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COMPARATIVE ANALYSIS OF THE DEGREE OF TECHNOLOGY IN FAMILY DAIRY UNDER STABLE AND MIXED MANAGEMENT SYSTEMS. CASE STUDY

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Abstract: Milk production systems can present different characteristics and productive and economic behavior, however, this depends on various factors that are not clearly defined. The objective of this work is to carry out a comparative analysis of the stabled and mixed management systems according to the degree of technification in family dairy production systems in the north-central region of Michoacán. For this, we worked with eight production units (UP). Four UPs were selected for each stabled and mixed production system (SP). Obtaining technical and economic data were collected for 12 months. The economic data was treated from the costing system. To determine the degree of modernization, a weighting of the machinery, equipment and resources used for production was used. The SP comparison was made with a Student's t mean difference analysis and Kendall's Tau b correlation analysis (0.05 significance). There is a statistically significant difference in the degree of technification of 0.68±0.12 for the stabled production system (SPE) and the mixed production system (SPM), which has 0.24±0.05. The difference includes l/milk/cow/year (3,834±954 l for SPE and 2,893±1,120 for SPM), liters of milk/Ha/year (7,368±3,490 for SPE; 6,494±2,194 for SPM); l/milk/wage/year (32,706±18,635 in SPE and 31,725±11,416 in SPM). However, the SPE has a higher production cost (5.74±0.58) than the SPM (4.73±1.21) and utility per liter of milk slightly lower (0.98±0.31 for SPE vs 1.04±0.86 in SPM) without statistically significant differences. This indicates that the degree of superior technification presented by the SPE is not sufficient to have an important influence on the group under study, which indicates that the type of peasant economy to which both groups belong is persistent.
Keywords: Family dairy, level of technology, cost of milk.

INTRODUCTION

Milk is a basic food for human beings and also represents an economic activity for families in the rural sector. In Mexico, four types of milk production systems are identified: specialized system, semi-specialized system, dual-purpose system and family-type system (Camacho, 2017 and Robledo, 2018).

The specialized system is characterized by its high level of technology, mainly related to mechanical milking machines, modern stables, a cooling tank and agricultural implements that help forage production. The prevailing breed type is Holstein, Swiss and Jersey. It participates with 50% of the national milk production in Mexico (Ríos et al., 2015 and Robledo, 2018).

The semi-specialized system is developed on small surfaces of land, with a medium technological level, they generally lack refrigeration, mechanical milking equipment and the cattle can be semi-stabled, that is, some hours of the day grazing and others in the corral (This is also known as a mixed system). The type of breeds used is Holstein and Brown Swiss. This system contributes 20% of the national milk production (Ríos et al. 2015 and Robledo, 2018).

The dual-purpose system is developed on small surfaces, also, with a medium technological level, they also do not have refrigeration systems and milking is usually manual. The handling of the animals can be mixed. The breeds used are Holstein with crosses with European Swiss. In this classification, 18% of the total milk production in Mexico is produced (Ríos et al. 2015 and Robledo, 2018).

Finally, the family production system is characterized by being developed on small surfaces, with small herds, and depends largely on family labor. That is why it can also be called "family dairy" The technological level is low, milking is manual and productivity

is low. The type of breeds they use is the Holstein with crosses with American Swiss or European Swiss. This system contributes 12% of the national milk production (Ríos et al. 2015 and Robledo, 2018).

A production system is defined as the set of agricultural management or practices (reproductive, health, food) that combines fixed and variable factors (soil, labor, livestock, machinery, etc.) and that, integrated with each other in an organized manner in a production process, they define the levels of production and efficiency that can be expressed by the production unit Smith et al (2002).

Efficiency can be expressed in biological and economic terms. In bovine production systems, biological efficiency can be represented by the production of milk and meat expressed in the different factors of production (land, labor and economic resource, which in this case is the cow) and in economic terms. it is represented by the level of income and utility from the same factors of production (Wadsworth, 1997). This biological efficiency is a factor that influences production costs and biological efficiency in the profitability of production units (Cortez, et al., 2013 and Posadas et al., 2014), so a strategy to increase them is through the intensification of production to make more efficient use of resources (Angón et al., 2013).

