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Article

Perspectives on continuity, milk quality and environment in milk production units in the state of Aguascalientes, Mexico

Carlos Eduardo Romo-Bacco [a]*

Neftali Parga-Montoya [a]

Arturo Gerardo Valdivia-Flores [b]

Rodrigo Gabriel Carranza-Trinidad [c]

María del Carmen Montoya Landeros [d]

Abril Areli Llamas-Martínez [a]

María Mayela Aguilar Romero [b]

[a] Universidad Autónoma de Aguascalientes. Centro de Ciencias Empresariales. Av. Prolongación Mahatma Gandhi #6601, Col. El Gigante, Ejido Arellano, 20340, Aguascalientes, Aguascalientes, México.

[b] Universidad Autónoma de Aguascalientes. Centro de Ciencias Agropecuarias. Jesús María, Aguascalientes, México.

[c] Instituto Nacional de Estadística y Geografía (INEGI). Dirección General de Estadísticas Económicas. Aguascalientes, Aguascalientes, México.

[d] Universidad Autónoma de Aguascalientes. Centro de Ciencias Básicas. Aguascalientes, Aguascalientes, México.

*Correspondng author: ceromo@correo.uaa.mx

Abstract:

The objective was to evaluate the productivity, the sale price of milk, the size and the perceptions of their owners about their environment, quality and permanence in milk

production farms in the state of Aguascalientes. Forty milk production units, with similar conditions of age (30 years), zootechnical management, availability of inputs and customers, were evaluated. The productive characteristics of the farms in relation to the herd size factor were compared through a MANOVA. A structural model was formulated to evaluate the effect of environmental factors on milk quality and farmers' intention to continue production units in the dairy activity. A positive influence was found on the productive scale of dairy farms, the obtaining of higher daily productivity per cow, better perception of quality and the sale price of milk. In the model, environmental factors were significantly associated with the assessment of milk quality by producers and their permanence in the dairy activity (14.2 and 22.7 %, respectively). This confirms that the perception of environmental factors could be considered as a crucial variable to increase milk quality, productivity and for the meeting between the interests of producers and the agribusiness, as well as to favor the performance and integration of the different links in the dairy production chain and boost the global competitiveness of the Mexican agri-food sector.

Key words: Competitiveness, Profitability, Agri-food production chain, Milk market.

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Introduction

The consumption of fluid bovine milk has remained relatively stable in different countries, however, milk production has increased markedly[(1)]; this suggests that the dairy industry has diversified its offer with the creation of new products, which give greater added value to milk. The quality, price and characteristics of each dairy product, as well as their availability in a timely and appropriate manner, are criteria associated with the competitiveness of the dairy sector in the Mexican altiplano[(2)]; also, the integration of producers in organizations for the collective purchase of inputs and for the insertion of products in the markets has shown the potential to promote economies of scale and improve their economic profitability[(3)]. Nevertheless, decision-making by representatives of some dairy organizations is complex and negotiations with the agro-industrial sector focus on ensuring the sale of raw milk, as well as meeting the demands of the agribusiness, especially in terms of quality and opportunity[(4,5)].

Some variables that are not directly associated with the productive management of dairy herds, such as the schooling of the producer, the size of the herd or the use of qualified

technical assistance[6], have been shown to have an influence on the productivity in Milk Production Units (MPU), so they are considered important in the evaluation of economic results[7].

Milk production in Mexico is carried out under different production systems; the characteristics that identify them are the use of the resources available for production, such as the labor used, the technification of dairy farms, the size of the area, the destination of milk, the number of milking cows, among others[8,9,10]. As part of the strategies for the consolidation of milk producers, especially small MPUs[11], the importance of promoting trust between the different actors in the production chains in order to integrate to achieve improvements in milk quality and competitiveness in the sector has been recognized[12].

The relationships of trust between the different actors of the agri-food production chains are made evident through commercial exchanges that generate development, well-being of the environment and increase in social capital[13]. In this sense, producer organizations that have favorable social capital have been identified in the state of Aguascalientes[14,15]; this implies greater advantages for the development of organizations with greater possibilities of success for the achievement of common objectives, both for the consolidated purchase of inputs for production and for the sale of milk[16,17]. It has been proposed[11,18,19] that, in order to meet the requirements of consumers, the different actors in the dairy production chain should have economic incentives proportional to the quality of their dairy products; this would have a positive impact on the stability and the possibly of growth of dairy farms, as well as on the structure of the dairy market, and would allow clarifying the challenges and strategies to reduce uncertainty about the outcome of the confluence of forces prevailing in the dairy industry[20].

