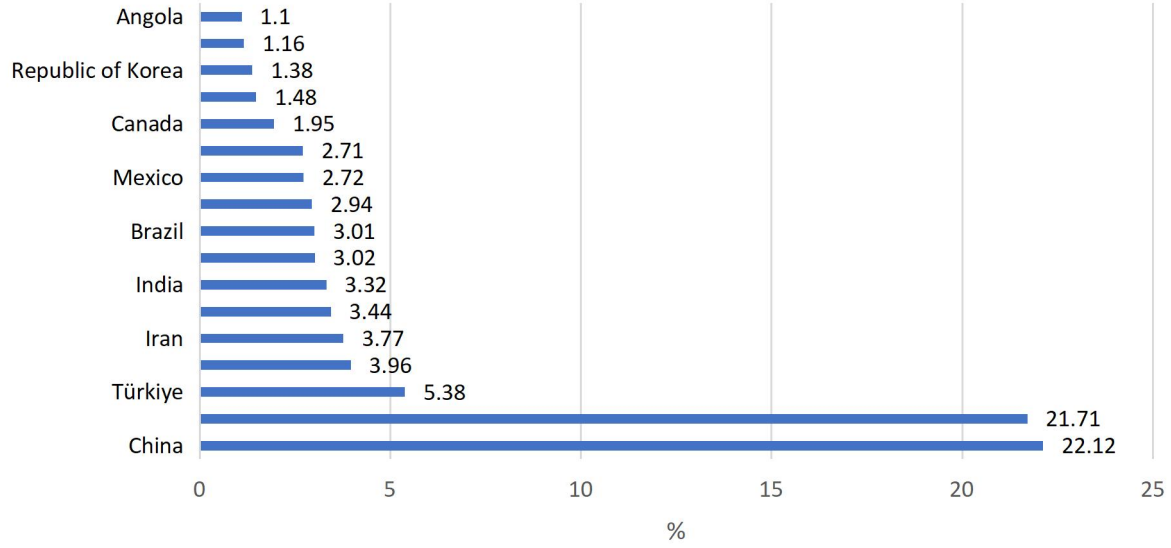
4-1 The Current Status of Global Honey Production and Trade

4-1-1 Global Honey Production

Global honey production amounted to 2,134.78 thousand tons in 2023. Data presented in Figure (2) indicate that China and Mainland China are the leading honey-producing countries, accounting for 22.12% and 21.71% of global production, respectively. Turkey ranked next with a production share of 5.38%, followed by Ethiopia, Iran, Argentina, India, the Russian Federation, Brazil, the United States of America, Mexico, Ukraine, and Canada, with respective shares of 3.96%, 3.77%, 3.44%, 3.32%, 3.02%, 3.01%, 2.94%, 2.72%, 2.71%, 1.95%, 1.48%, and 1.38%. Overall, the combined production of the aforementioned fifteen

countries accounted for 80.20% of global honey production, whereas the relative importance of production in the remaining countries did not exceed 19.8% in 2023.

Figure 2: The Relative Importance of the Major Honey-Producing Countries in 2023.