In the same way, Velasco et al. (2009) mention that the technological (management) decisions of the producers in their production units, as well as the type of technologies used, define the productivity of the production units and the competitiveness of the production systems. However, there are other factors that can intervene in the biological and technological parameters of cattle, such as the conditions of intensification in management, the genetics of the animals, as well as the technological and individual qualities of the animals (Lyshenko, et al, (2022).

Camacho et al. (2017) mention that the technological level in the family dairy can represent increases in productivity that range between 26 to 36%, as well as in the economic results of the production units.

On the other hand, Lopes et al., (2015) determined that the type of technologies within dairy farms can influence production costs, possibly due to the intensity of production when using more sophisticated technologies, so it has a effect on costs, by increasing productivity with the same inputs. These authors also state that costs could decrease by up to 15% and revenues could increase by up to 4%.

In family-type production systems, the combination of management practices and fixed and variable factors often differs in type, quantity and stock between year-round stabled management and a mixed management system; however, the degree of influence of the technological level and the combination of resource use and management on the productive and economic performance of family dairy farming in the north-central region of the state of Michoacán is not known.

Therefore, the objective of this work is to carry out a comparative analysis of stabled and mixed management systems according to the degree of technification in family dairy production systems in the north-central region of Michoacán.

MATERIALS AND METHODS

The present work was developed in production units (PU) classified within the family-type production system (SP) in the municipalities of Morelia and Álvaro Obregón, located in the North-Central Region of the state of Michoacán and classified in turn in mixed and stable management systems. The municipalities are located at an altitude that ranges between 1,800 and 1,860 meters above sea level (masl) at coordinates 19° and

22° north latitude and 101° and 114° west longitude. The region has a temperate sub-humid climate with summer rains C(w) and temperatures that range between 2.5° to 25.1° and an average of 15°C and annual rainfall close to 1000 mm (INEGI, 2018).

We worked with four production units in each municipality and each management system, respectively, having a total of eight PU distributed in the two municipalities.

Technical and economic information was collected during the year 2020 through monthly visits, to determine the production of milk and meat, as well as the income and expenses incurred in the PU, including those corresponding to the production of grains and fodder. For the determination of the production costs that will define the economic behavior of the PUs, the method of costing by activity was used, taking into account the cost of production of the grain and forage of the agricultural activity, to be included in the cost of production of the liter of milk (livestock activity). Family labor was assigned an opportunity cost, according to the regional salary.

To determine the Gross Profit per liter of milk, the formula was used: Gross Profit = Cash Sales – Cash Costs. (Carrillo Martínez et al., 2019)

To determine the Technification Degree, variables related to management and the technologies used for the production process were taken into account (De Freitas and Pinheiro, 2013), among which are the management of feeding with the use of alfalfa (Medicago sativa), triticale (Triticum aestivum) and commercial feed, the use of artificial insemination, milking with machinery (milking machine), and some assets used for forage production and livestock activities, among which are: tractor, mower, grain and forage mill, agricultural implements, trailer and truck. A value was assigned to each of the variables, adding a value of one among all of them. According to the presence or not of these in the production units, the results are shown by group. The comparative analysis was performed using descriptive statistics measures and the analysis of the difference in means by means of the Student's t-test with a 5% significance value. To identify the degree of association between the degree of modernization and the factors of this study, such as the different technical, biological and economic indicators, a Kendall Tau-b correlation analysis was performed, with a significance level of 0.05 (bilateral). Only those correlations that fall in the range of strong upwards (0.600 positive or negative) will be taken into consideration, according to the classification of Leyva and Flores (2014, p427).