Porter's model has been used in several industries to propose competitive corporate strategies[21,22]; this model proposes[23,24] the competition between five forces that favor or harm the competitiveness of a sector that goes to the product market: 1) bargaining power of suppliers; 2) bargaining power of customers; 3) threat of substitutes; 4) threat of new participants; and 5) rivalry between existing companies[23,25].

This model presupposes that the market is attractive to a company or organization when its structure is profitable for the actors present in the productive activities, so it influences its behavior and defines its competitive strategy; therefore, the success of each actor is conditioned by the structure of the market and by the interaction between the actors in the chain[26,27]. However, the effect of these forces on the development of companies comparable in age and productive characteristics has not been empirically demonstrated. Therefore, the objective of this work was to evaluate the productivity, the sale price of milk, the size and the perceptions of their owners about their environment, quality and permanence in milk production farms in the state of Aguascalientes.

Material and methods

Study design

The study was located in an area specialized in milk production in the municipality of Aguascalientes[5]. The total population (40 MPUs) of the register of members of a milk producers' organization, constituted since 1988 by a group of producers organized for the local and regional production and commercialization of bovine milk[28], was analyzed; this group settled in the same agricultural area, near the city of Aguascalientes, and had, since its inception, herds of comparable genetic quality and equivalent financial support[29], as well as other similar productive conditions and opportunities for the acquisition of inputs. The study conducted in 2018 showed that the group had a total of 5,693 cows, with an average daily production of 23.14 ± 6.9 liters per cow and an annual income from milk sales of US $ 17.7 million.

The owners or people in charge of the farms who gave their consent to obtain the information and productive data of each of the production units were interviewed. The questionnaire used to identify the characteristics of the MPUs included variables about the age and experience of the producer, sale price of milk, size, herd structure, predominant use of labor of hired personnel, as well as their perception of quality, the continuity of the MPU and the agents external to production; as well as other variables not used for this study, such as area, value of infrastructure, production and food costs, among others.

Variables

The category quality assessment was determined, for which producers were questioned about the economic incentives and penalties they receive for not producing milk with the optimal quality expected by the milk-receiving agribusiness. This category also included knowledge of the milk quality parameters demanded by customers, awareness of the possibility and benefits of producing quality milk[30]. In the same way, the variable continuity in the activity was determined, where the producers were questioned about their willingness to remain in the dairy activity.

To explore agents external to production, Porter's model[23] was adapted to evaluate the competitive forces of the agribusiness based on variables with a five-level Likert scale. The degree of agreement or disagreement of producers on the bargaining power of customers and

suppliers, competition between producers, facilities for the creation of substitute products, as well as the ease of entry to new competitors in the dairy activity were considered.

Hypotheses about the effects of the competitive forces of the agribusiness on different variables of dairy farms were also proposed.

H1: The competitive forces of the agribusiness have a significant positive influence on quality assessment.

H2: The competitive forces of the agribusiness have a significant positive influence on the continuity of dairy activity.

H3: A larger herd size positively influences the sale price of milk.

Statistical analysis

For the analysis of the productive characteristics of the MPUs, a statistical software was used[31]. A multivariate analysis of variance (MANOVA) was performed to determine if the means of the variables evaluated (age of the producer, hired labor, milking cows, productivity per cow (liter/day), sale price of milk) differed jointly between the different sizes of dairy farms (<50, 50-250 and >250 milking cows)[32]. For herd size, a previously proposed scale was used[33]. Likewise, an ANOVA[34] was performed to determine the differences of the means for each variable analyzed (age of the producer, milking cows, productivity per cow (l/d), sale price of milk) according to the size of the farm. When the assumptions of the ANOVA (normality and homoscedasticity) were not met, the equivalent nonparametric Kruskal-Wallis test was applied for the comparison of their respective medians. The Chi-square independence test was performed to evaluate the variables of hired personnel and continuity in the dairy activity in relation to the size of the farms. In all cases, a significance level of 5 % was used.

The variable of continuity was evaluated through a binary logistic model[35] with a significance level of 5 % to determine the degree of association with the other variables analyzed (size, age, milking cows, price, productivity, quality assessment and competitive forces of the agribusiness).

$$p = \frac{e^{b_0+b_1x_1+b_2x_2+\ \ldots}}{1+\ e^{b_0+b_1x_1+b_2x_2+\ \ldots}}$$

Where:

p = probability of continuing in the dairy activity

b_0 = constant

$b_{1,2,\ldots}$ = coefficients associated with each variable

$x_{1,2,\ldots}$ = variables evaluated (size, age, ...)