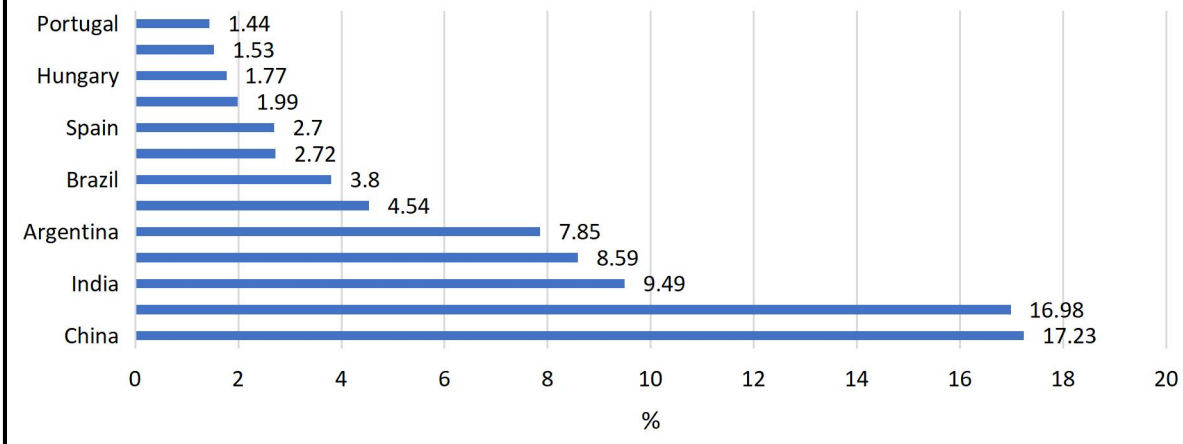


Source: Food and Agriculture Organization, FAOSTAT, 2023.

4-1-2 Global Honey Exports

Global honey exports amounted to 998.94 thousand tons, with a total value of 2,541.6 million USD in 2024. Data presented in Figure (3) indicate that China and Mainland China are the leading honey-exporting countries, accounting for 17.23% and 16.98% of total export volumes, respectively. India ranked next with a share of 9.49%, followed by Ukraine, Argentina, Vietnam, Brazil, Belgium, Spain, Germany, Hungary, Mexico, and Portugal, with respective shares of 8.59%, 7.85%, 4.54%, 3.80%, 2.72%, 2.70%, 1.99%, 1.77%, 1.53%, and 1.44%. Overall, the combined exports of the aforementioned thirteen countries accounted for 80.63% of total global honey exports, whereas the relative importance of export volumes from the remaining countries did not exceed 19.37% in 2024.

Figure 3:The Relative Importance of the Leading Honey-Exporting Countries in 2024.

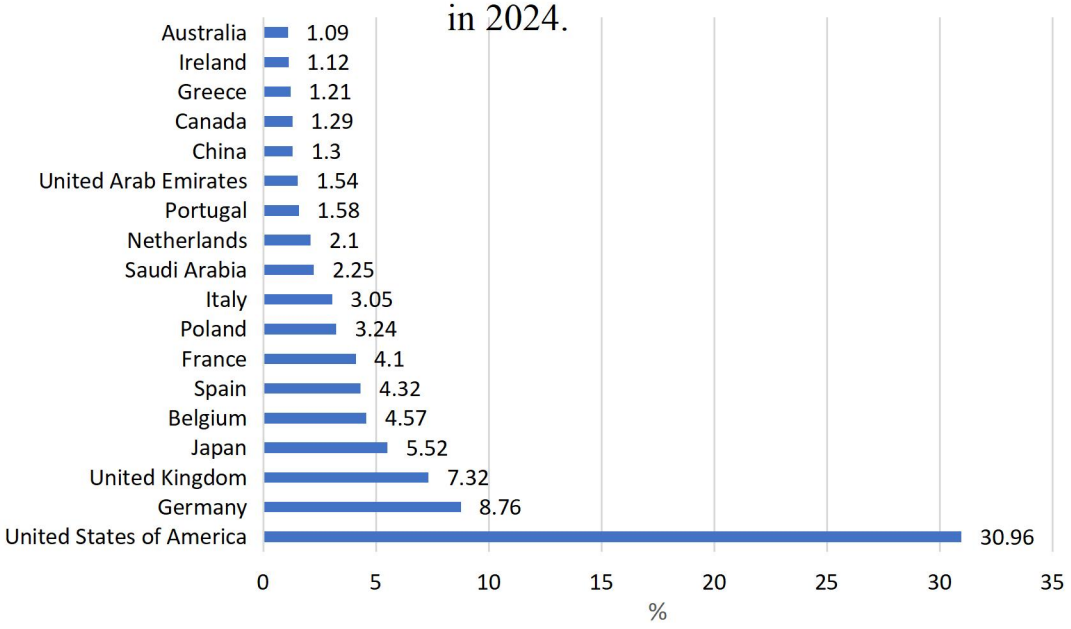


Source: Food and Agriculture Organization, FAOSTAT, 2024.