RESULTS AND DISCUSSION

The production units belonging to the stabled system keep the cows all year round in the corral, offering grains and cut fodder. All the fodder offered to the cattle is produced in the same production unit and consists of stubble, alfalfa, oats or chickpeas. The grains they offer are: bran (in 50% of the PUs) and corn grain in 100% of them. In the case of the UPs of the mixed system, the feed is mainly based on oats (25% of the UPs), chickpeas (25%) triticale (25%) and native grasslands. For the concentrate they offer bran (100%), commercial feed (100%) and corn grain (100%). The type of breeds they use are crosses between Holstein and Zebu (75%) and Holstein and Jersey (25%).

The breed of cattle they have is Holstein (50% of the UP) and crosses of Holstein with Simmental (25%) and Holstein with European Swiss (25%). This type of breed is found in the PUs of the two production systems, both stabled and mixed.

Within the characteristics of the PUs

shown in Table 1, it can be seen that only two of them have significant differences between the two management systems. These are the number of irrigated hectares and the degree of technification.

Regarding the degree of modernization, it is found that the producers of the stabled system have a greater amount of machinery and equipment that they use for agricultural and livestock activity. 100% of the producers of the stabled system have a tractor, harvester, grain and forage mill, agricultural implements and a trailer. Only 25% also have a truck. In contrast, the producers of the mixed system, only 25% have a tractor and it is the same Up that has a mill and agricultural implements. 100% have a truck and 25% have a trailer. Of the producers of the stabled system, 75% use artificial insemination and 25% order with a milking machine. The intensification of milk production allows the creation of optimal conditions for the rearing and feeding of the young because it increases the intensity of growth and development, it also accelerates the recovery of the investment in the cost of replacements. (Lyshenko, et al., (2022).

In the mixed system, 100% of the producers milk manually and use natural mating as a reproductive method for their cattle. These are the elements that mainly affect the degree of technification of the production units. These two technologies are considered basic and it is likely that the (mixed) production system does not facilitate the use of the milking machine, because it requires electricity or fuel, but it requires adequate facilities for its correct operation and having close to cows for efficient use. Lutsenko et al. (2021) mentions that the proximity to the milking area and the type of facilities in which it is milked, especially if mechanical milking is used. However, in the case of mechanical milking, the management of the milking machine also influences the productivity of the cow, especially due to the influence on the health of the udder and the presence of aerobic bacteria and proliferative anaerobic microorganisms in the milk.

The systems with stable management have a greater amount of land than those of the mixed type, however, they do not use all the hectares for livestock (62.2 ± 18 %). Due to the location of the UPs, these systems have access to irrigation and that allows them to cultivate cut fodder and keep livestock stabled throughout the year and make greater use of the machinery and agricultural implements they have. The characteristic of having irrigated land influences the type of fodder, such as the cultivation of alfalfa and oats as a winter crop. Consuming alfalfa throughout the year can represent an advantage to the stabled production system, because this forage has a high nutritional value (20% crude protein) and metabolizable energy (ME) of 2.31 Mcal/kg in DM, which can promote greater stability in production and increase the stocking rate and productivity of meat and milk (Clavijo and Cadena, 2011).

There is a different production in milk productivity per cow per year, despite the fact that statistically there is no significant difference. This may be due to the fact that in both production systems the type of breed is similar and the general characteristics that classify it. However, in quantitative terms, a higher milk production (3,834 l) can be observed in the stabled system compared to the mixed system (2,893 l), (see Table 2) If this production is compared with the degree of modernization of both systems, (0.68 for stabled and 0.24 for mixed) agree by Camacho et al. (2017) who affirm that systems with greater technification have higher productivity.

In relation to the efficiency in the use of land (liters of milk/ha/year) and labor (liters of milk/day/year), this is directly reflected in liters of milk per hectare and liters of milk

CONCEPT	STABLED	MIXED
Number of cows	10.8 ± 3.2	12.25 ± 6.02
Number of Animal Units	20.3 ± 2.6	20.4 ± 9.26
Number of hectares	11.4 ± 7.8	5.25 ± 2.22
Number of hectares for livestock	6.0 ± 2.2	5.25 ± 2.22
Number of irrigated hectares	10.6^{a} ± 6.5	1.5^{b} ± 3
Number of days	1.4 ± 0.5	1.0 ± 0
Number of people hired	0.8 ± 0.5	0
Degree of technology	0.68^{a} ± 0.12	0.24^{b} ± 0.05

Table 1. Characteristics of the Production Units by Management System

Source: Elaboration with own data.