The logistic model, once the previous equation was linearized, was given as:

$$log\left(\frac{p}{1-p}\right) = b_0 + b_1x_1 + b_2x_2 + \ \ldots$$

The proposed hypotheses were also tested based on a model of structural equations using the partial least squares method (PLS-SEM)[36-39]. The internal consistency of the group of variables that influence the competitive forces of the agribusiness and the assessment of quality was evaluated; when the variables were correlated with each other, it was considered that there was *Reliability*; in addition, the existence of *Validity* was considered when the correct measurement of the variables was verified with the partial least squares (PLS) method[40,41].

For the evaluation of the categories of the model, the following variables were included: bargaining power of suppliers, bargaining power of customers, threat of substitutes, threat of new entrants and rivalry between existing companies for the category of competitive forces of the agribusiness and, for the category of assessment of milk quality: the economic incentives and penalties they receive for producing poor quality milk, knowledge of the milk quality parameters demanded by customers, awareness of the possibility of producing better quality milk and the benefits of producing quality milk. In the analysis, only the variables that were significant were selected so that the model had satisfactory goodness-of-fit test indices[40,42]. Table 1 shows the variables included in the final structural model, for the competitive forces of the agribusiness: the entry of rival producers into the market, the threat of new products and substitutes for dairy products; as well as those that were considered in the assessment of milk quality: knowledge of quality parameters and penalties for not producing quality milk. Both categories were considered latent or reflective because their evaluation was made from the individual measurements of the included variables, so their covariance was evaluated to validate each category[40,43].

Table 1: Consistency and measurement of indicators for category validity

Category	Variable	Validity convergent				CRI(>0.7)
		ALC (>0.700)	RI (>0.5)	T-value (>2.57)	AVE (>0.5)	
Forces of the agribusiness	Competitors	0.767	0.588	3.280	0.522	0.765
	New products	0.628	0.394	1.741		
	Substitute products	0.766	0.587	3.497		
Assessment of quality	Parameters[1]	0.794	0.510	1.802	0.578	0.732
	Penalty[2]	0.725	0.356	1.362		

ALC= average loads of the category; RI= reliability indicator; AVE= average variance extracted index; CRI= composite reliability index.

[1] Knowledge of milk quality parameters; [2] Knowledge about the penalties for not producing quality milk.

The composite reliability index (CRI) was also considered to measure internal consistency[43,44]; this index took into account the factorial loads of each indicator and was obtained by calculating the square of the sum of factorial loads and the sum of the variance of the error terms for each category, arguing that if this criterion is satisfied, there will be consistency and reliability. The estimated CRI was 0.765 and 0.732 for the competitive forces of the agribusiness and quality assessment, respectively, which exceeded the recommended value of 0.708[45]. The average extracted variance Index (AVE) was also calculated, which represented the mean value of the square of the loads or factors associated with each category[46]. To assess the internal consistency of the measuring instrument and of the variables in each category, Cronbach's alpha coefficient was calculated; it was also used to measure the reliability of the scales and the affinity that exists in the category, as well as to have an evaluation sensitive to the number of items on the measurement scale[47].

Finally, to measure the discriminant validity of the categories, the Fornell-Larcker criterion[46] was calculated and it was validated that each category shared more variance with its corresponding variables than with the variables of the other category, that is, that the AVE of each category was greater than the square of the correlation with the other category of the structural model. A correlation between categories of 0.377 and AVEs of 0.522 and 0.578 for competitive forces of the agribusiness and for the assessment of quality, respectively, were obtained.

In the analysis of cross-loadings, discrimination between the variables was observed, considering that those that showed the highest factorial load were closely associated with the corresponding category[39,43,48]. The hypotheses proposed were evaluated with the structural model using the Bootstrapping technique (500 cases), in order to obtain sufficient evidence to adequately estimate the confidence intervals and increase the accuracy of the parameters[49].

Results and discussion

With the structural model proposed, it was found that the competitive forces of the agribusiness had a significant effect on the categories and crucial variables of a group of MPUs developed with similarity of age, zootechnical resources and market situation, in such a way that the MPUs that reached the best price per liter of milk are those with larger and more productive herds; which, if generalized, could be having a positive impact on the development of the Mexican agri-food sector.

The main characteristics of the dairy farms evaluated reflected the heterogeneity of intensive dairy production in the Mexican Altiplano, however, the productive system used in most of the MPUs was the stabled one, where most of the producers surveyed said they preferred the use of herd confinement facilities for milk production; the above could be, in part, a reflection of the climatological characteristics of the state of Aguascalientes (average annual temperature of 18.3 °C and average annual rainfall of 530.3 mm)[50], as well as the product of the conformation of the group of producers surveyed, who migrated in the 80s from the urban limits for the establishment of specialized MPUs[29].

