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Article

Characterization of family dairy systems in the state of Aguascalientes, Mexico, based on social variables, agricultural-livestock variables, and productivity

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Abstract:

The objective was to determine the social, agricultural-livestock, and productive characteristics of the family dairy system of Aguascalientes. A total of 180 milk production family units were visited randomly. The sample size was a finite population of production units with dairy activity (99 % confidence level). Social, agricultural-livestock, and productive aspects were recorded through a survey. Ejido property (65 %) predominates over small property (34.5 %). Family labor represents 89.1 %, and the average age of the producer

is 49.6 yr, where 20.6 % of them are under 50 (P<0.01). Fifty-five percent of the producers attended only elementary school (P<0.01). The sale of milk is the only source of income of the production units (92.8 %), and they are not self-sufficient in forage production (79.2 %). The total number of hectares on the small property (12.4 ± 1.1) was higher than the ejido system (8.4 ± 1.2) (P<0.05). The main crops were corn, in irrigated (55.0 %) and rainfed areas (51.1 %), and alfalfa (48.3 %). The predominant breed was Holstein (91 %). Milking was mechanical (75.5 %). Milk production per cow in the ejido system was higher than that of the small-property system (17.6 *vs*. 14.5 L/d; P<0.05). Family labor contributes to the viability of the family dairy production system. Nevertheless, the low adoption of technology and the insufficiency of cultivation areas to produce forage in quantity and quality limit the productivity of the system.

Keywords: Family dairy system, Traditional dairy system, Backyard dairy system, Social aspects, Agricultural aspects.

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Introduction

Bovine milk production in Mexico was 13,332 million liters (2023). It is the third most important livestock product in economic terms, with 17 % of the national value; however, despite growing 1.8 % annually on average (2010-2023), it only supplies 80 % of the demand, and 61 % of powdered milk is imported for domestic consumption[1,2]. Mexico is an importer of powdered milk, fluid milk, and dairy products, where imports of skimmed milk powder have increased by 128 % in the last 12 yr, with an average annual growth of 9.3 %, which meant 3,705 million liters, and 1,158 million dollars (2023); for its part, the import of dairy products is higher[2]. This limits the growth of the dairy industry and the profit to the producer[3-11], with a 35 % reduction in the price of milk[3,12] in addition to increases in costs that compromise the income of the family dairy system[6-8,13].

A study reports a 33.9 % reduction in the gross value of production (2005-2013)[7], which leads to a substantial reduction in the family production system, being displaced by a system of greater specialization and technification whose vertical structure allows it to obtain greater added value[6-8,13]. This causes the abandonment of the dairy business and the impoverishment of thousands of family dairy production units, a decrease in the number of

productive animals, and greater technological dependence[14-17]. For this reason, it is essential to consider alternative models of development with the purpose of promoting the production of the domestic market and the capitalization of the productive sector, such as offering a minimum guaranteed price for milk (higher than the international price) and reducing the profit margin of retailers in order to reduce dependence on dairy imports[6,18]; in some cases, encouraging the displacement of the family sector to a more specialized one with greater technological adoption and linked to the processing industry that allows a greater opportunity for negotiation[6-7]; or also the productive reconversion of the production unit[8,19-20].

In Mexico, the family diary production system contributes 30 % of total production; it represents 23 % of breeding cows[2] and 78 % of production units[21]. The advantages of this system are a low production cost and sustainability in the supply at the national level, despite the dependence on external inputs[22], where approximately 97 % are related to the operation of the system and the replacement of animals[23]. Nevertheless, production efficiency is lower due to low technological adoption, the ownership of small agricultural properties with a high risk of climate impact, and limitations in the quantity and quality of forage production compared to more technified dairy systems[16-17,24]. For this reason, the family dairy system is considered subsistence production and in the range of food poverty due to its low productivity[4,25], and therefore other activities outside the production unit are resorted to[4,16-17].

