



EVALUATION OF MEXICAN NATIVE AND HYBRID MAIZE (ZEA MAYS) SILAGES FOR SUSTAINABLE MILK PRODUCTION †

[EVALUACIÓN DE ENSILAJES DE MAÍZ NATIVO E HÍBRIDO (ZEA MAYS) DE MÉXICO PARA LA PRODUCCIÓN SOSTENIBLE DE LECHE]

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SUMMARY

Background. Maize cultivation and dairy cattle represent two of the main economic activities in Mexico. **Objective.** Determine the forage yield (ton / ha) and forage quality of the maize silage produced in Mexico and estimate potential milk production. **Methodology.** For this purpose, 13 studies carried out in Mexico, were analyzed according to study area (north vs. center of Mexico) and variety (native vs. hybrid). For inclusion in the final database, the studies should have been including agronomic and chemical variables such as: dry matter yield (DMY) (ton / ha), plant density (number of plants / ha), dry matter content (DM), crude protein (CP), neutral detergent fiber (NDF), ash or organic matter (OM), dry matter digestibility (DMD), neutral detergent fiber digestibility (NDFD), starch and fat content. The data were analyzed using a completely randomized statistical design. **Results.** The forage DMY (dry matter yield) / ha, and the milk production (ton DM / ha) were higher (P <0.0001) for the central region with respect to the northern region. Regarding to the milk production (kg milk/ ha) the native silages produced more (P <0.05) than the hybrids. A positive correlation was observed for the content of NEL (net energy of lactation) (MJ / kg DM) and kg milk / ton DM. **Implications.** The native maize of Mexico thus has the potential to provide greater production of milk / ha and kg Milk/ per ton DM with respect to hybrid maize, due to the higher digestibility of the NDF that causes the higher NEL. **Conclusions.** The use of native maize in Mexico is a viable alternative for use as a silage in feed for dairy cows, with higher milk production per hectare and per ton of dry matter compared to hybrid maize.

Keywords: Corn silage; Forage; Maize; Milk production; Native.

RESUMEN

Antecedentes. El cultivo de maíz y el ganado lechero representan dos de las principales actividades económicas en México. **Objetivo.** Determinar el rendimiento del mismo (ton/ha) y la calidad del forraje (ton/ha) del ensilaje de maíz producido en México y estimar la producción potencial de leche. **Metodología.** Para ello, se analizaron 13 estudios realizados en México y se dividieron según su zona de estudio (norte vs. centro de México) y variedad (nativa vs. híbrida). Para su inclusión en la base de datos final, los estudios debían incluir variables agronómicas y químicas como: rendimiento de materia seca (RMS) (tonelada/ha), densidad de plantas (número de plantas/ha), contenido de materia seca (MS), proteína cruda (PC), fibra detergente neutra (FDN), cenizas o materia orgánica (MO), digestibilidad de la materia seca (DMS), digestibilidad de la fibra detergente neutra (DFDN), contenido de almidón y grasa. Los datos se analizaron mediante un diseño estadístico completamente aleatorio. **Resultados.** El RMS del forraje/ha, y la producción de leche/ha fueron mayores (P <0.0001) para la región centro con respecto a la región norte. En cuanto a la producción de leche (kg de leche/ha) los ensilados nativos produjeron más (P <0,05) que los híbridos. Se observó una correlación positiva para el contenido de NEL (energía neta de lactancia) (MJ / kg de MS) y kg de leche / tonelada de MS. **Implicaciones.** El maíz nativo de México tiene, pues, el potencial de proporcionar una mayor producción de leche / ha y por tonelada de MS con respecto al maíz híbrido, posiblemente debido a la mayor digestibilidad de la FND que provoca una mayor NEL. **Conclusiones.** El uso de maíz nativo en México es una alternativa viable para su uso como ensilaje en la alimentación de vacas lecheras, con mayor producción de leche por hectárea y por tonelada de materia seca en comparación con el maíz híbrido.

Palabras clave: Ensilaje de maíz; Forraje; Maíz; Producción de leche; Nativo.

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INTRODUCTION

The cultivation of corn and the production of dairy milk represent two of the main economic activities in Mexico (Reta *et al.*, 2015; Espinoza *et al.*, 2007). According to SAGARPA (2016), there is a population of 2.3 million dairy cows, from which 85% are located on small-scale farms, contributing approximately 70% of the national milk supply per year, with a reported annual production per cow of 5190 L (Posadas *et al.*, 2016). In the same context, the national production of dairy milk for the second quarter of 2017 reached 5670 million liters, with a total production of 11.808 million liters (SIAP, 2017). In 2016, Mexico imported 209,803 tons of milk powder to cover national supply needs, a number which is expected to increase (Portalechero, 2017).

