https://doi.org/10.22319/rmcp.v12i2.5652

Article

Analysis of beekeeping profitability by strata in Aguascalientes, Mexico

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Abstract:

The present research focused on analyzing the cost structure and profitability in the beekeeping production process. Sampling techniques were utilized to randomly select 56 beekeepers from a total of 230; they were grouped into three strata: producers with 20 to 50 hives (small), 51 to 200 hives (medium), and more than 200 hives (large). The total economic cost of production was found to be mainly composed of the variable cost, with an average relative share of 55.4 % in the three strata. Feed expenditure is the primary concept, considering that 90.0 % of beekeepers feed sugar or fructose when there are no blossoms to sustain the hive. The fixed cost represents 14.0 % of the total. The largest expenditure was due to the depreciation of machinery and field equipment. Opportunity costs represent 30.6 % on average for the three strata. The average yield per hive was 25.4 kg/year. In conclusion, considering the economic analysis, the activity is not viable for stratum I, since it does not consider the value of all the resources involved in the productive process (opportunity costs). Likewise, in this stratum the main income comes from other activities. In financial terms, the activity is viable in all three strata, which indicates that it has the

capacity to cover both the fixed and the variable costs. When opportunity costs are included, the fixed and variable costs decrease.

Key words: Bees, Productivity, Competitivity.

Received: 26/03/2020

Accepted: 11/09/2020

Introduction

In Mexico, beekeeping is of great socioeconomic and ecological importance and is considered one of the main livestock activities generating foreign exchange[1]. Generally, this activity is associated only with the production of honey, pollen, royal jelly, and propolis; however, bees are also essential to the balance of the environment, due to their collaboration in pollination. It is estimated that, out of the 90 % of pollination that occurs in flowering plants worldwide, 67 % is carried out by insects, which constitute the most important group of pollinators for both wild and cultivated plant species[2].

According to figures from the livestock sector, Mexico ranks between fifth and sixth in the world as a producer of honey, having produced 62,320 t in the year 2018[3]. The value of exports for 2018 increased by 15 % over the previous year[3], and the volume was 60 % higher than that of 2017[1].

The state of Aguascalientes is located in the Mexican highlands. In this region, due to the semi-arid climate, a large number of shrubs such as mesquite (*Prosopis laevigata*) bloom, and the Arizona beggarticks (*aceitilla*, *Bidens* spp.) flower in the rainy season. In 2018, Aguascalientes had an inventory of 15,312 hives[4]. According to the Beekeeping Product System of Aguascalientes (2018)[5], 230 beekeepers depend on bee production with only two bloomings per year: that of *aceitilla* in November, and that of mesquite in April. In the study area, more than 60 % of the honey is harvested in spring, with the mesquite (*Prosopis laevigata*) as a source of wild nectar. Unlike in the studied region, in southeastern Mexico there is such a great diversity of flowers that we cannot analyze their influence on honey production under the corresponding agroclimatic conditions[6]. Aguascalientes has a competitive advantage in honey because it is of the monoflora type, which means that it has relatively homogeneous characteristics[6], as evidenced by the difference in price with respect to the national average[7].

However, although there is a competitive advantage, there are factors that have caused a large number of beekeepers to abandon the activity or lower their production levels. A first adverse factor is low rainfall, which results in low grazing activity and a shortage of food[8]. Additional factors are low producer prices in the honey market (there is a wide variation between producer and final consumer prices), deficient technical training in production, and high input costs[9].

Other important apicultural products in this area are propolis, royal jelly, pollen, wax, biological material, queen bees, and genetic material[10]. In this scenario, the competitiveness of any production system or process in the domestic market is determined by its level of profitability. Profitability is estimated by deducting the costs incurred in order to obtain the product from the sales value of a certain amount of product[9]. In this sense, it is necessary to carry out a cost-benefit analysis and calculate the equilibrium prices in the region for the different types of beekeepers.

Therefore, the objective of the present work was to estimate the cost structure, as well as a cash flow, and a financial and economic analysis[11] of the beekeeping production in the state of Aguascalientes, in order to determine the level of unit profits or profitability of the system. The hypothesis was that the cost of equipment, tools and inputs utilized in the production process have an inverse relationship with the profits obtained by the beekeeper in this region.

