The Mexican Beekeeping Agri-food System: A descriptive analysis

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ABSTRACT

Objective: To conduct a descriptive analysis of the historical and current situation of honey production in Mexico.

Design/Methodology/Approach: We used the Food Balance Sheet obtained from the FAOSTAT website and the statistics of livestock production in Mexico recovered from the website of the Servicio de Información Agrícola y Pesquera (SIAP). We chose ten variables: production, import, export, per capita consumption, number of hives, production volume, economic value, price paid to producers, yield, and revenue per unit. The analysis describes the variables in the last recorded year at a global and local level, as well as the changes and trends according to the available historical records.

Results: In 2019, Mexico held the ninth place in honey production with 64,000 t and had the capacity to export around 50 % of said production. Between 2006 and 2016, the number of hives increased by 6%, while production volume and yield decreased by 1.6% and 7.5%. In contrast, the economic value, the price paid to producers, and the revenue per unit increased by 14%, 5.7%, and 8.5%.

Study limitations/Implications: This type of study relies on records of statistical information systems, whose availability depends on the variable of interest.

Findings/Conclusions: In Mexico, beekeeping is practiced throughout the country, making it self-sufficient in terms of domestic honey consumption while allowing its participation in the international market. Therefore, the country has optimization opportunities, especially in the central and northern areas, that have the lowest number of hives and production volume levels.

Keywords: Beekeeping, Honey, Descriptive analysis.

Citation: Álvarez-Sánchez, G. F., Zaldívar-Cruz, J. M., Sauri-Duch, E., Sol-Sanchez, A., Moscoso-Ramírez, P. A., Sanchez-Chino, X. M. (2024). The Mexican Beekeeping Agri-food System: A descriptive analysis. *Agro Productividad*. https://doi.org/ 10.32854/agrop.v17i4.2553

Academic Editors: Jorge Cadena Iñiguez and Lucero del Mar Ruiz Posadas
Guest Editor: Daniel Alejandro Cadena Zamudio

Received: March 23, 2023.
Accepted: January 15, 2024.
Published on-line: April 29, 2024.

Agro Productividad, 17(4). April. 2024. pp: 3-10.

INTRODUCTION

Beekeeping has great relevance worldwide, providing not only environmental services of pollination —on which approximately 286 cultivated species depend (Castellanos-Potentiano *et al.*, 2016)— but also honey, which is the main beekeeping product marketed in 135 countries (FAO, 2021).

In Mexico, beekeeping has become socioeconomically salient since it represents a significant source of jobs and income in rural areas and an opportunity to attract foreign exchange (Magaña *et al.*, 2007). Honey production was recorded in the 32 states of the

country (31 states and Mexico City), which was recognized in 2019 as the ninth honey producer (with 64,000 t) and as the fifth exporter worldwide (with 32,000 t) (FAO, 2021).

Obtaining information on the performance of beekeeping production in Mexico is only possible thanks to statistical information systems (SIS). Using SIS and adequately interpreting agricultural statistics enable the making of public policies and optimal decisions that favor efficiency and better yields in the agriculture and livestock, agro-industrial, and forestry sectors (Chávez *et al.*, 2017).

In Mexico, several institutions are devoted to generating agricultural information and statistics, such as the Servicio de Información Agrícola y Pesquera (SIAP). However, despite their availability, these sources of information are seldom used in scientific research as a tool in the description of the beekeeping agri-food system (BAS).

Considering the above, the purpose of this study was to conduct a descriptive and referenced analysis of the historical and current situation of honey production in Mexico using statistical information from national and international institutions. Our goal is to obtain evidence that encourages the development of the beekeeping system.

MATERIALS AND METHODS

For this study, we analyzed three SIS: the Food and Agriculture Organization Corporate Statistical Database (FAOSTAT), the Sistema de Información Agroalimentaria y Pesquera (SIAP), and the Instituto Nacional de Estadística y Geografía (INEGI).

FAOSTAT offers worldwide statistical data on a wide range of topics. For our study, we selected the Food Balance Sheet (FBS). The SIAP is in charge of generating statistics and geographic information on agri-food matters in Mexico, offering production reports, monographic descriptions, statistics, and even satellite images and dynamic maps.