Different superscript letters represent statistically significant difference

CONCEPT	STABLED	MIXED
Liters of milk/cow/year	3,834 ± 954	2,893 ± 1,120
Liters of milk/ha/year	7,368 ± 3,490	6,494 ± 2,194
Liters of milk/day/year	32,706 ± 18,635	31,725 ± 11,416
Kg of beef/cow/year	320 ± 46	217 ± 90
Cost of a liter of milk	5.74 ± 0.58	4.73 ± 1.21
Feed Cost Percentage	56.4 ± 10.5	55.2 ± 18.8
Concentrate Cost Percentage	38.5 ± 28.5	57.7 ± 27
Percentage of cost of fodder	61.6 ± 28.5	42.3 ± 26.9
Price of a liter of milk	6.5 ± 0.58	6.13 ± 1.25
Utility per liter of milk	0.98 ± 0.31	1.04 ± 0.86
% income from livestock	53.98^{a} ± 10.31	88.50^{b} ± 23
Kg of milk/hour	11.2 ± 6.38	10.86 ± 3.91

Table 2. Average technical and economic indicators in the Production Units by Management System

Source: Elaboration with own data.

Different superscript letters represent statistically significant difference

	Degree of technology
Production system	-0.770
Productor	-0.837
Number of irrigated hectares	-0.738

	Production system
Productor	0.756
Number of hired employees	-0.775
Liters of milk per cow/year	-0.756
Liters milk/hectare	-0.661
	Productor
Number of irrigated hectares	-0.849
Number of hired employees	-0.732
Liters of milk per cow/year	-0.714
Fixed assets	-0.643
	Number of irrigated hectares
Number of hired employees	0.738
Liters of milk per cow/year	0.694
Cost of a liter of milk	0.789

Table 3. Correlation between the factors that characterize the production systems and the degree of technification

per hour of labor, regardless of whether it is family or contract labor. Irimia et al (2014) mention that the efficiency of the workforce, when accounting for inputs and outputs, will depend directly on the productivity of the animals.

Table 2 also shows that the cost of production per liter does not present significant differences between one system and another. This result of no statistically significant differences is also repeated in the cost structure related to feed costs. This may be due to the fact that, in global terms, the percentage destined for animal feeding is similar in both systems, however, where there is a different percentage, it is in the percentage destined for the acquisition of concentrate and forage. It is observed that the mixed system uses a higher proportion of feed cost (57.7%) for the use of the concentrate, while for the production of forage it is less by almost 19.3%. This can be related to the quality of forage that is produced in the stabled system (alfalfa), which is perennial and has a higher protein quality than corn stover and chickpeas. It is seasonal, so they must complement the feed with commercial concentrate, especially in the dry season.

A statistically significant difference was not determined between the price paid to the producer per liter of milk, with a difference of ₡37 cents, however, the range between the stabled system is 6 to 7 pesos per liter of milk, while in the mixed group is from 5.5 to 8 pesos per liter. This is due to the fact that the market to which the sale is destined in the PUs of the stabled system is the bottler, while in the mixed SP group, 25% sell the milk to a collection center in the region, who pays for the milk. according to quality.

When relating the price of milk to the cost of production, it is observed that, in terms of utility per liter of milk, the stabled SP has a slightly lower utility ($0.06 pesos) than the mixed system, despite the fact that the difference in cost per liter of milk is $1.37 pesos higher in the stabled system than in the mixed system. This difference in costs may be due to the depreciation implied by the equipment and machinery (reflected in the degree of technification) that the PUs of the stabled system have. This behavior coincides with that reported by Lopes et al. (2015) who, in a study where they classified milk PU into groups with high, medium and low technology, concluded that economic efficiency is higher in the high technology group and is related to the gross and net margin in the PU and to in turn, is related to investment levels.