Material and methods

Location of the area

The state of Aguascalientes is located at the following coordinates: 22°27'35" N, 21°37'20" S, north latitude, and 101°50'07" E, 102°52'27" W, west longitude, and is bordered to the north, northeast and west by Zacatecas, and to the southeast and south, by Jalisco. It represents 0.3 % of the country's surface area[12].

Sampling

The sample was calculated based on the population of beekeepers that are members of the beekeeping product system of the state of Aguascalientes. According to data from 2018, the register consisted of 230 beekeepers[5]. Field information was collected through

questionnaires; these were applied directly to the producers in the study area. The data presented come from the 11 municipalities of the state of Aguascalientes. It was used the stratification criteria provided by Vélez[13] and Fachini[14], where the beekeepers were classified into three categories according to the number of their hives: Small (10 to 50), Medium (51 to 200) and Large (more than 200). The stratified random sampling technique was used. The variable that was associated with the sampling procedure for variance estimation was the number of hives per beekeeper, and the error limit was 5%.

The final sample size was estimated based on the following formula:

$$\boldsymbol{n} = \frac{N * Z_{\alpha}^{2} * p * q}{d^{2}(N-1) + Z_{\alpha}^{2} * p * q}$$

Where: n= final sample size; Z=1.96 (confidence level); p= expected ratio (0.05); q= 1-p; N= total number of producers (230); d= accuracy (0.05).

The sample consisted of 56 beekeepers included in the State Beekeeping Product System. The first stratum accounted for 11 % (7) of the final sample; the second stratum, for 40 % (22), and the third stratum, for 49 % (27). The information was processed using an Excel spreadsheet.

Content of the survey

The questions included in the questionnaire were divided into the following aspects:
Technical handling: 1) Level of the beekeepers' knowledge of production activities; 2) Level of technical expertise; 3) Control of the percentage of Africanization in the zone; 4) Genotype; 5) Queen bee change frequency; 6) Frequency of hive replacement; 7) Feeding of the apiaries; 8) Disease and pest control; 9) Time invested in beekeeping.
Costs: 1) Feed costs, 2) Pests and diseases, 3) Change of queen, 4) Labor, 5) Transfer, and 6) Other costs.
Production: 1) Number of producers; 2) Number of hives; 3) Total production; 4) Location of the hives.
Income: 1) Price of honey and by-products; 2) Production; 3) Sale.

Method

For the description and analysis of the social aspects related to beekeeping production, the following variables were considered: the importance of the genetic factor, technical

management and the environment, organization for production and technical assistance. The elements considered for the processing and analysis of the technical coefficients were as follows: labor, number of apiaries, number of hives, food implements, disease control, number of harvests, among others. Labor and input costs were calculated considering the following variables: the number of day laborers used for the various activities and the expenses incurred to purchase sugar, vitamins, varroa control, among others.

A cost analysis was performed as by Sagarnaga *et al*[11] with the methodology used by the United States Department of Agriculture (USDA), whose theoretical and methodological bases conform to the standards recommended by the Working Group on Costs and Returns of the American Agricultural Economics Association (AAEA).

Within this context, the USDA classifies costs into two types: operating costs and allocated overhead. Washington State University classifies the costs into fixed and variable costs and disaggregates them into economic, financial, and disbursed costs. Financial costs include only fixed and variable costs; disbursed costs include, in addition to fixed and variable costs, the cash required to pay down the principal on long-term loans and to cover the producer's household expenses. Economic costs include financial costs and the opportunity cost of production factors[11].

Opportunity costs were calculated: land, labor, capital and business management. The value of all resources in the production process was used, regardless of whether they represented disbursed or undisbursed expenses. Once the production costs were quantified, the target price was determined for each of the strata, where the minimum price was identified to ensure profitability[15].