Food balance sheet (FBS)

Food Balance Sheets (FBS) are useful databases for assessing a country's or entity's food capacity concerning food availability.

We procured the FBS from the Food Balance Sheets section on the FAOSTAT website. From this source, we selected a total of five variables (production, import, export, national demand, and *per capita* consumption) recorded for a period of 29 years (1990-2019) (FAO, 2021).

Once downloaded, we integrated the data from the FBS into a spreadsheet and homogenized the fields and units of measurement. Finally, we generated a data table with 680,000 records. To conduct the exploratory data analysis, we used dynamic tables in Excel.

Performance of the beekeeping agri-food system (BAS)

We obtained national statistical data from 31 files on the SIAP website. Said files contain livestock production statistics from 1990 to 2020 (SIAP 2021). The data for livestock areas came from the 2016 Agricultural, Livestock, and Forestry Census on the INEGI website. We subsequently integrated the data into a spreadsheet to identify spelling errors, inconsistencies, and omissions. Finally, we generated a data table with 665,000 records.

Based on this last database, we identified a total of four variables of interest: Number of hives (NH), production volume (PV), economic value of production (EV), and average price paid to producers (PP). In addition, we generated two more variables: Yield (Y), by dividing PV by NH, and revenue per unit (RPU), which resulted from dividing EV by NH. Exploratory data analysis and calculations were performed using pivot tables in Excel.

The purpose of describing the BAS was to outline the most relevant aspects of the system. We divided our analysis into two levels. The first one comprised the statistical description of the variables of interest for 2016 (because 2016 was the last year providing records for number of hives, even though data for the rest of the variables are available until 2020). The second level of description considered the changes and trends of the variables of interest from 2006 to 2016. For our evaluation, the monetary values were deflated to the base year 2010 using the National Consumer Price Index (NCPI).

RESULTS AND DISCUSSION

BAS performance in a global context

In 2019, global honey production reached 2.4 million tons, with China contributing 457,000 t (24.7% of the world total), making this country the leading honey producer globally. Mexico contributed 64,000 t or 3.5% of the global production, which placed it as the ninth honey producer worldwide, third in the American continent, and second in Latin America, surpassed only by Argentina, that contributed 79,000 t of honey or 4.3% of the global total (Table 1).

The *per capita* consumption of honey worldwide for the same year was 0.43 kg. In Mexico, the *per capita* consumption reached only 140 g, three times less than the average in the leading producer countries (Table 1).

The apparent national demand (AND) amounted to 24,000 t and was supplied with 37.5% of the national production, which left 62.5% of the remaining production for export (Figure 1). These production and consumption values have had ups and downs between 1990 and 2018.

Table 1. Statistics of the main honey-producing countries for 2019 (FAO, 2021).

Principales países productores	Production (thousands of ton*)	Participation (%)	Consumption *per capita* (kg año^{-1})
China	457	24.7	0.22
Türkiye	108	5.8	1.17
Argentina	79	4.3	0.03
Iran	78	4.2	0.92
Ukraine	71	3.8	0.41
USA	70	3.8	0.64
India	67	3.6	0.01
Russia	65	3.5	0.41
Mexico	64	3.5	0.14
Ethiopia	50	2.7	0.43
Global	2427	100	0.43[1]

[1]=global average

Honey production in Mexico has remained mostly stable, ranging from 50,000 to 60,000 t. The lowest figure was recorded in 1995 and 1996, when only 49,000 t were obtained, while the maximum production occurred in 1991, reaching 66,000 t of honey (Figure 1).

During the same period, the AND —with its ups and downs— presented a slight increase of 4%, going from 23,000 t in 1990 to 24,000 t in 2018. In contrast, annual *per capita* consumption showed a decrease of 46% in the same period, going from 0.26 kg in 1990 to 0.14 kg in 2018, also with ups and downs throughout the period, with a maximum consumption of 0.36 kg person^{-1} year^{-1} in 2001 and a minimum consumption of 0.14 kg person^{-1} year^{-1} in 2015 (Figure 1).