For the variable average age of the producers surveyed, which was 52.65 ± 12.15 yr, significant differences were found ($P<0.05$); other studies[51] mention that small-scale milk producer groups have favorable conditions in the MPUs to generate greater added value to production when the owners are older. In the present study, it was observed that only a little more than a third of the MPUs evaluated had the support of family members to carry out the work of milk production, which could suggest a change in the structure of dairy organizations of similar size, or that this type of organizational structure finds greater advantages in salaried labor, since the use of family labor to support the performance of the different productive activities does not prevail[8,52,53]. It was found that not only the MPUs with the highest number of milking cows have mostly hired personnel, this characteristic was also identified in the MPUs with the lowest number of milking cows ($P>0.05$); this coincides with other studies[54] where the use of (unpaid) family labor is not the key factor that determines the economic success of dairy farms.

The average daily productivity per cow for the MPUs evaluated was 23.14 ± 6.9 L, there were significant differences (P<0.05) for the different herd sizes, with the sizes with the highest number of milking cows being the ones that obtain the highest number of liters per cow per day. The productivity per cow per day reported in this study was higher in relation to other results previously shown[33,55]; this suggests that the efficiency in the use of the resources available in the MPUs by dairy farmers has increased.

Compared to small MPUs, those with larger herds (>250 milking cows) showed higher productivity per cow and better sale price of milk (P<0.05) (Table 2); this coincides with what was established in other studies[11,33], where the scale in milk production units plays a determining role in economic or quality characteristics that could grant advantages to producers. On the other hand, 41.6 % of the producers with the lowest number of milking cows indicated that their relatives intended to give continuity to the dairy activity of the MPU, however, as the size of the herd grew, the positive response increased, the size of the groups and the dispersion of the response did not allow ensuring the significance of this effect (P=0.116). This suggests that there may be endogenous and exogenous elements in the MPUs that contribute to owners projecting their continuity, such as the market, economic profitability and expectations of growth and improvement.

Table 2: Main characteristics of milk production units (MPU) by farm size

Variable/Category	<50 milking cows	51 to 250 milking cows	> 250 milking cows	*P*-value
MPU	12	21	7	
Age of the owner, years	52.5 (39– 8)^{AB}	63 (56–64)^{B}	45 (38–52)^{A}	0.012*
Hired labor (yes/no)[1]	7/5	12/9	5/2	0.792
Milking cows, No.	35.8 ± 10.5^{a}	131.6 ± 64.6^{b}	357.1 ± 59.1^{c}	0.000***
Productivity per cow, L/d	21.9 ± 9.6^{a}	21.8 ± 4.6^{a}	28.9 ± 5.1^{b}	0.019*
Sale price, $/L	6.3 (6.25–6.4)^{A}	6.4 (6.3–6.4)^{B}	6.5 (6.5– 6.7)^{C}	0.001**
Willingness to continue in the dairy activity (yes/no)[1]	5/7	11/10	6/1	0.166
Assessment of quality[2]	0.312	0.310	0.392	0.938
Competitive forces of the agribusiness[3]	3.05	3.13	3.42	0.558

$^{a-c}$ Mean ± standard deviation, by row, those with different superscripts differ (P<0.05).

$^{A-C}$ Median, by row, those with different superscripts differ (P<0.05).

* P<0.05, ** P<0.01, *** P<0.001.

[1] Chi-square with two degrees of freedom.

[2] Average number of mentions of any of the 4 factors evaluated in the assessment of milk quality.

[3] Average of the degree of agreement in the Competitive Forces of the Agribusiness with Likert scale (1-5).

Regarding the binary logistic model evaluated, it was determined that the competitive forces of the agribusiness and the price had a significant impact (P<0.05) with the willingness to continue in dairy farms; by observing the coefficients of the model, it was established that continuity in the MPUs is more likely as the price of milk or the influence of the competitive forces of the agribusiness increases. Previous studies mention that agribusiness has control over the primary sector in Mexico, even that it has had a positive impact on the permanence of milk producers[5], this suggest that continuity in the MPUs is influenced by favorable interactions with other participants in the production chains.