Results

Investments in hives and equipment

The beekeeping production units in Mexico are classic standard beehives. In Aguascalientes, the beekeepers build the hive with a support (mostly made of bricks), a floor, a brood chamber (langstroth type), and a roof, with two elevations. Table 1 shows the investment by each producer stratum. Regarding the investment in field equipment, its total value increases as the producer increases the number of hives; this is due to the need for greater installation capacity (core holders, brood chambers, and supers, mainly). The second and third strata increase considerably in work equipment, due to their greater capacity; some of the necessary

components are the extractor, sedimentation tank, and uncapping bench. Producers of the first stratum (80 %) do not have the necessary technology; therefore, they opt to rent these serv
ices mainly during the harvest.

Table 1: Investment by the beekeeper ($)

	Producer strata by number of hives		
	1-50	**51-200**	**Over 200**
Work team	15,805.6	150,000.0	165,050.0
Field material	25,900.0	140,535.0	400,800.0
Total investment	41,705.6	290,535.0	565,850.0
Coefficient of variation (%)	38.9	14.9	19.46

Source: Prepared by the authors with data from the survey to beekeepers, 2018.

The difference between the strata was the investment in field and warehouse equipment and the quality of the equipment; i.e. an extractor for 80 frames is almost five times the value of one for 32 frames, or 10 times the value of one for galvanized sheets. The high costs cause beekeepers in stratum I to resort to renting equipment (cellars) for harvesting.

Cost structure

The production, economic, financial and disbursement costs were estimated by stratum, according to the number of hives, based on the information gathered from the surveys. The percentage structure of total costs is mainly composed of variable costs. Considering opportunity costs, the variable cost for stratum I is 51.9% (Table 2); 54.1 % for the second stratum (Table 3), and 60.2 % for the third stratum (Table 4).

Table 2: Production cost structure ($) of Stratum I (1-50 hives)

Concept of costs	Economic	Financial	Disbursed
Variable costs			
Food	12,801.78	12,801.78	12,801.78
Medications	182.14	182.14	182.14
Maintenance	1,000.00	1,000.00	1,000.00
Purchase of queens	3,295.25	3,295.25	3,295.25
Fuel	6,988.89	6,988.89	6,988.89
Total variable costs	24,268.07	24,268.07	24,268.07
Fixed costs			
Land rentals	-	-	-
Indirect labor	-	-	-
Family labor	-	-	-
Equipment depreciation	2,000.00	2,000.00	-
Depreciation of field material	3,000.00	3,000.00	-
Other fixed costs	1,445.00	1,445.00	1,445.00
Total fixed costs	6,445.00	6,445.00	1,445.00
Opportunity costs			
Opportunity cost of land (rent)	1,500.00	-	-
Working capital	4,170.56	-	-
Producer/family labor	5,600.00	-	-
Business management	4,800.00	-	-
Total opportunity costs	16,070.56	-	-
Total costs	46,783.63	30,713.07	25,713.07

Table 3: Production cost structure ($) of Stratum II (51-200 beehives)

Concept of costs	Economic	Financial	Disbursed
Variable costs			
Food	40,319.07	40,319.07	40,319.07
Medications	1,008.00	1,008.00	1,008.00
Maintenance	1,500.00	1,500.00	1,500.00
Purchase of queens	14,182.08	14,182.08	14,182.08
Fuel	13,640.00	13,640.00	13,640.00
Labor	4,008.18	4,008.18	4,008.18
Total variable costs	74,657.33	74,657.33	74,657.33
Fixed costs			
Land rentals	3,000.00	3,000.00	3,000.00
Indirect labor	-	-	-
Family labor	-	-	-
Equipment depreciation	7,260.00	7,260.00	-
Depreciation of field material	4,840.00	4,840.00	-
Other fixed costs	2,080.00	2,080.00	2,080.00
Total fixed costs	17,180.00	17,180.00	5,080.00
Opportunity costs			
Opportunity cost of land (rental)	1,500.00	-	-
Working capital	29,053.50	-	-
Producer/family labor	8,400.00	-	-
Business management	7,200.00	-	-
Total opportunity costs	46,153.50	-	-
Total costs	137,990.83	91,837.33	79,737.33

Source: Prepared by the authors with data from the survey to beekeepers, 2018.