Like production and consumption per capita, honey exports decreased from 44,000 t in 1990 to 40,000 t in 2018 —9% less for said period (Figure 1). Despite this decline, Mexico still holds an important place in the international market since its production volume is high enough to maintain its export vocation. Each year, the country places around 50% of its honey production in the international market (Chan-Chi *et al.*, 2018).

However, the international markets' strict quality and safety standards increase production costs, as they force producers to modify the traditional forms of hive management and solve health problems by acquiring superior materials. This, in turn, allows them to maintain their presence in said markets (Magaña *et al.*, 2016).

For their part, imports have been virtually unnecessary to satisfy national demand —1,000 tons of honey were imported in 2001 and 2002 only (Figure 1).

BAS performance from a local context

In 2020, beekeeping was practiced in all 32 states of the country and in 1,525 municipalities, with Jalisco, Yucatán, Chiapas, Campeche, Veracruz, and Oaxaca having the largest number of honey-producing municipalities (Table 2).

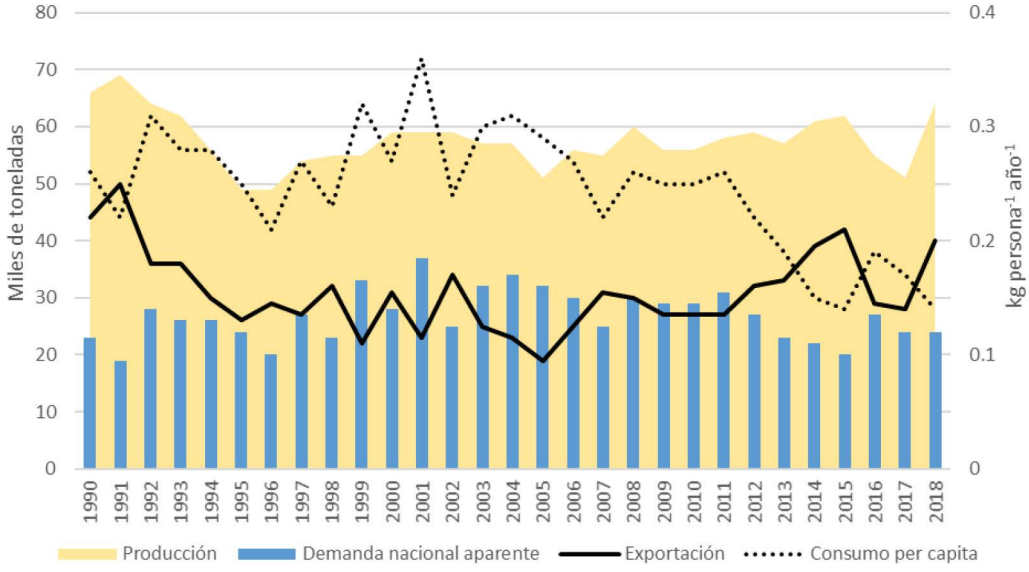

Figure 1. Food Balance Sheet (FBS) for Mexico, 1990-2018 (FAO, 2021).

In 2016, the NH nationwide reached 1,859,350 (Table 2). The states with the highest NH are in the south and southeast of the Mexican Republic, with Yucatán having the highest established NH: 250,073, that is 13.4% of the national total (Table 2). In contrast, most of the states with the lowest NH are in the north and northwest of the country (Figure 2a).

Table 2. BSA performance variables by state in Mexico for 2020 (SIAP, 2021).