4-1-3 Global Honey Imports

Global honey imports amounted to 823.41 thousand tons, with a total value of 2,354.2 million USD in 2024. Data presented in Figure (4) indicate that the United States of America is the largest importer of honey, accounting for 30.96% of total import volumes. This is followed by Germany, the United Kingdom, Japan, Belgium, Spain, France, Poland, and Italy, with respective shares of 8.76%, 7.32%, 5.52%, 4.57%, 4.32%, 4.10%, 3.24%, and 3.05%. Saudi Arabia accounted for 2.25% of global honey imports, followed by Netherlands, Portugal, the United Arab Emirates, China, Canada, Greece, Ireland, and Australia, with respective shares of 2.10%, 1.58%, 1.54%, 1.30%, 1.29%, 1.21%, 1.12%, and 1.09%. Overall, the combined import volumes of the aforementioned eighteen countries accounted for 85.31% of total global honey imports, whereas the relative importance of imports by the remaining countries did not exceed 14.69% in 2024.

Figure 4: Percentage of the Major Honey-Importing Countries in 2024.



Source: Food and Agriculture Organization, FAOSTAT, 2024.

4–2 Current and Proposed Geographical Distribution of Honey Imports

4–2–1 Current Geographical Distribution of Honey Imports

An examination of the current pattern of the geographical distribution of honey imports indicates, based on the data presented in Table (1), that the average quantity of imported honey amounted to 19.71 thousand tons, with a total value of 81.36 million USD during the period 2019–2023. The Kingdom of Saudi Arabia imported honey from 67 countries. Pakistan ranked first, accounting for 16.36%, followed by China mainland with 16.14%, and then Germany and India, with shares of 11.52% and 10.95%, respectively. In addition, the Kingdom imported honey from Mexico at 7.94%, followed by Spain, Egypt, New Zealand, Hungary, the United Arab Emirates, Argentina, Yemen, Thailand, Australia, and Türkiye, with shares of 7.27%, 5.62%, 3.34%, 2.73%, 2.38%, 2.36%, 2.31%, 2.31%, 1.90%, and 1.81%, respectively.

Based on the foregoing, it is evident that the combined relative importance of the quantity imported from the fifteen aforementioned countries amounted to 94.94%, whereas the total relative importance of the quantity imported from the remaining countries did not exceed 5.06% during the period 2019–2023. The average import price of honey in the Kingdom of Saudi Arabia ranged between a minimum of 1.85 thousand USD per ton from Thailand and a

maximum of 15.69 thousand USD per ton from Yemen, with an overall average of 4.13 thousand USD per ton. By calculating the geographical concentration coefficient for both the quantity and value of honey imports, it was found to be 31.34% and 30.76%, respectively, over the study period. This indicates a broad diversification in the sources of honey imports during the period 2019–2023.

Table 1: Geographical Distribution of the Kingdom of Saudi Arabia's Honey Imports during the Period 2019- 2023.

Country	Quantity Tons	Value Thousand USD	Import Price Thousand USD/ ton	Relative Importance %	
				Quantity	Value
Pakistan	3224.45	9339.38	2.90	16.36	11.48
China, mainland	3181.60	5980.18	1.88	16.14	7.35
Germany	2270.89	16038.40	7.06	11.52	19.71
India	2159.41	5139.83	2.38	10.95	6.32
Mexico	1565.45	5007.26	3.20	7.94	6.15
Spain	1432.61	6381.58	4.45	7.27	7.84
Egypt	1107.39	2793.81	2.52	5.62	3.43
New Zealand	658.91	7915.72	12.01	3.34	9.73
Hungary	538.59	3508.47	6.51	2.73	4.31
United Arab Emirates	468.86	2046.26	4.36	2.38	2.52
Argentina	465.91	1373.58	2.95	2.36	1.69
Yemen	456.34	7160.06	15.69	2.31	8.80
Thailand	454.99	841.34	1.85	2.31	1.03
Australia	374.70	1320.31	3.52	1.90	1.62
Türkiye	357.02	1241.75	3.48	1.81	1.53
China, Hong Kong	142.17	401.15	2.82	0.72	0.49
United Kingdom	91.10	386.42	4.24	0.46	0.47