In 2013, Mexico was identified as one of the most affected countries by climate change. Furthermore, maize production is the main peasant farming activity in Mexico. Nearly 2 million peasant producers participate in this activity, and 85 percent have less than 5 ha farms. In Mexico, maize represents the main crop used for the dairy milk production and human consumption (Jiménez-Leyva *et al.*, 2016), and an undetermined amount is allocated as straw, green fodder, and to a lesser extent for the silages for cattle feed (Celis-Álvarez *et al.*, 2016; Jiménez-Leyva *et al.*, 2016). According to the SIAP (2016) reports, in Mexico in 2015, an area of 445,775 ha was planted in the rainy season and 161,623 ha in irrigation for fodder maize, with yields of 19.29 and 47.55 ton / ha of dry matter (DM) and green matter (GM), respectively. Given that the great heterogeneity of agroclimatic conditions has a negative impact in agriculture production and results in variable yields of DM of maize silage, there is a need to optimize the use of forage.

The StAnD (sustainable animal diets) method (Makkar and Ankers, 2014) is a tool that integrates several dimensions of sustainability, including the three P (people, planet, and profitability) dimensions, and gives an overall picture of the current state of a production system. The indicators corresponding to each dimension allow for the detection of specific problems or particular limitations that may be addressed in order to improve the sustainability of the system (Makar and Ankers, 2014; FAO, 2014). One indicator of the StAnD method is “do not use cereals in animal diets and improve the use of native resources” (Planet dimension). This study used the StAnD method to evaluate the sustainability of native and hybrid silages in Mexico and can help to guide agricultural practices and policies in accordance with the economic and environmental performance of different maize production systems. The objective of the present study was to determine the quality and forage yield (ton / ha) of some of the corn silages

produced in Mexico and to estimate the potential milk production with the Milk 2006 program.

MATERIALS AND METHODS

Data collection

An information search was carried out focused on collecting studies related to maize forage yield and quality produced in the different geographic regions of Mexico, which were grouped into three general zones, taking as a criterion of classification their climatic characteristics (Améndola *et al.*, 2005): 1. northern zone or arid and semi-arid region, composed of the states of Baja California Norte, Baja California Sur, Coahuila, Chihuahua, Durango, Nuevo Leon, San Luis Potosi, Sonora, Tamaulipas and Zacatecas; 2. central zone or integrated temperate region, consisting of the states of Aguascalientes, Mexico City, State of Mexico, Guanajuato, Hidalgo, Jalisco, Michoacán, Morelos, Puebla, Querétaro and Tlaxcala; 3. southern zone or tropical dry and humid region, containing the states of Campeche, Colima, Chiapas, Guerrero, Nayarit, Oaxaca, Quintana Roo, Sinaloa, Tabasco, Veracruz and Yucatan.

The publications were obtained from searches in databases such as Elsevier, Google, SCOPUS, Web of Science and Redalyc. The search strings consisted of terms found in the title, abstract and keywords. The terms used were: “corn”; “silage”; “forage yield”; “chemical composition”; “nutritional value”; “high valleys of Mexico”, “Mexico”, any plurals of these terms, and combinations of these terms, and thirteen articles were selected (Núñez *et al.*, 2001; Núñez *et al.*, 2003; Peña *et al.*, 2006; Ruiz *et al.*, 2006; Antolín *et al.*, 2009; Anaya *et al.*, 2009; Núñez *et al.*, 2010; Albarrán *et al.*, 2012; Tadeo *et al.*, 2012; Jurado *et al.*, 2014; Morales *et al.*, 2014; Franco *et al.*, 2016; Jiménez-Leyva *et al.*, 2016).

Inclusion criteria

The selection process limited the results to studies published between 2001 and 2016. For inclusion in the final database, the studies should have been include agronomic and chemical variables such as: dry matter yield (DMY) (ton / ha), plant density (number of plants / ha), dry matter content (DM), crude protein (CP), neutral detergent fiber (NDF), ash or organic matter (OM), dry matter digestibility (DMD), neutral detergent fiber digestibility (NDFD), starch and fat content, as well as region of origin and genetic line (native vs. hybrid).