Entidad	Municipios	NH[1]	PV (t)	EV (m$)	PP ($ kg^{-1})
Aguascalientes	11	17500	517.9	23.6	45.5*
Baja California	5	8672	297.9	14.7	48.7*
Baja California Sur	4	4680	201.7	9.6	47.6*
Campeche	13	205377*	5374.5*	165.5*	30.7
Chiapas	82	161822*	5434.5*	220.7*	41.6
Chihuahua	18	34061*	637.2	30.8	47.4*
Ciudad de México	7	9337	96.1	5.0	51.9*
Coahuila	19	17000*	222.3	11.3	51.2*
Colima	9	4000	494.3	22.9	46.0*
Durango	24	16884*	471.5	23.4	52.5*
Guanajuato	34	39523	654.1	32.2	49.5*
Guerrero	60	81194*	1963.3*	90.4*	47.7
Hidalgo	67	23454	1399.0*	59.6	42.7
Jalisco	109	120128*	6059.2*	283.2*	46.6*
México	73	40657*	876.1	44.2*	50.3*
Michoacán	113	67842*	2041.9*	105.9*	52.8*
Morelos	33	66180*	1954.2*	86.6*	43.4
Nayarit	16	11312	460.3	19.5	44.3
Nuevo León	8	4720	257.7	11.7	45.4*
Oaxaca	244	116860*	4592.3*	185.0*	40.9
Puebla	166	91951*	2449.6*	106.6*	43.7
Querétaro	15	2028	63.4	2.7	43.1
Quintana Roo	9	120188*	2132.8*	52.1*	23.2
San Luis Potosí	46	44202*	1145.5*	52.8*	47.8*
Sinaloa	19	19237	179.4	7.7	42.9
Sonora	28	19184	565.6	27.1	48.0*
Tabasco	17	10542	405.0	18.2	45.1*
Tamaulipas	24	22854	708.9	28.6	40.5
Tlaxcala	55	32003	454.0	19.7	43.3
Veracruz	122	138009*	4645.2*	202.8*	43.9
Yucatán	103	250073*	5528.6*	138.9*	25.0
Zacatecas	54	57876	1881.4*	83.8*	45.2*
Nacional	1525	1859350	54165.3	2187.0	
Promedio nacional		58104.7	1692.7	68.3	44.3

NH: number of hives; PV: production volume; EV: economic value of production; PP: average price paid to producers; t: tons, *: values over national mean; [1]: data for 2016.