Myanmar	89.13	189.28	2.12	0.45	0.23
Kyrgyzstan	86.68	463.51	5.35	0.44	0.57
France	73.79	595.59	8.07	0.37	0.73
Austria	73.66	292.64	3.97	0.37	0.36
Other countries*	440.35	2939.88	6.67	2.25	3.64
Total	**19714.00**	**81356.40**	**4.13**	**100**	**100**

* Oman, Bulgaria, Ukraine, Greece, Switzerland, Bosnia and Herzegovina, Sudan, Jordan, Italy, Kuwait, Kazakhstan, Syrian Arab Republic, Brazil, Romania, Slovenia, United States of America, Lebanon, Libya, Serbia, Viet Nam, Uruguay, Zambia, Poland, Azerbaijan, Netherlands, Canada, Cyprus, North Macedonia, Chile, Morocco, Ethiopia, Finland, Georgia, Tajikistan, Palestine, Ireland, Belgium, Peru, Portugal, Russian Federation, Afghanistan, Armenia, Cameroon, Indonesia, Republic of Korea, Rwanda.

Source: Food and Agriculture Organization, FAOSTAT, 2019–2023.

4–2–2 Proposed Geographical Distribution of Honey Imports

The proposed geographical distribution was developed with the aim of reducing the value of Saudi honey imports, in accordance with the following models:

First Proposed Model:

This model is referred to as the restricted free model, which allows honey imports to be sourced from lower-priced countries, provided that the quantity imported from any single country does not exceed 30% of its export capacity, in addition to taking into account the average import capacity of the Kingdom of Saudi Arabia.
The objective function and constraints of the proposed model are specified as follows:

$$\boldsymbol{Min}: 2.9\,X_1 + 1.88\,X_2 + 7.06\,X_3 + 2.38\,X_4 + 3.20\,X_5 + 4.45\,X_6 + 2.52\,X_7 + 12.01\,X_8 + 6.51\,X_9 + 4.36\,X_{10} + 2.95\,X_{11} + 15.69\,X_{12} + 1.85\,X_{13} + 3.52\,X_{14} + 3.48\,X_{15} + 2.82\,X_{16} + 4.24\,X_{17} + 2.12\,X_{18} + 5.35\,X_{19} + 8.07\,X_{20} + 3.97\,X_{21} + 6.67\,X_{22}$$

Subject to:

$$X_1 \le 1167.41 \quad X_7 \le 827.84 \quad X_{13} \le 2905.07 \quad X_{19} \le 119.24$$
$$X_2 \le 42470.32 \quad X_8 \le 3220.55 \quad X_{14} \le 1333.09 \quad X_{20} \le 1377.10$$
$$X_3 \le 7792.72 \quad X_9 \le 5148.75 \quad X_{15} \le 2878.10 \quad X_{21} \le 505.56$$
$$X_4 \le 22509.28 \quad X_{10} \le 1224.14 \quad X_{16} \le 71.21 \quad X_{22} \le 77865.5$$

$X_5 \leq 7022.57$ $X_{11} \leq 20266.25$ $X_{17} \leq 959.34$
$X_6 \leq 8178.55$ $X_{12} \leq 399.89$ $X_{18} \leq 871.56$
$X_1 + X_2 + X_3 + X_4 + \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + X_{22} \geq 19714.00$

The first twenty-two constraints indicate that the quantity of honey imports does not exceed 30% of the average export capacity of these countries. The final constraint stipulates that the total quantity of Saudi honey imports from all countries does not exceed the average import volume of honey, amounting to 19.71 thousand tons during the period 2019–2023.

The data presented in Table 2 show that the proposed geographical distribution of Saudi honey imports involves importing honey from China mainland and Thailand, due to their relatively lower prices. Based on this proposed geographical distribution, the value of Saudi honey imports can be reduced from 81.36 million USD to 36.98 million USD, representing a decrease of 44.38 million USD, which accounts for 54.55% of the average value of Saudi honey imports during the period 2019–2023.