Fifty-five (55) percent of family milk production is acquired by the processing industry, and the rest for the production of artisanal cheeses and their derivatives; but in recent years, the industry has demanded higher standards of milk quality to meet the expectations of its customers, which represents a challenge to remain a supplier[13,17,25]. In Mexico, the family dairy system is integrated into community structures whose social ties have an organized economic base, this being a rooting factor that offers important sources of self-employment, and almost all of the income of the family dairy producer; it generates more than one million direct and indirect jobs, and 3-4 million Mexicans depend on the sector[4,18,25].

This work aims to determine the socio-economic characteristics of the agricultural-livestock and productive environment of the family dairy system in Aguascalientes, Mexico, and to identify the critical points that limit permanence, development, and productive efficiency.

Material and methods

The study included seven representative localities of the family dairy system in Aguascalientes in 2020. Through a random survey, technical visits were made to bovine milk

production units representative of the family system, both of the ejido property and of small property. Calculations were made for a non-probabilistic sample size of a finite population of dairy production units in Aguascalientes[26], standard deviation of milk production in the family sector of Aguascalientes[24], and a confidence level of 99 %[27].

The study was conducted in 180 family bovine milk production units and information on social, agricultural-livestock, and productive aspects was recorded.

The localities identified as representative of the family dairy system were:
Aguascalientes, southern area (n= 40), El Llano (n= 37), Tepezalá (n= 20), Asientos (n= 19), Aguascalientes, sierra area (n= 21), Jesús María (n= 17), and Pabellón de Arteaga (n= 26).
An analysis of the number of cows per unit of production was carried out using a normal distribution, and three groups were categorized by herd size (HS):
1) Herd of 10 or fewer breeding cows (HS1) (n= 49).
2) Herd of 11 to 20 breeding cows (HS2) (n= 72).
3) Herd of 21 or more breeding cows (HS3) (n= 59).

By land tenure (TEN), the family dairy production under study was subclassified into:
1) Ejido livestock farming (n= 118).
2) Small livestock farming (n= 62).

Variables assessed

Social, agricultural-livestock, and productive variables

The variables evaluated were the age of the producer; schooling; land tenure; labor used in agricultural work; if they kept economic and productive records; the use of artificial insemination and natural mating; and whether milk production is the main source of household income. The following was evaluated: self-sufficiency in forage production, the use of crop residues, and type of mechanical traction. Description of the main crops intended for animal intake and self-consumption for humans, forage corn in irrigated and rainfed areas, alfalfa, and other crops, such as rye grass, oats, barley, nopal, common vetch, and the cultivation of beans in both types of land tenure. The following was analyzed: the use of milk production records, economic and technical-productive, if they had pasture land for livestock use, use of manure, and whether they had technological adoption of conservation tillage. The percentage of producers in the family milk production system with crops of irrigated (PIC) and rainfed corn (PRC) and alfalfa (PALF) was recorded. Likewise, the following was

recorded: the number of breeding cows (NBC) and cows in production (NCP), milk produced per day in the production unit (TLH) and the total number of hectares in the production unit (TNH); and the daily milk production per cow in the milking line (PMC) (PMC=TLH/NCP) was calculated.