The final database included a total of 144 records, from which 137 were from hybrid maize and seven from native maize. Data were collected from studies in the north (n=120) and center (n =40) regions of Mexico without finding any information from the southern zone.

Calculations

The missing values for NDFD were calculated using a regression equation with the data obtained from all the registered studies (native n=7, hybrid n=135) that did not contain this information:

$$\text{NDFD (\%)} = 77.96 (\pm 1.85) + [(\text{NDF \%}) * (-0.36 (\pm 0.95))]$$

The missing data for starch and fat in those works that did not contain this information were adjusted according to the NRC (2001). The net energy of lactation (NEL, MJ / kg DM), total digestible nutrients (TDN), kilograms of milk per ton of dry matter (kg milk / ton DM) and kilograms of milk per hectare were determined (kg milk / ha) using the MILK2006 spreadsheet (Shaver, 2006).

Statistical analysis

To identify differences between maize production systems and their distinct dimensions, Kolmogorov-Smirnov tests were applied to determine if the resulting scores varied significantly with respect to a normal distribution. After the data was determined to have a normal distribution, the datasets were analyzed by a model with a completely randomized design and Tukey's average comparison test ($P < 0.05$). These analyses were carried out with the SAS statistical software (Statistical Analysis System, 2004).

Data on dry matter production, chemical composition of silage and milk production were analyzed using a completely randomized design. The information was computed through an analysis of variance with the SAS program (2002), and significant statistically differences ($P < 0.05$) were assessed with a comparison of Tukey test (Steel and Torrie, 1997). The statistical model was:

$$Y_{ijk} = \mu + \text{region}_i + \text{genetic line}_j + \mathcal{E}_{ij}$$

where: Y_{ijk} = dry matter, chemical composition, and milk production (forage yield, plant density, DM, DMD, CP, NDF, TDN-DM, NEL, kilograms of milk), μ = general mean, region_i = effect of the variety ($n = 2$, central and north), genetic line = effect of the method ($n = 2$, native and hybrid) and \mathcal{E}_{ij} = random error. In the present study we did not consider the interaction region + genetic line, because it was not significant, and for this reason only the main effects are considered.

Subsequently, a Pearson correlation analysis was carried out between the variables of forage production, chemistry composition and milk production, with the program SPSS (2012), variables that include a summary of others should not be considered, in this case TDN did not correlate with CP and NDF.

Finally, a multiple linear regression analysis was performed to generate prediction equations for the net energy of lactation (NEL, MJ / kg DM), kilograms of milk per ton of dry matter (kg milk / ton DM) and kilograms of milk per hectare (kg milk / ha), using the correlations with the highest degree of association between the aforementioned variables ($r > 0.3$). In carrying out all the analyses, specialized software was used (Statistical Package for Social Science [SPSS], 2012).

Considering the dependent variables (y) in the present study, and the independent variables (x), the following was considered

$$y = (b_0 + b_1 \cdot x_1 + b_2 \cdot x_2 + \dots + b_n \cdot x_n) + \mathcal{E}_i$$

where:

y = NEL, MJ / kg DM, milk kg / ton DM and kg milk / ha, b_0 = intercept of y , $b_{n(1,2,n)}$ = slope of the straight line adjusted to the data, $x_{n(1,2,n)}$ = independent variables that are included in the model, \mathcal{E}_i = model error.

The dependent variable y = NEL (MJ / kg DM) was correlated with the independent variables NDFD(%) and NDF (%), for y = Kg milk/ton DM it was correlated with the independent variables NEL, (MJ/kgDM) and NDFD(%), for y = Kg milk/ton DM it was correlated with the independent variable (Forage yield, ton DM/ha).

RESULTS

The DM yield per ha (Table 1) was higher ($P < 0.0001$) for the central region (24.8%) than in the northern region, whereas the plant density in the northern region was higher ($P < 0.0001$) compared to the center. The DMD was four points smaller ($P < 0.0001$) in for the center region than in the northern region. The CP content was higher ($P < 0.0001$) for the northern region than the center region. The estimated NEL (MJ / kg DM) and kg of milk per ton / DM were not different between regions ($P > 0.05$). Milk production / ha, however, was higher ($P < 0.0001$) in the central region compared to the northern region.