Table (2): Proposed Models for the Geographical Distribution of the Quantity and Value of Saudi Honey Imports

Country	**The First Model**		**The Second Model**		**The Third Model**		**The Fourth Model**	
	Quantity Tons	**Value Thousand USD**	**Quantity Tons**	**Value Thousand USD**	**Quantity Tons**	**Value Thousand USD**	**Quantity Tons**	**Value Thousand USD**
Pakistan	-	-	4174.6	12106.34	1167.41	3385.49	1167.41	3385.49
China, mainland	16808.93	31600.79	4704.5	8844.46	13106.39	24640.01	10097.72	18983.71
Germany	-	-	1782.7	12585.86	1782.7	12585.86	1782.7	12585.86
India	-	-	2759.7	6568.09	1077.5	2564.45	1077.5	2564.45
Mexico	-	-	755.3	2416.80	379.9	1215.6	379.9	1215.6

						8		8
Spain	-	-	574.7	2557.42	574.7	2557.42	574.7	2557.42
Egypt	-	-	1675.4	4222.01	446.5	1125.18	446.5	1125.18
New Zealand	-	-	112.0	1345.12	112	1345.12	112	1345.12
Hungary	-	-	243.3	1583.88	243.3	1583.88	243.3	1583.88
United Arab Emirates	-	-	179.3	781.75	179.3	781.75	179.3	781.75
Argentina	-	-	635.2	1873.84	281.5	830.43	281.5	830.43
Yemen	-	-	52.8	828.43	52.8	828.43	52.8	828.43
Thailand	2905.07	5374.38	999.3	1848.71	-	-	2905.07	5374.38
Australia	-	-	233.3	821.22	233.3	821.22	233.3	821.22
Türkiye	-	-	180.3	627.44	-	-	180.3	627.44
China, Hong Kong	-	-	300.0	846.00	-	-	-	-
United Kingdom	-	-	50.8	215.39	50.8	215.39	-	-
Myanmar	-	-	206.9	438.63	-	-	-	-
Kyrgyzstan	-	-	40.9	218.82	-	-	-	-
France	-	-	25.9	209.01	25.9	209.01	-	-
Austria	-	-	27.1	107.59	-	-	-	-

Other countries	-	-	0.1	0.33	-	-		
Total	19714.0	36975.17	19714.0	61047.13	19714.0	54689.32	19714.0	54610.44

Source: Results of solving the proposed linear programming models using WinQSB 2.0.

Second Proposed Model:

This model involves importing honey from all countries from which imports were previously made, totaling 21 countries, in addition to a group of 46 other countries, based on the average import price and the minimum and maximum quantities imported from each country during the period 2019–2023. The objective function and constraints of the proposed model are specified as follows:

$$\boldsymbol{Min}: 2.9\,X_1 + 1.88\,X_2 + 7.06\,X_3 + 2.38\,X_4 + 3.20\,X_5 + 4.45\,X_6 + 2.52\,X_7 + 12.01\,X_8 + 6.51\,X_9 + 4.36\,X_{10} + 2.95\,X_{11} + 15.69\,X_{12} + 1.85\,X_{13} + 3.52\,X_{14} + 3.48\,X_{15} + 2.82\,X_{16} + 4.24\,X_{17} + 2.12\,X_{18} + 5.35\,X_{19} + 8.07\,X_{20} + 3.97\,X_{21} + 6.67\,X_{22}$$

Subject to:

$4174.6 \geq X_1 \geq 1167.41$ $891.8 \geq X_9 \geq 243.3$ $155.3 \geq X_{17} \geq 50.8$

$4704.5 \geq X_2 \geq 1732.1$ $831.3 \geq X_{10} \geq 179.3$ $206.9 \geq X_{18} \geq 16.6$

$3083.6 \geq X_3 \geq 1782.7$ $635.2 \geq X_{11} \geq 281.5$ $113.8 \geq X_{19} \geq 40.9$

$2759.7 \geq X_4 \geq 1077.5$ $800.2 \geq X_{12} \geq 52.8$ $128.4 \geq X_{20} \geq 25.9$

$2734.8 \geq X_5 \geq 379.9$ $999.3 \geq X_{13} \geq 0.20$ $125.8 \geq X_{21} \geq 27.1$

$2828.8 \geq X_6 \geq 574.7$ $545.5 \geq X_{14} \geq 233.3$ $11303.87 \geq X_{22} \geq 0.05$