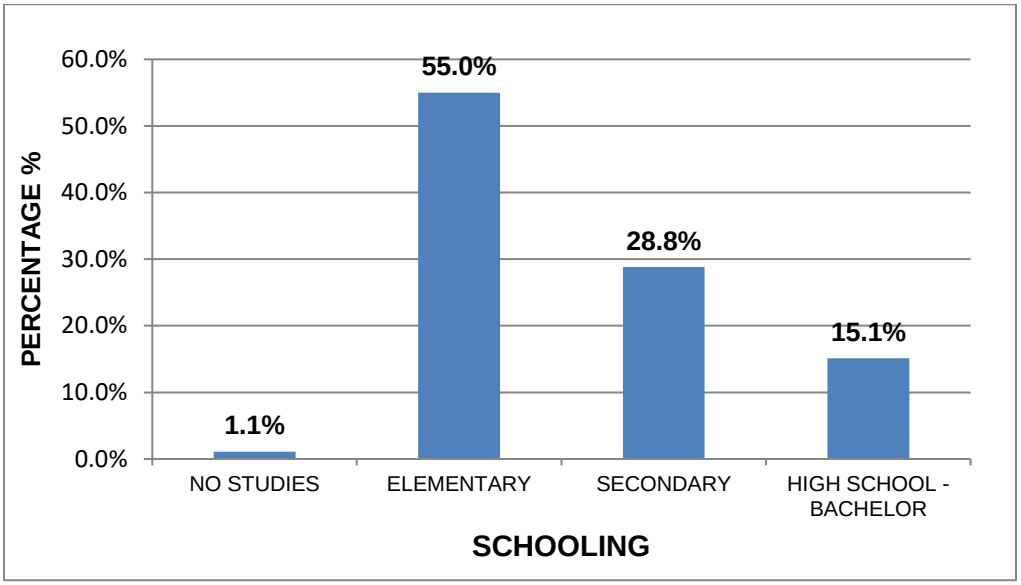
Statistical analysis

The type of land tenure and labor used in agricultural work, percentage of producers with or without arable land, self-sufficiency in the production of forage for feeding cows, use of economic and productive records, use of artificial insemination and natural mating, use of crop residues and cow manure on the land, and use of the rangeland were subjected to a descriptive analysis. Age, education, and main source of income were analyzed using a Chi-square test[27]. A descriptive analysis was carried out for both types of land tenure on the proportion of the main crops for dairy cow feed, forage corn and alfalfa; the cultivation of other forage species, cereals, and legumes, such as oats, barley, nopal, common vetch, and beans; the use of rangelands; the number of breeding cows and the reproductive method used for the cows. The variables PIC, PRC, and PALF were analyzed by means of a chi-square test by TEN and HS. PMC, NBC, NCP, and TNH were analyzed by means of a two-way classification factor analysis, where the independent variables considered were TEN and HS[28].

Results

The family bovine milk production units were of the ejido type (65.5 %) and the rest (34.5 %) were privately owned. The labor employed in these production systems is predominantly family labor (89.1 %); the rest, 11.9 %, employ day workers, which is added to family members. Ninety-six point seven (96.7) percent of the producers know how to read and write, being similar between the type of land tenure and the size of the herd ($P>0.05$). Fifty-five (55) percent, 28.8 %, and 15.1 % of the producers hold elementary, junior high school, and high school education, respectively ($P<0.01$); in contrast, 1.1 % have no education ($P<0.01$) (Figure 1).

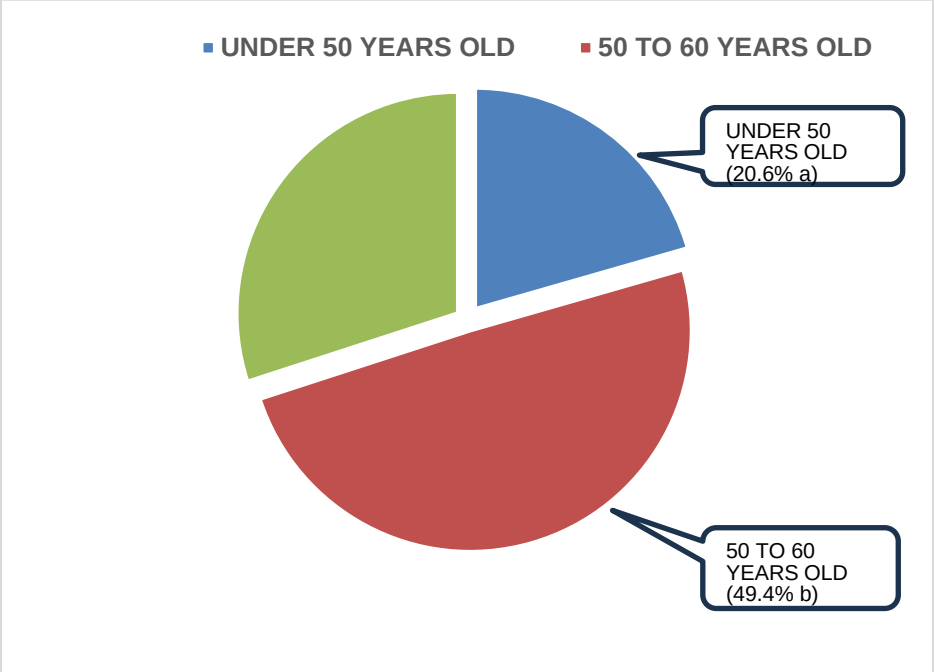
Figure 1: Schooling of producers in the family dairy system in Aguascalientes, Mexico