Regarding the variety (Table 2), the forage yield (Ton DM/ha) per ha was higher for the hybrids ($P < 0.0018$) with respect to the native silages, but similar ($P > 0.05$) in terms of plant density and CP content, NDF, DMD and NDFD. The percentage of DM was higher ($P < 0.001$) for the hybrids with respect to the natives. A tendency ($P = 0.07$) was observed for the content of NEL and kg milk / ton DM to be higher in the native silages with respect to the hybrids, and for milk yield, (kg milk/ ha) to be higher in the native silages ($P < 0.03$) compared to hybrids.

Table 1. Forage production (ton / ha) density of plants, chemical composition of silage and its potential milk production (kg milk / ton DM and kg milk / ha) of corn silage sown in the central and northern region of Mexico.

Variable	Central region N.40			North region N.120			SEM	P Value
	Maximum	Minimum	Average	Maximum	Minimum	Average		
Forage yield (ton DM/ha)	34.20	9.50	20.73	22.10	9.40	15.58	0.831	0.0001
Plant Density, ha	85000	62500	67062	100000	23000	84745	1834	0.0001
DM%	43.60	11.10	29.03	44.80	18.40	30.21	1.20	0.6096
DMD%	70.30	47.70	63.20	76.10	60.40	67.81	0.99	0.0001
CP%	10.00	4.40	6.84	10.30	6.40	8.06	0.23	0.0001
NDF%	69.90	33.80	56.39	68.00	31.00	56.96	1.67	0.8647
NDFD %	68.40	43.00	57.68	66.80	50.30	57.46	0.78	0.9962
TDN%-DM ¹	72.73	59.42	63.53	71.75	47.14	63.64	0.67	0.4487
NEL	6.53	5.23	5.61	6.44	4.60	5.65	0.01	0.2614
MJ/KgDM ¹								
Kg milk ton/DM ¹	615.54	440.77	492.24	602.94	327.64	495.25	9.15	0.3024
Kg milk/ ha	38829	13888	25644	28093	9153	21131	975.29	0.0001

DM = dry matter content, DMD = dry matter digestibility, CP = crude protein, NDF = neutral detergent fiber, NDFD = neutral detergent fiber digestibility, TDN = total digestible nutrients NEL = net energy for lactation (MJ / kg DM), kg milk / Ton DM = kilograms of milk per ton of dry matter, Kg Milk / ha = kilograms of milk per hectare.

Table 2. Forage production (ton / ha) density of plants, chemical composition of silages and their potential milk production (kg milk / ton DM and kg milk / ha) of hybrid and native corn silages sown in Mexico.

Variable	Native silage N.7			Hybrid silage N.135			SEM	P Value
	Maximum	Minimum	Average	Maximum	Minimum	Average		
Forage yield (ton DM/ha)	22.30	14.10	18.34	34.20	9.40	19.23	1.41	0.0018
Plant Density ha	22,500	62,500	65,714	100,000	62,500	80,492	3,112	0.6226
DM%	23.10	17.10	20.95	44.80	11.10	30.34	2.05	0.0001
DMD %	69.50	55.30	65.56	78.30	47.70	66.56	1.68	0.1144
CP%	9.50	4.70	6.97	10.30	4.40	7.75	0.435	0.7266
NDF%	61.10	36.30	52.56	69.90	31.00	57.02	2.84	0.1261
NDFD %	67.70	52.40	58.72	68.40	43.00	57.46	1.33	0.3715
TDN-DM % ¹	69.81	60.66	65.33	72.73	47.14	63.52	1.26	0.1058
NEL, MJ/KgDM ¹	6.11	5.44	5.82	6.53	4.60	5.65	0.026	0.0700
Kg milk ton/DM ¹	568.10	464.28	516.84	615.54	327.64	493.24	15.52	0.0733
Kg milk/ ha ¹	27,442	15,499	22,687	38,829	9,153.73	22,399	1,654.97	0.0307

DM = dry matter content, DMD = digestibility of dry matter, CP = crude protein, NDF = neutral detergent fiber, NDFD = neutral detergent fiber digestibility, TDN = total digestible nutrients NEL = net energy for lactation (MJ / kg DM), kg milk / Ton DM = kilograms of milk per ton of dry matter, Kg Milk / ha = kilograms of milk per hectare

In Table 3 a positive correlation was observed ($P < 0.01$) for DM production and kg milk / ha. Likewise, a positive correlation was observed ($P < 0.01$) for the NDFD and TDN, and for the content of NEL (MJ / kg DM) and kg milk / ton DM.