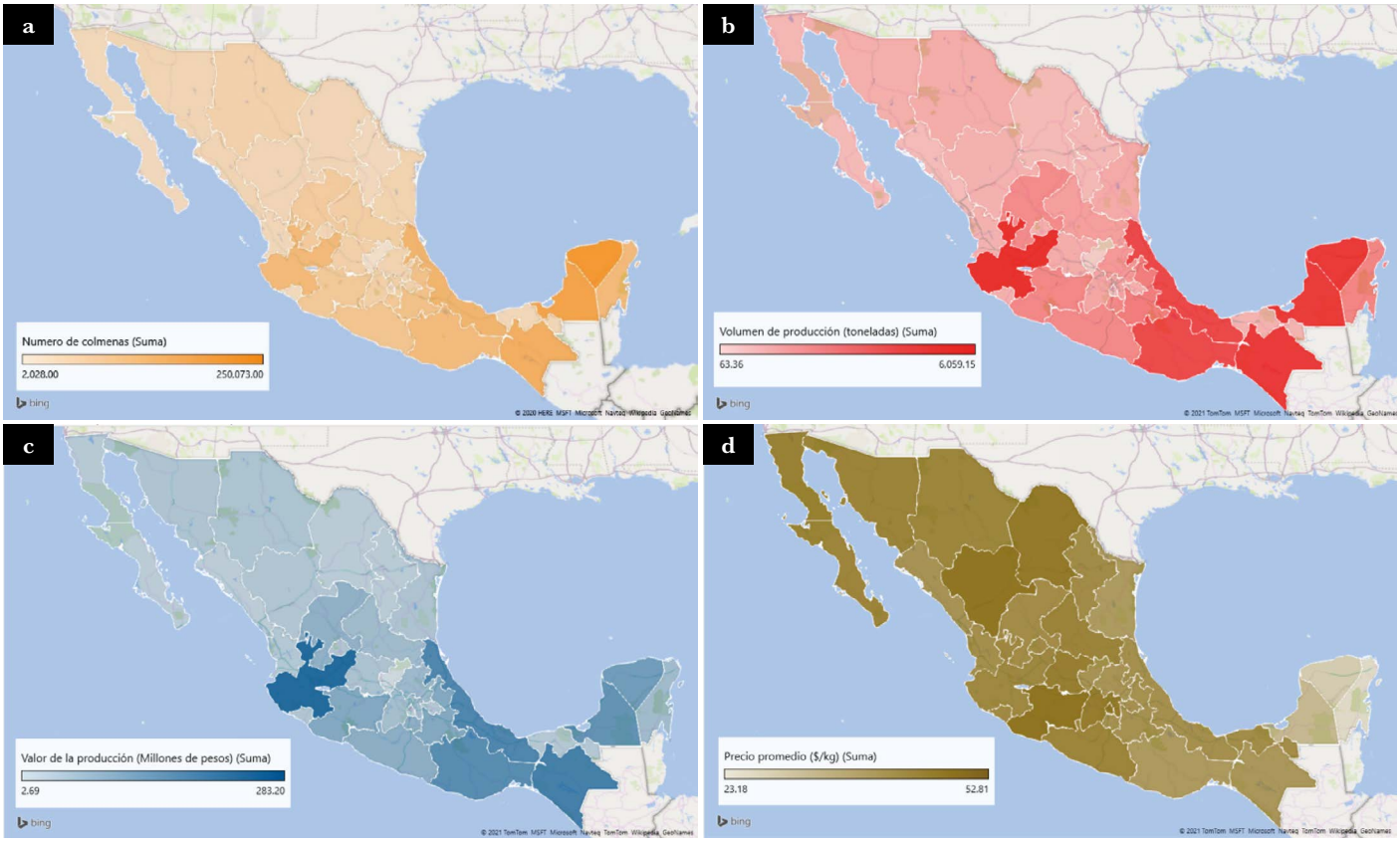

Figure 2. Geographic distribution of BAS performance variables in Mexico. a) NH for 2016, b) PV, c) EV, and d) PP for 2020.

In 2020, the total PV of honey was 54,165.3 t, which reached an EV of 2,187 million pesos. Jalisco had the highest PV with 6,059.2 t or 11.2% of the national production and an EV of 283.2 million pesos (Table 2). Again, the other states with high PV and EV are in the south and southeast of the Mexican Republic (Figures 2b and 2c).

The PP per kilogram of honey at the national level was estimated at \$44.3 kg^{-1} (Table 2). As for the geographical distribution, in Figure 2d we can observe that the best PPs converge in the north and center of the country, possibly due to the low production levels in this same area, where the states holding the last places in NH and PV are located. Michoacán has the maximum PP, estimated at \$52.8 kg^{-1} of honey (Figure 2d).

The recorded PPs for the country differ largely from the price paid per exported kilogram of honey, since the price paid to beekeepers is usually determined by the wholesale exporter or someone seeking to supply an international marketer. This depends both on the demand in the international market (import) and on the profit margin sought by commercial agents, which means that beekeepers have virtually no power to negotiate in most markets (Magaña *et al.*, 2016).

Changes and trends of BAS in Mexico, 2006-2016

The BAS has had a small increase in the number of productive hives at the national level, going from 1,747,033 in 2006 to 1,859,350 in 2016. This increase equals 6% of the

initial value (Figure 3) and would also entail an increase in the PV of honey at the national level. However, the PV decreased: while in 2006, 58,121.3 t of honey were produced, in 2016 the figure was 57,202.4 t, a reduction of nearly 919 t or 1.6% of the initial PV (Figure 3). Even though the causes of this decrease in production are not clear, it may be attributed to diseases, pests, deficient use of agrochemicals, and even delays in the blooming of nectar-polliniferous plants due to climate change (Baena-Diaz *et al.*, 2022).

There was also a decrease in the average Y per hive: while in 2006, the yield reached 33.3 kg of honey per hive, in 2016, the yield was 30.8 kg —a decrease of 7.5% (Figure 3).

The analysis of the production EV for the BAS began with the deflation of prices through the NCPI based on 2010 data (Banxico, 2018). From 2006 to 2016, there was a notable upward trend in the production EV, which went from 1,728.5 million pesos in 2006 to 2,009.7 million pesos in 2016, that is, an increase of more than 281 million pesos, or 14% of the initial EV (Figure 3). This was the result of a 5.7% increase in the PP at the national level for the same period, which went from \$44.3 to \$47 kg^{-1}, generating an increase in the RPU from \$989.4 to \$1,080.9 per hive (Figure 3).