[abc] Different letters indicate a statistically significant difference ($P<0.01$).

The age range of the producers is from 18 to 86 years, with an average of 49.6 years, which was similar between type of tenure and herd size ($P>0.05$). Twenty point six (20.6) percent of producers are under 50 yr of age; 49.4 % are between 50 and 60 yr old, and 30 % are over 60 yr old, respectively ($P<0.01$) (Figure 2).

Figure 2: Age of the producer in the family dairy system in Aguascalientes, Mexico



[abc] Different letters between segments indicate statistical difference ($P<0.01$).

Ninety-two point eight (92.8) percent of the producers indicated that the sale of the dairy product and its derivatives represents 100 % of their total income; however, 17.8 % of the producers have complementary income (P<0.01) (Figure 3).

Figure 3: Main source of income for the producers in the family dairy system in Aguascalientes, Mexico

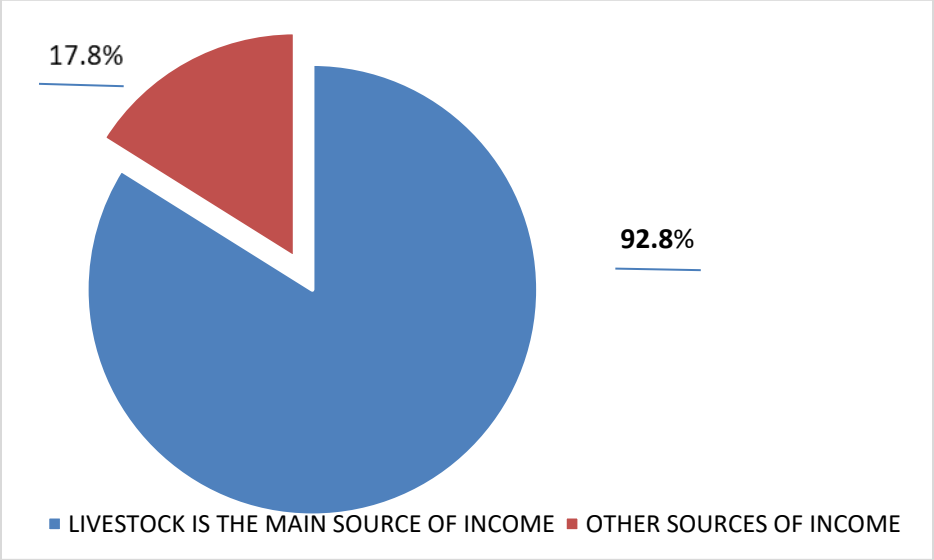


Table 1 shows that the total number of hectares (TNH) for forage production on the small property (12.4 ± 1.1) is higher than that observed in the ejido system (8.4 ± 1.2) (P<0.05). Likewise, herds with more than 10 breeding cows had a higher TNH than herds with 10 or fewer (P<0.05). Sixty-one and 59.3 % of the producers of the ejido system grow forage corn and alfalfa in irrigated areas, a figure higher than what is observed in the small property, 43.5 and 25.8 %, respectively (P<0.05). In contrast, a higher percentage of small-property farmers (67.7 %) grow forage corn in rainfed areas than in the ejido system (42.3 %, P<0.05). In herds of 20 or more breeding cows, there is a higher percentage of producers who grow corn in irrigated areas (66.1 %) and a lower percentage in rainfed areas (38.9 %) than in herds with less than 20 breeding cows (P<0.05). The percentage of producers with alfalfa crops was similar among the different herd sizes (P>0.05).

Table 1: Total number of hectares (TNH); percentage of producers that grow irrigated corn (PIC), rainfed corn (PRC), and alfalfa (PALF) by effect of land tenure types and herd size

	n	TNH (μ ± SE)	PIC (%)	PRC (%)	PALF (%)
Type of land tenure:					
Ejido	110	8.4 ± 1.2 [a]	61.0 [a]	42.3 [a]	59.3 [a]
Small property	54	12.4 ± 1.1 [b]	43.5 [b]	67.7 [b]	25.8 [b]
Herd size:					
2 to 10 breeding cows	44	8.0 ± 1.2 [a]	40.8 [a]	61.2 [a]	42.8 [a]