$1675.4 \geq X_7 \geq 446.5$ $705.9 \geq X_{15} \geq 180.3$

$2166.7 \geq X_8 \geq 112.0$ $300.0 \geq X_{16} \geq 36.4$

$$X_1 + X_2 + X_3 + X_4 + X_5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + X_{22} \geq 19714.00$$

The first twenty-two constraints indicate that the quantity of Saudi honey imports from each country does not exceed the maximum quantity previously imported and does not fall below the minimum quantity imported during the study period. The final constraint stipulates that the total quantity of Saudi imports from all countries does not exceed the average import volume of honey, which is 19.71 thousand tons during the period 2019–2023.

The data presented in Table 2 show that the proposed geographical distribution of Saudi honey imports involves increasing the quantities imported from several countries, primarily Pakistan, China mainland, India, Egypt, Argentina, Thailand, Hong Kong, and Myanmar, while reducing imports from the remaining countries. Based on this proposed geographical distribution, the value of Saudi honey imports can be reduced from 81.36 million USD to

61.05 million USD, representing a decrease of 20.31 million USD, which accounts for 24.96% of the average value of Saudi honey imports during the period 2019–2023.

Third Proposed Model:

This model restricts honey imports to countries that consistently exported honey to the Kingdom of Saudi Arabia every year without interruption, totaling 15 countries during the period 2019–2023.The objective function and constraints of the proposed model are specified as follows:

$$\boldsymbol{Min}: 2.9\,X_1 + 1.88\,X_2 + 7.06\,X_3 + 2.38\,X_4 + 3.20\,X_5 + 4.45\,X_6 + 2.52\,X_7 + 12.01\,X_8 + 6.51\,X_9 + 4.36\,X_{10} + 2.95\,X_{11} + 15.69\,X_{12} + 3.52\,X_{14} + 4.24\,X_{17} + 8.07\,X_{20}$$

Subject to:

$$2665.0 \geq X_1 \geq 1167.41 \qquad 8178.55 \geq X_6 \geq 574.7 \qquad 20266.25 \geq X_{11} \geq 281.5$$
$$42470.32 \geq X_2 \geq 1732.1 \qquad 827.84 \geq X_7 \geq 446.5 \qquad 399.89 \geq X_{12} \geq 52.8$$
$$7792.72 \geq X_3 \geq 1782.7 \qquad 3220.55 \geq X_8 \geq 112.0 \qquad 1333.09 \geq X_{14} \geq 233.3$$
$$22509.28 \geq X_4 \geq 1077.5 \qquad 5148.75 \geq X_9 \geq 243.3 \qquad 959.34 \geq X_{17} \geq 50.8$$
$$7022.57 \geq X_5 \geq 379.9 \qquad 1224.14 \geq X_{10} \geq 179.3 \qquad 1377.10 \geq X_{20} \geq 25.9$$
$$X_1 + X_2 + X_3 + X_4 + X_5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + X_{22} \geq 19714.00$$

The first fifteen constraints indicate that the quantity of honey imports does not exceed 30% of the average export capacity and does not fall below the minimum quantity imported from each country during the study period. The final constraint stipulates that the total quantity of Saudi imports from all countries does not exceed the average import volume of honey, which is 19.71 thousand tons during the period 2019–2023.

The data presented in Table 2 show that the proposed geographical distribution of honey imports involves increasing the quantity imported from China mainland to 13.11 thousand tons, with a value of 24.64 million USD, while reducing imports from the remaining countries. Based on this proposed geographical distribution, the value of Saudi honey imports can be reduced from 81.36 million USD to 54.69 million USD, representing a decrease of 26.67 million USD, which accounts for 32.78% of the average value of Saudi honey imports during the period 2019–2023.