With respect to fixed costs, it was found that the participation is 13.8 %, 12.5 % and 15.8 %, respectively. Continuing with the fixed costs, a direct relationship was observed in the second and third strata. That is, by having more hives, the beekeeper chooses to acquire higher capacity technology. On the other hand, there is a need to increase the number of apiaries, which would entail higher land rental costs.

Table 4: Production cost structure ($) of Stratum III (more than 200 beehives)

Concept of costs	Economic	Financial	Disbursed
Variable costs			
Food	115,475.36	115,475.36	115,475.36
Medications	3,000.00	3,000.00	3,000.00
Maintenance	3,600.00	3,600.00	3,600.00
Purchase of queens	38,124.45	38,124.45	38,124.45
Fuel	23,335.00	23,335.00	23,335.00
Labor	9,963.03	9,963.03	9,963.03
Total variable costs	193,497.84	193,497.84	193,497.84
Fixed costs			
Land rentals	6,000.00	6,000.00	6,000.00
Indirect labor	9,963.03	9,963.03	9,963.03
Family labor	-	-	-
Equipment depreciation	19,380.00	19,380.00	-
Depreciation of field material	12,920.00	12,920.00	-
Other fixed costs	2,625.00	2,625.00	2,625.00
Total fixed costs	50,888.03	50,888.03	18,588.03
Opportunity costs			
Opportunity cost of land (rent)	3,000.00	-	-
Working capital	51,717.50	-	-
Producer/family labor	10,200.00	-	-
Business management	12,000.00	-	-
Total opportunity costs	76,917.50	-	-
Total costs	321,303.37	244,385.87	212,085.87

Source: Prepared by the authors with data from the survey to beekeepers, 2018.

Within the variable costs, the item with the highest participation is feed, in the state of Aguascalientes beekeepers feed the bees sugar and fructose. Feed is provided when there is no flowering and is important for the survival of the bees; in this sense, this variable cost increases progressively as the producer increases the number of hives. The second item with the highest share is the cost of transportation, which basically refers to the fuel used to carry out the technical management of each apiary. The third item corresponds to the labor required to carry out beekeeping activities; the largest number of day laborers is required during the harvest season (March-April).

Fixed costs are mainly composed of the depreciation of field infrastructure, followed by the depreciation of work and protection equipment. In the case of the depreciation of working equipment (extractor, uncapping bench, stainless steel drum, etc.), it has an inverse relationship to the number of hives.

Opportunity costs represent 34.3 % for stratum I, 33.4 % for stratum II, and 24.0 % for stratum III, with the cost of working capital making the largest contribution. For the calculation of opportunity costs of the producer's labor, the daily wages were quoted at 200 as a reference of the price of a daily wage in the region. Respondents in the first stratum consider that they require 28 d of labor per year to operate their hives; those in the second stratum consider that it takes them 42 d of labor, and those of the third stratum reported requiring 51 d of labor. The beekeepers in the region consider that the land has an opportunity cost of $1,500, with the understanding that, if the land is not used, it can be rented to other beekeepers at the aforementioned cost.

In order to assess business management, producers in stratum I considered that they work one hour a week to manage the apiaries; those of stratum II work 3 h per week, and those of stratum III reported working 5 h a week to plan their activities. The estimated financial cost per kilogram of honey produced is $45.92, $31.54 and $25.49, respectively, for each stratum.

Revenues and profitability

When beekeepers depend mostly on beekeeping, they have more hives; on the contrary, when beekeepers have fewer hives, they tend to choose to engage in other income-generating activities. In order to estimate their income was estimated as follows, according to survey data: an average yield of 19.6 kg per hive at a price of $65 was considered for stratum I; 26.4 kg per hive at a price of $50.9, for stratum II, and 30.2 kg per hive at a price of $50.45, for stratum III.

Table 5: Percentage contribution to total income

Concept	**Strata by number of hives**		
	20 to 50	**51 to 199**	**200 or more**
Economic contribution of beekeeping	9.6	32.5	62.8
Honey	97.2	87.0	88.0
Beeswax	1.0	1.6	3.9
Polen	0.0	0.0	0.3
Nuclei	0.0	3.7	2.4
Others	1.8	7.7	5.5
Total	100.0	100.0	100.0

Source: Prepared by the authors with data from the survey of beekeepers, 2018.