The resulting prediction equations for calculating the NEL (MJ / kg DM), kg milk / ton DM and kg milk / ha are presented in Table 4. The use of two variables explained the greater variation for NEL (MJ / kg DM) and kg milk / ton DM, while for kg milk / ha only one variable was used.

DISCUSSION

In the northern region, fodder maize of tropical or temperate origin is used, which has a smaller harvest cycle, as well as smaller stems and fewer leaves, which decreases DM production, in addition to requiring a greater number of plants to reach an optimum forage yield; However, this increase does not mean a higher production of biomass per unit area (Ballard *et al.*, 2001) as found in the present study, as the native maize is the one that presented a greater amount of DM.

Table 3. Correlation matrix between forage production and plant density by hectare in Mexico compared to its chemical composition of silage and its potential milk production (kg) per ton DM and kg milk / hectare.

Variables	Plant density, ha	DM%	DMD %	CP%	NDF%	NDFD%	TDN %-DM	NEL, MJ / Kg DM	Kg milk/ ton DM	Kg milk/ ha
Forage yield (ton DM/ha)	-0.308**	0.453**	0.380**	0.352**	0.183*	-0.143	-0.115	-0.160	-0.153	0.940**
Plant density ha		0.149	0.570**	0.336**	0.045	0.005	-0.112	-0.131	-0.119	-0.347**
DM%			-0.155	0.114	-0.114	0.084	-0.157	-	-	0.365**
DMD%				0.116	-0.169*	0.200*	0.258**	0.259**	0.228**	-
CP%					0.373**	0.302**		0.251**	0.264**	-
NDF%						-	-	-	-	0.281**
NDFD%						0.769**		0.538**	0.578**	0.001
TDN-DM%								0.460**	0.525**	0.022
NEL, MJ / Kg DM								0.967**	0.988**	0.210*
Kg milk/ ton DM									0.994**	0.176*
										0.181*

* P <0.05, ** P <0.001, *** P <0.001

DM = dry matter content, DMD = dry matter digestibility, CP = crude protein, NDF = neutral detergent fiber, NDFD = neutral detergent fiber digestibility, TDN = Total digestible nutrients, NEL = Net Energy for Lactation (MJ / kg DM), kg milk / Ton DM = kilograms of milk per ton of dry matter, Kg Milk / ha = kilograms of milk per hectare.

Table 4. Equations to estimate ($y = a + bx_1 + bx_2$) the NEL (MJ / kg DM), Kg milk / ton DM and kg milk / ha, using maize silage sown in Mexico.

Y	Equation	R ²	P Value
NE _L (MJ/kg DM)	$Y = 1.454 (\pm 0.180) + 0.002 (\pm 0.0001) * (\text{NDFD}\%) - 0.004 (\pm 0.0001) * (\text{NDF}\%)$	0.30	0.001
Kg milk/ton DM	$Y = -306.06 (\pm 5.75) + 550.31 (\pm 4.35) * (\text{NE}_L, \text{MJ/kgDM}) + 1.01 (\pm 0.08) * (\text{NDFD}\%)$	0.99	0.001
Kg milk/ha	$Y = 2007.62 (\pm 638.07) + 1062.67 (\pm 32.48) * (\text{Forage yield, ton DM/ha})$	0.88	0.001

DM = Dry matter content, NDFD = neutral detergent fiber digestibility, NDF = neutral detergent fiber, NEL = Net Energy for Lactation (MJ / kg DM), kg milk / Ton DM = kilograms of milk per ton of dry matter, Kg Milk / ha = kilograms of milk per hectare.

González *et al.* (2008) and Aragón *et al.* (2005), mention that in the center of Mexico from 87 to 90% of maize that is sown has a larger (larger than what those from the north) stem size, which encourages higher production (ton DM / ha). The altitude of the plant, as well, can influence the increase of milk production / ha (Wu and Roth, 2005), although this type of corn, because of its maturation stage at the time of cutting, has a lower amount of CP (Bal *et al.*, 2000) compared with the maize sown in other latitudes (Ali *et al.*, 2012; Khan *et al.*, 2015), which contains a higher content of CP and NEL at the time of silage.

The forage yield (ton DM / ha) and the DM content were higher in the hybrid corn than the natives' silages presented in this study, which may be due to the age of the plant at the time of cutting (Deaville and Givens, 2001). Elizondo and Boschini (2002)

mention that when comparing hybrid maize against natives with the same age at the time of cutting, the hybrid maize surpasses the dry matter content 50% with respect to the native ones, which coincides with the present study.