11 to 19 breeding cows	67	11.2 ± 1.0 [b]	55.5 [a]	54.1 [a]	43.0 [a]
20 or more breeding cows	53	12.0 ± 1.1 [b]	66.1 [a]	38.9 [b]	57.6 [a]

μ ± SE = mean ± standard error.

[ab] Different letters by column within the same main effect indicate a significant difference ($P<0.05$).

Seventy-two-point one (72.1) percent of producers have one to two plots for agricultural use; 13.1 % of them have three plots and 14.8 % more than four. Fifty-six-point two (56.2) percent of producers use crop residues to feed their live animals and 28.9 % incorporate them into the soil. Eighty-nine-point one (89.1) percent use mechanical traction to cultivate their land, 10.4 % did not respond, and only 0.5 % use both mechanical and animal traction. Eight point eight (8.8) percent do not have arable land and depend on the purchase of forage for cow feed, and 5.5 % use communal rangeland areas during the rainy season to supplement cow feed. Eighty-eight percent of the producers do not know conservation tillage. Seventy-nine-point two (79.2) percent of family dairy producers are not self-sufficient in forage production.

Table 2 shows the forage production crops of the bovine milk production system of the family system in Aguascalientes. The three main crops are forage corn in irrigated and rainfed areas, 55.0 and 51.1 %, respectively, and alfalfa (48.3 %). Irrigated rye grass is grown by 14.4 % of the ejido members, whereas in the case of the small property, it is not cultivated; oats (11.1 %), barley (1.1 %), nopal (0.5 %), and common vetch (0.5 %) represent the rest of the crops of the family system. Fifteen percent of the producers of the family system in both types of land tenure, ejido or small property, grow beans on 1.4 ha on average for their own consumption.

Table 2: Main crops in the family dairy systems in Aguascalientes, Mexico

Crops	FP (n)	%	EP (n)	Ejido system (ha)	SPP (n)	Small property (ha)
Irrigated corn	99	55.0	72	4.0 (0.5-18.0)	27	4.8 (0.5-20.0)
Rainfed corn	92	51.1	50	6.9 (0.5-35.0)	42	7.6 (1.0-32.0)
Alfalfa	86	48.3	70	2.3 (0.5-9.0)	16	2.8 (1.0-6.0)
Grass (rye grass)	26	14.4	26	3.8 (1-10)	---	---
Beans	27	15.0	18	1.4 (0.25-5.0)	9	1.3 (0.5-4.5)
Oats	20	11.1	17	1.7 (0.5-5.0)	3	3.6 (1.0-8.0)
Barley	2	1.1	1	4.0	1	3.0
Nopal	1	0.5	1	1.0	---	---
Common vetch	1	0.5	1	2.0	---	---
Rangeland	12	6.6	5	8.0 (2.0-20.0)	7	18.8 (2.0-42.0)

FP= family producers; EP= ejido producers; SPP= small property producers.