When performing a correlational analysis between all the factors that may be associated with the degree of modernization, it was found that there are three factors that have a strong direct correlation: the production system (coinciding with the significant difference between systems and the degree of modernization), the producer himself (who makes management decisions and the use and application of resources) and the number of irrigated hectares.

Table 3 shows a strong correlation between the degree of modernization with the production system (-0.770) and the number of hectares (-0.738) in negative, which can be interpreted in that the production system can influence the degree of correlation in a negative way, especially in the case of the mixed system, where the more characteristics of this system are found in the PU, the lower the degree of technification. Among these characteristics is the possession and/or use of irrigated land, which are determining factors for the type of forage cultivated. In the same sense as the previous one, if the mixed system has fewer hectares of irrigation, the degree of technification is lower, since it does not require machinery and equipment for agricultural work, unlike the stabled system,

who also have a more hectares in general.

In the case of the producer (-0.837) it is observed that the correlation is very strong. This result is related to the role that producers have within the type of family-type production system and the characteristics of the peasant economy (where the mixed production system is classified), whose purpose is not strictly the acquisition of assets or accounting for returns from investments, but what they seek is the reproduction of economic activity and family subsistence (Landini, 2011). Therefore, the closer the mentality and form of production of the PUs is to the concept of the peasant economy, the lower the degree of technification.

When looking for a second level correlation, between the three factors that are directly related to the degree of technification, it is observed that the factors that the workforce has an important role for the degree of technification, finding a strong correlation between this factor with the production system (-0.775), the producer (-0.732) and the number of irrigated hectares (0.738). These correlations indicate that the number of people hired decreases the greater the characteristics of the mixed system and this is also a characteristic of the producer, who in both systems (stabled and mixed) the prevailing workforce is the family type. In the case of the association between the people hired and the hectares of irrigation, a strong positive correlation is observed, because to use the machinery and equipment that affect the degree of technification.

Another factor that is strongly correlated is that related to the biological efficiency of the cows, expressed in liters of milk per cow per year with the production system and the producer. This correlation is also negative, which can be interpreted as productivity per cow will decrease in systems that have higher characteristics of the mixed system. In the same way, it will decrease if the producer makes the decisions and has the resources and characteristics of mixed systems. This same effect is reflected in the efficiency of land use when transforming it into liters of milk per hectare (-0.661).

One more factor that has a strong correlation with irrigated hectares is the cost of a liter of milk (0.789), which makes sense, when observing that milk productivity in the stabled system is higher in quantitative terms than in the mixed SP and This productivity may be due to the type of forage and the planting and harvesting season of the crops grown in the hectares that have water availability.

Finally, there is a negative correlation between the producer and fixed assets (-0.643). This data may be due to the type of decisions made by producers belonging to the peasant system, who have their own rationality and decision-making strategy, focusing on the use of family labor for economic activity, focusing on giving use as much as possible to family labor and not necessarily to profits on invested capital (Landini, 2011; Van del Ploeg, 2010), so their goals and objectives are not in the investment of fixed assets. This is complemented by the data observed in the characterization of the systems, where in the stabled system they receive 53.9% of their family income from livestock, while in the mixed production system it is 88.5%. This means that, in effect, this last SP has characteristics more closely related to the peasant economy, seeking the subsistence of the family and not necessarily the complementation of income with other additional economic activities.

CONCLUSIONS

There is a similarity in the production systems related to size and productivity in the different factors of production, such as land and labor. The degree of technification

is the one that has the greatest influence on the differentiation of production systems, mainly due to the availability of water for farmland and, consequently, the secondary use that can be given to them, when using the harvest also for the sale of fodder and grain and become a source of additional income, which strengthens the stable management system, thus reflecting on the superiority of milk production. However, the stabled system does not present a difference in the unit utility of the liter of milk than the stabled system, as could be expected, which reflects that despite having a higher degree of technification from the acquisition of assets for the production agriculture, it is necessary to make efficient use of its resources and thus achieve greater economic efficiency.

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