Regarding the assessment of the hypotheses proposed in this study, it was estimated that the effects of the competitive forces of the agribusiness explained 14.2 % of the variation in the assessment of milk quality ($t \geq 1.96$; $P \leq 0.05$) and explained 22.7 % of the continuity in the dairy activity ($t \geq 2.57$; $P \leq 0.01$) (Table 3), which is considered to have a high impact in socioeconomic studies[43,48]. To measure the total influence of the category of competitive forces of the agribusiness, this category was excluded from the analysis and with this, the size of its real effect on the structural model was determined. In the case of the size of the effect on the category of quality assessment and on the variable of possibility of continuity in the dairy activity, a significant f^2 effect of medium size was found (>0.15)[42,56]; this determines a model where the effects of the competitive forces of the agribusiness are not affected by the other variables involved in the final structural model. The quality of dairy products found in the markets is closely related to the quality of raw milk[57], therefore, the importance of properly attending the processes within the MPUs in order to contribute to ensuring the quality of milk and its derivatives is reaffirmed.

Table 3: Results of the tests of the hypotheses proposed with the structural model

Hypothesis	Relationship	Standardized coefficient β	*T*-value	f^2	R^2
H_1: The competitive forces of the agribusiness have a significant positive influence on quality assessment.	Competitive forces of the agribusiness → Quality assessment	0.377**	2.383	0.166	0.142
H_2: The competitive forces of the agribusiness have a significant positive influence on the willingness to continue in dairy activity.	Competitive forces of the agribusiness → Willingness to continue in the dairy activity	0.476***	4.285	0.292	0.227
H_3: A larger herd size positively influences the sale price of milk.	Herd size → Sale price of milk	0.541***	4.153	0.433	0.293

f^2 Effect size: >0.02= small effect; >0.15= medium effect; >0.35 big effect (Cohen, 1988).
R^2: >0.20 = Weak; >0.33 Moderate; >0.67 = Substantial (Chin, 1998).
** P<0.01, *** = P<0.001.

It has been mentioned[19] that milk producers should be aware of the risk factors that may arise in milk production because it is a perishable product, this would favor the improvement of the quality of the product, especially due to the use of cooling tanks for milk collection; which suggests that institutional and market measures that are unrelated to production could act as an entry barrier for new competitors in the dairy agribusiness, and have effects on the competitiveness of the actors in the production chain, reducing the possibility of incorporating new technological advances[58], this would indirectly affect the generational transition in primary production units.

The positive influence of herd size on the sale price of milk was 29.3 % ($t \geq 2.57$; $P \leq 0.01$). To evaluate the size of the effect of the variable in the model, it was excluded from it and it was found that the size of the herd had a significant f^2 effect, which can be considered as strong (>0.35)[42,56] (Table 3); this coincides with studies that mention that the scale of production positively affects competitiveness and has an impact on the production processes of dairy farms[33]; in this way, the efficient use of resources in dairy farms would result in greater development of the sector.

Continuity in the MPUs has been valued as a factor associated with successful productive characteristics[59]; in this study, the producers recognized that the conditions of low productive efficiency were not a trigger for the immediate abandonment of dairy activity. However, producers with better use of their resources expressed their willingness to remain in the activity in the face of price fluctuations in the markets for inputs and dairy products[60,61]. Coincidentally, as a strategy for the continuity of dairy farms, it has been shown that the efficient use of the resources available in production units is key to carrying out improvements in production processes, seeking to reduce costs[62,63].

In this study, it was found that producers identified the assessment of the success of organizations as the situation that occurs when positive economic indicators are achieved, especially profitability[55]. In addition, they recognized that the integration of producers with other actors involved in the production chain could increase their chances of success[64]. It has been pointed out that horizontal integration, in some cases, facilitates access to the raw materials involved in production[65,66]; in this sense, alternatives to increase the value of primary production would promote the increase in the profitability of the MPUs and would contribute to the obtaining of social benefits of the actors involved in the dairy production chain[14,15,67]. Similarly, the vertical integration of producers through formal linkage mechanisms established with the industry could avoid the vulnerability of dairy production systems[68]. In this study, it was identified that the competitive forces of the agribusiness could impact on the consolidation of organizations in the primary sector; the associated producers who managed to adapt to their environment show favorable conditions for achieving greater growth and economic success.

Conclusions and implications

As formulated in the proposed hypotheses, the competitive forces of the agribusiness had a significant positive effect on the characteristics of milk production units, especially on the importance that producers attribute to the attention of crucial variables such as milk quality and permanence in the dairy activity. This permanence is more likely as the price of milk increases and as they have a favorable perception about the competitive environment of the production unit. This suggests that the implementation of strategies by farmers and authorities that promote the increase in the productivity of dairy farms will have beneficial effects on the Mexican agri-food sector, especially when they are oriented towards the production of quality milk, and that the latter contributes to satisfy markets that demand genuine dairy products. The meeting point between the interests of producers and agro-industrialists can converge in strategies, promoted by the State, that promote the production and development of the Mexican agri-food sector.

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