Table 3 shows that milk production per cow in the milking line was higher in the ejido system (17.6 ± 0.5) than in the small property system (14.5 ± 0.7) ($P<0.05$). The number of breeding cows and cows in production were similar due to the effect of land tenure ($P>0.05$). In herds with 20 or more breeding cows, milk production per cow in milking line per day (17.5 ± 0.7) was higher than that observed in herds with less than 20 cows ($P<0.05$). Ninety-one (91) percent of the cows in the family systems are Holstein, 8 % American Brown Swiss, and 1 % undefined; where 99 % of the breeding cows come from the same farm. In the family dairy system, only 44, 33, and 23 % of the production units record the milk production of the day, the economic aspects, and technical-productive aspects of the herd, respectively. Seventy-two-point seven (72.7) percent, 22.7 %, and 4.4 % of producers use artificial insemination, natural mating, and both reproductive methods, respectively. The type of milking used by 75.5 % of the producers is mechanical with a two-cow milking machine, the rest milks manually; the milking parlor does not exist and this is carried out in the throughs of the pens.

Table 3: Milk production per cow/day (PMC), number of breeding cows (NBC), and number of cows in production (NCP) by effect of land tenure types and herd size (Mean ± SE)

	n	PMC	NBC	NCP
Type of land tenure:				
Ejido	118	17.6 ± 0.5 [a]	15.9 ± 0.5 [a]	12.7 ± 0.5 [a]
Small property	62	14.5 ± 0.7 [b]	16.9 ± 0.5 [a]	13.9 ± 0.5 [a]
Herd size:				
2 to 10 breeding cows	49	15.4 ± 0.7 [a]	6.9 ± 0.8 [a]	5.5 ± 0.7 [a]
11 to 19 breeding cows	72	15.1 ± 0.6 [a]	14.1 ± 0.7 [b]	10.9 ± 0.6 [b]
20 or more breeding cows	59	17.5 ± 0.7 [b]	28.4 ± 0.7 [c]	23.4 ± 0.7 [c]

[abc] Different letters by columns within the same main effect indicate a significant difference ($P<0.05$).

Discussion

The family dairy system in Aguascalientes is predominantly of the ejido type, where the main workforce are family members and they carry out all field work, milking, breeding, feeding, general zootechnical management of the herd, cultivation and administration tasks, characteristics that are similar to those observed in other family herds in Mexico[15-17, 29]. The fact that the family intervenes in the work of the family dairy system represents days of work with a low wage, which allows the milk production system to be maintained in subsistence conditions, as has been considered by other authors[4,17,25]. Some units of the family dairy system employ non-family day workers, most likely because they have a larger herd size that exceeds the family labor force; the family no longer contributes the necessary days of work to the productive structure due to the high migration in the rural sector that is in search of other opportunities[17,30]; or because generational replacement is taking place slowly, both in the ejido system and in small-property system, which is consistent with what has been mentioned in other studies[16-17,31].

In the study, the predominant breed is Holstein, the level of milk production per cow per day in the milking line in this study was 16.5 L, slightly higher than that reported in family systems in Mexico[15-17,29], perhaps because there are breeds with greater specialization in milk production or the opportunity to have a better diet. Nevertheless, the milk production per cow per day recorded in this study is considered to be a low production efficiency compared to that observed in intensive production systems[13]. The sum of the factors of the low level of production per cow per day recorded in the family system, the high costs of inputs, the low prices offered by fluid milk, which is related to the excessive import of milk and its derivatives[3,7,11], results in a decrease in income per unit of production, which does

not cover investment and operating costs, limiting the productivity of the system; there is a high risk of not staying in business, and family production units decrease[15-18,20]. It is also possible that a part of the family sector is displaced by a more intensive, technified and vertical sector that participates in the marketing and value-added segment of the product[6-8,19]. The imminent disappearance of the family dairy sector, which is in conditions of subsistence and rural poverty[16-17,20,25], is a blow to food self-sufficiency and the limited promotion of productivity, with an increase in the dairy sector of only 1.8 % per year in the last 15 years[2].