The slight decrease in the national beekeeping activity in terms of PV, NH, and Y is due to problems of a disparate nature that have affected productivity levels.

We can group the structural causes of these problems under two main points: 1) the Africanization of bees and the presence of the Varroa destructor mite, both of which constitute the main health problem of bee colonies since they considerably reduce the bee population and honey yield (Baena-Díaz *et al.*, 2022); and 2) the stagnation of Mexican honey competitiveness in the world market due to the lack of better handling and packaging technologies, as well as to the lack of interest in characterizing and differentiating the product, which could bring an added value (Campos-García *et al.*, 2018).

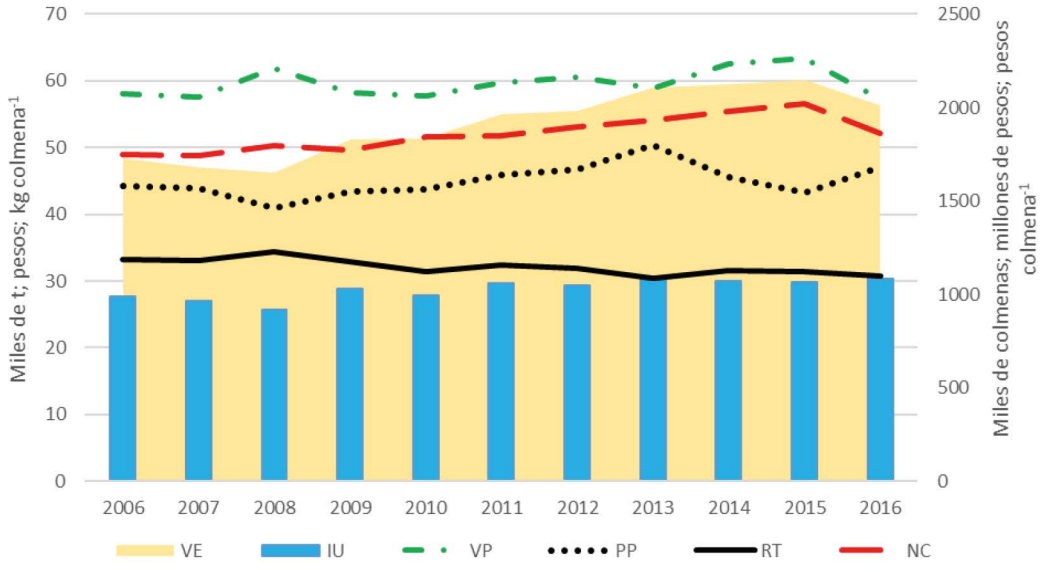

Figure 3. BAS performance in Mexico, 2006-2016: EV (millions of pesos), RPU (pesos $hive^{-1}$), PV (thousands of t), PP (pesos), Y (kg $hive^{-1}$), NH (thousands of hives).

CONCLUSIONS

Mexico has an outstanding beekeeping tradition: virtually all its states practice beekeeping. The country can satisfy the national demand for honey without resorting to imports due to its low ***per capita*** consumption (140 g person^{-1} year^{-1}). This enables the country to place nearly 50% of its production in the international market, meaning it holds a place among the top 10 countries with the highest volume of honey production.

Geographically, the south-southeast area of the country is home to the states with the best results in NH, PV, and EV. However, the states in the center and north of the country have the best PP per kilogram of honey.

Like any other agri-food system, the BAS has experienced ups and downs in performance variables over the years. Broadly, from 2006 to 2016, the average PV and Y per hive decreased by 1.6% and 7.5%. In contrast, the NH, EV, PP, and RPU showed 6%, 14%, 5.7%, and 8.5% increases. All this indicates that the BAS presents opportunities for management optimization, which would increase production levels and eventually contribute to the development of the municipalities and communities dedicated to beekeeping.

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