As beekeepers acquire more hives, the income generated from beekeeping increases its share of the total income (Table 5). In this sense, it was noted that honey is the main product commercialized in the market.

In financial terms, beekeeping is viable in all three strata, i.e. it has the capacity to cover both fixed and variable costs (Table 6). On the other hand, in economic terms, the activity is not viable in stratum I; this indicates that the factors of production are not adequately remunerated. In strata two and three, the activity is viable in economic terms because it remunerates fixed costs, variable costs, the producer's labor, the cost of investment and business management, and the depreciation.

Table 6: Costs, revenues and profitability ($)

		Economic	Financial	Disbursed
Stratum I	Total costs	46,783.63	30,713.07	25,713.07
	Total revenues	44,096.67	44,096.67	44,096.67
	Net income	- 2,686.96	13,383.60	18,383.60
	Profitability ratio, %	-5.7	43.6	71.5
Stratum II	Total costs	137,990.83	91,837.33	79,737.33
	Total revenues	148,275.20	148,275.20	148,275.20
	Net income	10,284.37	56,437.87	68,537.87
	Profitability ratio, %	7.5	61.5	86.0
Stratum III	Total costs	321,303.37	244,385.87	212,085.87
	Total revenues	483,711.50	483,711.50	483,711.50
	Net income	162,408.13	239,325.63	271,625.63
	Profitability ratio, %	50.5	97.9	128.1

Source: Prepared by the authors with data from the survey to beekeepers, 2018.

The prices of honey are differentiated by the type of nectar available in the region. In this case, the largest production comes from the mesquite flower[16], which is among the best listed at the international level[17]. An inverse relationship was identified between the volume of production and the respective price, because the producer of stratum I sells his product to the local market, while strata II and III sell wholesale at a lower price in the national and international market (Table 7). Although small beekeepers achieve a higher price, they obtain lower profitability due to factors such as marketing channels, technical management, economy of scale, added value and limited governmental support.

Table 7: Bee honey markets (%)

	Local	National	International
Stratum I	92.78	7.22	0.00
Stratum II	34.50	23.00	43.50
Stratum III	24.38	27.50	47.12

Source: Prepared by the authors with data from the survey to beekeepers, 2018

Break-even price

The break-even point indicates the magnitude of production and the price at which the honey must be sold or produced in order to prevent a loss (Table 8).

Table 8: Break-even prices by stratum ($)

	Economic	Financial	Disbursed
Stratum I	69.95	45.92	38.45
Stratum II	47.39	31.54	27.38
Stratum III	33.51	25.49	22.12

Source: Prepared by the authors with data from the survey to beekeepers, 2018.

In stratum I, $69.95 is the price necessary to cover the cost of all resources, including family labor of the production unit, business management and net invested capital costs. Prices above $69.95 generate a return to risk assumed by the producer; below this amount they imply a return to the producer's labor, business management and a return on net invested capital that is lower than what could be generated with the best alternative use of resources.

Also in the same stratum, the equilibrium price of $45.92, which the necessary price to cover the financial costs according to the accounting systems, implies zero retribution to the producer's labor. Prices below the break-even price imply a decrease in retained earnings. A price of $38.45 covers the cash costs of the production process. For strata II and III, the economic, financial and disbursed equilibrium prices are lower than that of the first stratum.

Discussion

Based on the information gathered from the study area, it is clear that the need to acquire work equipment (increased capacity of the extractor, uncapping bench, mini-spinner, wax recuperator, sedimentation tank) and field equipment (supers, brood chambers, nuc frames,

etc.) increases as the beekeeper acquires more hives. Thus, beekeepers in stratum II and III who operate with more than 51 hives have a production of more than one and a half tons, which leads them to choose to increase the capacity of machinery installation (stainless steel), thus favoring the safety of the products. The findings are consistent with studies[18] where they mention that the percentage of implements increases directly with the number of hives. In another similar study, it was stated that the inventory or possession of complementary equipment, such as extractors, uncapping tools and benches, funnels, knives, among others, increased progressively with the size of the apiary[19]. Similarly, other authors[20] conclude that the greater the number of hives, the greater the investment in the hives.