Forage yields (ton DM / ha) were higher than those found by Mussadiq *et al.* (2013) and Cusicanqui and Lauer (1999), who reported 11.7 and 17 tons of DM / ha of hybrid maize respectively, but similar to those of Cox and Cherney (2001), who reported 19.5 ton DM / ha in hybrid maize. Herrero *et al.* (2010) and McDermott *et al.* (2010) mentioned that the integration of animal manure plays an important role in improving the equilibrium of nutrients in the soil and during crop production. Although 87% of farmers apply manure fertilizer, only 12% adequately perform this practice by first composting the manure, while another 50% apply manure after

two weeks of drying. The remaining percentage of farmers apply fresh manure (Paulino Flores *et al.*, 2017).

Lasmar de Oliveira *et al.* (2017) in tropical climates (1085 kg milk / ton DM) and Mussadiq *et al.* (2013), with 1207 kg of milk / ton DM are higher than the present study (499 ±8 kg milk/ ton DM). Cox and Cherney (2001) found a milk yield that varies from 11.3 to 18.5 ton of milk / ha, lower yields than the present study (22.4±0.1 ton of milk/ha). It is also evident that despite this lower DMY in native maize compared to hybrid maize, a greater quantity of milk (kg milk / ha) is produced, which is still conserved by small producers and is easily commercialized (Boschini and Elizondo, 2004) in the region. This increase in milk production that occurs in native maize can be explained because the hybrid maize, while presenting a greater amount of forage, decreases the production of ears (Dwyer *et al.*, 1998), which can decrease the amount of starch in the plant causing lower milk yields per ton DM and kg milk / ha (Ferraretto and Shaver, 2012; Lascano *et al.*, 2016). If we look at Table 2, native corn silage can give us more kg milk/ton DM, possibly due to higher NDFD, since higher NDFD increases DM intake. Oba and Allen (1999), defined that a 1 unit increase in NDFD in the diet results in a 0.168 kg/day increase in DM intake, 0.23 kg/d of milk yield, and 0.25 kg/d of 4.0% fat-corrected milk. Simply put, lactating dairy cows will consume more forage that has a higher energy content when forages have a higher NDFD content. The NDFD content of the forage can have a large impact on the energy value of the diet. As the NDFD content of the maize silage increases (considering that all other nutrients, i.e. CP, NDF, fat, etc. are constant) the TDN content of the silage increases (Table 2). Thus, an increase in the TDN content of native corn silage results in an increase in the energy content of the diet and the potential milk yield (Oba and Allen, 2000; Tine *et al.*, 2001; Kendall *et al.*, 2009).

In this system, the standard native production yield of maize is 18 tons / ha. This relatively low yield renders these enterprises less economically viable compared with other countries, especially considering the low market prices for maize and high dependency of these farmers on government subsidies.

The correlations obtained in this study agree with Shaver and Lauer (2006) and the Milk2006 model. Schwab *et al.* (2003) mention that the Milk2006 model has the basic concept of a summative energy equation, which is fulfilled in this study, obtaining a significant correlation regarding the concentration of NEL and the estimated production of kg milk / ton DM ($r = 0.99$).

The resulting equations (Table 4) to predict the NEL and kg milk / ton DM were acceptable using only two variables, which may be since the two variables

used in the MILK2006 model were used, which are calculated according to the variables used in this model (Schwab *et al.*, 2003; Mussadiq *et al.*, 2013). The equation to calculate the milk yield (kg milk/ ha) resulting in this study is like Mussadiq *et al.* (2013), who mention that this means of calculating kg milk / ha is a combination of quality and quantity parameters of maize silage according to what is established by the MILK2006 model.

CONCLUSIONS

The use of native maize in Mexico is a viable alternative for use as a silage in feed for dairy cows, due to the higher digestibility of the NDF that causes the higher NEL, with higher milk production per hectare and per ton of dry matter compared to hybrid maize. Likewise, it would be expected a greater milk production / ha in the central region of the country. This circumstance can reinforce the use of local native varieties for their productive characteristics, thus preserving the indigenous biodiversity of corn seeds, the nation's cultural heritage, which would support government involvement in their care. More studies are required to evaluate the chemical composition of maize silage, especially the inclusion of starch, fat, and its digestibility for a better approximation.

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Compliance with ethical standards. The authors declare that they have complied with national and international standards and the paper presents original data compilation that has not been submitted to another journal.

Data availability. The data is available from the correspondence author on request.

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