Fourth Proposed Model:

In this model, the Kingdom of Saudi Arabia imports honey exclusively from traditional international markets (those markets that accounted for 94.94% of the average quantity of Saudi honey imports during the period 2019–2023). The fifteen traditional markets are as

follows**:** Pakistan, China mainland, Germany, India, Mexico, Spain, Egypt, New Zealand, Hungary, United Arab Emirates, Argentina, Yemen, Thailand, Australia, and Türkiye**.** The objective function and constraints of the proposed model are specified as follows:

$$\boldsymbol{Min}: 2.9\,X_1 + 1.88\,X_2 + 7.06\,X_3 + 2.38\,X_4 + 3.20\,X_5 + 4.45\,X_6 + 2.52\,X_7 + 12.01\,X_8 + 6.51\,X_9 + 4.36\,X_{10} + 2.95\,X_{11} + 15.69\,X_{12} + 1.85\,X_{13} + 3.52\,X_{14} + 3.48\,X_{15}$$

Subject to:

$$2665.0 \geq X_1 \geq 1167.41 \qquad 8178.55 \geq X_6 \geq 574.7 \qquad 20266.25 \geq X_{11} \geq 281.5$$
$$42470.32 \geq X_2 \geq 1732.1 \qquad 827.84 \geq X_7 \geq 446.5 \qquad 399.89 \geq X_{12} \geq 52.8$$
$$7792.72 \geq X_3 \geq 1782.7 \qquad 3220.55 \geq X_8 \geq 112.0 \qquad 2905.07 \geq X_{13} \geq 0.20$$
$$22509.28 \geq X_4 \geq 1077.5 \qquad 5148.75 \geq X_9 \geq 243.3 \qquad 1333.09 \geq X_{14} \geq 233.3$$
$$7022.57 \geq X_5 \geq 379.9 \qquad 1224.14 \geq X_{10} \geq 179.3 \qquad 2878.10 \geq X_{15} \geq 180.3$$
$$X_1 + X_2 + X_3 + X_4 + X_5 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots + X_{22} \geq 19714.00$$

The first fifteen constraints indicate that the quantity of honey imports does not exceed 30% of the average export capacity and does not fall below the minimum quantity imported from each country during the study period. The final constraint stipulates that the total quantity of Saudi imports from all countries does not exceed the average import volume of honey, which is 19.71 thousand tons during the period 2019–2023.

The data presented in Table 2 show that the proposed geographical distribution of honey imports involves increasing the quantities imported from China mainland and Thailand, while reducing imports from the remaining countries. Based on this proposed geographical distribution, the value of Saudi honey imports can be reduced from 81.36 million USD to 54.61 million USD, representing a decrease of 26.75 million USD, which accounts for 32.87% of the average value of Saudi honey imports during the period 2019–2023.

5- Conclusion

Based on a comparative economic analysis, global honey exports reached 998.94 thousand tons, valued at 2,541.6 million USD, while global honey imports amounted to 823.41 thousand tons, valued at 2,354.2 million USD in 2024. The observed discrepancy between global honey export and import volumes can be attributed to several key factors: (1) Timing differences in shipment and arrival, particularly at the beginning and end of the year, (2) Losses during transportation and storage, which are recorded under exports but not reflected in import statistics, (3) Re-exports and transit shipments, (4) Variations in customs classification, including honey recorded under other tariff headings, (5) Shipments rejected

for non-compliance with health standards, which may be counted as exports but not appear in import data, (6) Unofficial or unreported trade, especially small cross-border shipments that are not accurately recorded in some countries.

During the period 2019–2023, the average quantity of Saudi honey imports amounted to 19.71 thousand tons, with a total value of 81.36 million USD. With the objective of importing the same quantity at a lower cost, four proposed linear programming models were developed to minimize the total value of Saudi honey imports. A comparative analysis of the proposed models indicated that Model 1 involves higher risks, due to the limited sourcing from China and Thailand. In contrast, Models 2, 3, and 4 are capable of reducing import costs by 24.96%, 32.78%, and 32.87%, respectively. Based on these results, the most economically efficient strategy for reducing Saudi honey import costs is for the Ministry of Commerce to restructure the geographical distribution of honey imports by implementing Model 4. This approach would reduce total import costs from 81.36 million USD to 54.61 million USD, achieving a saving of 26.75 million USD, which represents 32.87% of the average import value over the period 2019–2023. Moreover, the average import price per ton could decrease from 4.13 thousand USD to 2.77 thousand USD, reflecting a 32.93% reduction. This reduction in import costs is expected to lower retail prices, thereby making honey more affordable for low-income consumers.

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