As beekeepers increase their hives, investment in field equipment is outpacing investment in machinery. This is consistent with what was reported for the state of Morelos, Mexico[13], where investments in machinery and equipment for beekeeping are said to be minimal; therefore, beehives represent the largest investment in absolute terms.

According to the results of the study region, in the first stratum, the investment per hive was $933.33 (coefficient of variation of 20 %); $819.98 (coefficient of variation= 23.7 %) in the second, and $768.51 (coefficient of variation 32 %) for the third stratum, with an average of $830.60, which is lower than what was reported in the Mayan communities of the central coast of Yucatan, where the overall average investment per hive was $1,201.3 pesos[19].

Regarding the cost structure in general for Mexico[9] it is estimated that the production costs of the beekeeping activity are composed mainly of variable costs, with a relative share of 67.1 %, while fixed costs represent a proportion of 32.9 % of the total cost. On the other hand, with respect to total cost, Yucatan reported a contribution of 77.9 % for variable cost and 22.1 % for fixed cost[19]. With respect to the breakdown of the financial costs mentioned above, the estimated average at the national and state level was lower than the estimate for Aguascalientes. Thus, in the study area, for stratum I the variable financial cost contributed 79.0 % of the total; it was 81.3 % for stratum II, and 79.2 % and for stratum III.

As for variable costs specifically, sugar represented 53.0 % of total variable costs for the first stratum; 54.4 %, for the second stratum, and 60.0 %, for the third stratum, with a total average of 55.8 %. These estimated percentages present a significant difference compared to the results of other studies[19] that report an average of 38.7 % for the first stratum, 54.4 % for the second stratum, and 60.0 % for the third stratum, with a total average of 55.8 %. A probable cause of this percentage difference may be due to the fact that the intervals between one flowering and the next are longer in the studied area (given the climatic conditions); therefore, the cost of feeding is increased.

On the other hand, for the state of Nayarit, producers with fewer hives (stratum I) were found, through a model for the generation of costs in beekeeping enterprises, to have a greater

expenditure in transportation; for the second (stratum II), the greatest expense is in the production material, and for the third stratum, it is labor[21].

In the particular case of fixed costs, depreciation (depreciation in infrastructure, protection equipment and equipment) represented 63.0 % of total fixed costs. This was lower than that reported by other authors[19], of 88.4 % in average. When the analysis is made by adding opportunity costs (economic analysis), there is a decrease in the fixed and variable cost items.

When beekeeping is the main economic activity, this is manifested by the possession of a larger number of apiaries. In contrast, when there are few hives, beekeepers diversify their economic activities[20]. For this reason, in strata II and III of this study, a larger number of producers depended primarily on beekeeping.

Also, little diversification was found to exist in beehive production; 90.7 % of beekeepers produce only honey, which is their main source of income. This percentage coincides with that observed in Argentina, which is 82 % in average[21], while in some regions of Mexico it is 99.5 %[19].

The estimated break-even prices at the financial level ($45.92 per kilogram of honey for the first stratum, $31.54 per kilogram of honey for the second, and $25.46 for the third) were similar to those reported for some regions of Mexico[22]. In Nayarit, the break-even point for income among beekeepers with 100 hives was found to be $14,865.00; $73,715.00 among beekeepers with 450 hives, and $52,642.00 among beekeepers with 600 hives[23].

Conclusions and implications

The economic profits of small producers were observed to be negative, while those of the second and third strata are positive. The positive profitability for medium and large producers may be due to the scale of production, as these reduce input costs by purchasing in large volumes and assured sales prices. Based on the above results, it can be deduced that, in the state of Aguascalientes, stratum II and III practice medium- and high-scale beekeeping, while stratum I practices low-scale beekeeping, characterized by traditional management, which does not take into account administrative costs. In order to attain their consolidation, small producers must invest capital and purchase the technology necessary for the formation of small businesses, so that they may increase their production and thus be able to negotiate in the market. Based on the analyzed data, it can be concluded that there is a potential for the diversification of apicultural by-products in high demand in the market, such as royal jelly, propolis, pollen, wax, bee nuclei, and queens.

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