In Aguascalientes, 92.8 % of the producers in the family system sell fluid milk directly to the industrial sector or for the transformation of the product through artisanal methods, which represents their main source of income, which is similar to what is observed in other regions of Mexico[15,17]; however, producers need another source of income to complement daily spending, which makes this family production system persist, perhaps because they have no other option for development. Other authors have reported that the rural and family system is maintained by foreign remittances[15,17,32-33], which serve as investment capital in productive units[17,33].

The family dairy system has community roots that generate thousands of direct and indirect jobs for families in the rural sector[22], and should be considered in rural development plans and programs to implement competitive models of self-sufficiency in milk production[3,8,19]; the adoption of technology and the reduction of production costs through good livestock practices[18,20,24]. It has also been described that there is a need for product transformation to obtain greater added value by the productive sector in association with industry[8], above-average and direct-to-producer price, and reduction of retailers' profit margins[6]. All this in order to reduce dependence on dairy imports, which would promote production in the domestic market, greater opportunity for negotiation, fair price, capitalization, and survival of the productive sector[6-8,18,20].

On the other hand, even though 96.7 % of the producers know how to read and write, a high percentage of producers have not had the opportunity to access to education, which reflects the lack of opportunities for social development of people who are in the family milk production business. In other studies, it has been described that slow generational change or the level of basic education are factors that limit the adoption of technology and technical assistance, and therefore the family system cannot be more productive or competitive[16-17,31,34].

The number of hectares of dairy farming production units in the family system allocated to forage production is really small and, therefore, there is no forage self-sufficiency in quantity and quality[24,35] to maintain or increase the productive herd and productivity, aspects that are similar to those found in other studies[15-17,29]. This is confirmed by the relationship observed

in intensive production systems of a greater number of breeding cows with more irrigated cultivation areas, greater sufficiency of quality forage and adoption of technology, which explains the increase in production efficiency per cow in line compared to small herds[8,13].

The low technological adoption of good management practices in agricultural and livestock areas[8,13,17], the lack of investment in infrastructure and the insufficient amount of farmland are factors that limit the productivity and growth of the family dairy system[13,16-17,29]. In fact, a determining factor in the survival of the family system has been the lack of commercialization at a fair price[15,17], which generates fluctuations in the productive efficiency of the system and the exit of the business, mainly by the production units of the family system[14-15,17], which could suggest an increase in rural migration to urban areas due to lack of employment opportunities, sufficient income, and development, but at the same time, it increases informality in the urban sector[30].

Conclusions and implications

Innumerable technical and operational factors, size of the property, type of land, water, genetics, sufficiency and quality of forages, among others, limit the increase in the productivity of the production units in the family dairy system and make them less efficient, causing most of these production units to be considered only subsistence units. With the use of family labor and the economic income from other activities, this system of family production subsists, but at the same time, they cannot aspire to grow technologically, or productively, and therefore, Mexico cannot achieve self-sufficiency in milk production. Production efficiency will have to increase significantly at the same time as the need to create alternative business model schemes, with their own name and technical assistance, that provide new products derived from milk and are accompanied in marketing to promote an increase in productivity and the value of production. This could be a trigger and salvation for the family sector in addition to promoting the direct sale of high-quality and safe whole milk to the consumer, without barriers in the marketing of its product, and the priority of marketing the national product by the processing industry. It is the only way for the family dairy system to become an efficient sector less foreign-dependent.

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