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Article

Nixtamal and Tortilla quality on improved maize [*Zea mays* L.] genotypes for the humid tropic in México

Calidad de nixtamal y tortilla en genotipos de maíz [*Zea mays* L.] mejorados para el trópico húmedo de México

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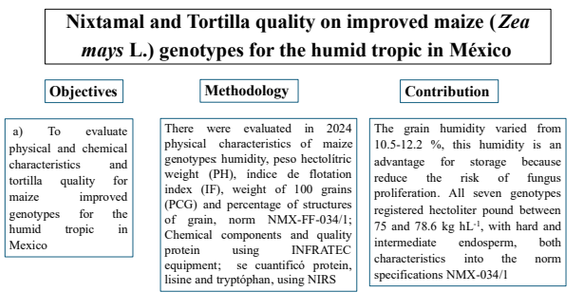
Abstract

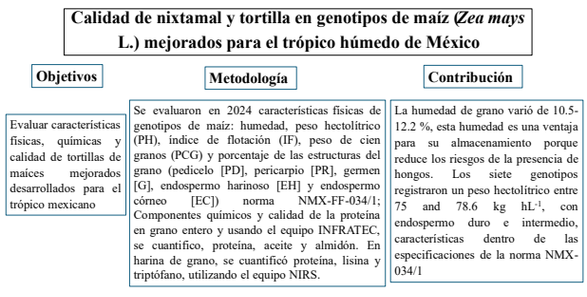
With the objective of evaluating physical and chemical characteristics and tortilla quality for maize improved genotypes for the humid tropic in Mexico, during fall winter season 2023/24 under irrigation conditions there were evaluated seven maize genotypes from Cotaxtla experiment station, INIFAP; These genotypes were produced in plots of 4 rows 5 m long and 80 cm wide in plant density of 62,500 plants ha^{-1}; The grain humidity varied from 10.5-12.2 %, this humidity is an advantage for storage because reduce fungus proliferation. All seven genotypes registered hectoliter pound between 75 and 78.6 kg hL^{-1}, with hard and intermediate endosperm, both characteristics into the norm specifications NMX-034/1, these genotypes can be processed by the traditional Nixtamalization and floury industries. V-537C registered 1.63 kg of tortilla for each kg of maize grain and presented intermediate hard endosperm and there were produced soft tortillas, Finally, V-537C presented the highest content of Lysine but not for Tryptophane content.

Resumen

Con el objetivo evaluar las características físicas, químicas y calidad de tortillas de maíces mejorados para el trópico mexicano, durante el ciclo otoño invierno 2023/24 bajo condiciones de riego se evaluaron siete genotipos de maíz del Campo Cotaxtla, INIFAP; Estos genotipos fueron producidos en parcelas de 4 surcos de 5 m de largo separados a 80 cm en una densidad de 62,500 plantas ha^{-1}; La humedad de grano varió de 10.5-12.2 %, esta humedad es una ventaja para su almacenamiento porque reduce la presencia de hongos. Los siete genotipos registraron un peso hectolítrico entre 75 and 78.6 kg hL^{-1}, con endospermo duro e intermedio, características dentro de las especificaciones de la norma NMX-034/1, estos genotipos pueden ser procesados por la industria tradicional de Nixtamalización y de la harinización, V-537C registró 1.63 kg de tortilla por cada kg de grano, presentó dureza intermedia y produjo tortillas suaves; Finalmente, V-537C presentó los más altos contenidos de Lisina, pero no de Triptófano.



Quality protein, Nixtamal, tortilla, humid tropic



Calidad de proteína, nixtamal, tortilla, trópico húmedo

Area: Development of strategic leading-edge technologies and open innovation for social transformation

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Introduction

In México, Maize is the most important crop because it is part of the diet for human consumption, the sown area, and generates 36% of the agriculture production value. During 2022, there were sown in México, 7.47 million of hectares with maize, with 3.90 t ha^{-1} in yield and a total production of 26.55 million tons, with an apparent *per cápita* consume of 338.10 kg; From the total production, 19.35 million tons were utilized for the direct consume which of them, 67% through the masa and tortilla industry in the nixtamalization process and 33% is through the flour industry. Besides, during 2022, 17.40 million tons of yellow grain were imported for industry and animal feed [SIAP, 2022].

In the tropical region in México, during 2022, there were sown 2.8 million of hectares with maize, which of them one million are located in agronomic provinces of good and very good productivity, and 91 thousand hectares are sown under irrigated conditions; In this area is feasible the use of improved seed of hybrids, synthetics and varieties with high yield potential under favorable conditions of clime soil and management by farmers [SIAP, 2022; Espinosa *et al.*, 2019; Sierra *et al.*, 2019].

Maize in Mexico have multiple uses as grain, fodder and industrial use; however, the most important use is the direct consumption through the tortillas, tamales, Huchepos, Corundas, Atoles, totopos, tlayudas, Pozole, among others. Maize is an invention of Mexican men, however, the process of nixtamalization is an invention of Mexican women and through this process, they have created multiple dishes and ways for direct consumption [Sierra *et al.*, 2019; Sierra *et al.*, 2024]

In maize breeding through evaluating different environments are identifying better genotypes in yield, adaptation, and agronomic traits, however, is very important that farmers have access to seed with genetic, physiological, physical and sanitary good quality [Andres *et al.*, 2017; Espinosa *et al.*, 2012; Flores *et al.*, 2016; Sierra *et al*., 2016a; Sierra *et al.*, 2016].

The tortilla is the most common way in human consumption of maize and is part of the diet of all Mexican people, and demand greater white maize production.

Thus, in the maize breeding program at Cotaxtla experiment station, which belongs to INIFAP in México, there have been conducting research for generating hybrids, synthetics and open pollinating maize varieties with very good adaptability to different environmental conditions, greater yield and productivity, tolerant to principal diseases, drought and lodging; adaptation to clime, soil and management by farmers; Besides, these genotypes have been adopted by seed producers and farmers in the southeast in México [Espinosa *et al.*, 2019; Sierra *et al.*, 2019; Reyes 1985; Andrés *et al.*, 2014; Andrés *et al.*, 2016; Sierra *et al.*, 2016]. The Tuxpeño race in the humid tropics has been the basis for genetic improvement for this region; principally white grain focused to human consumption. However, is very important to evaluate the grain and tortilla quality, physical and chemical characteristics according with the industrial in nixtamalization and fluoring norms. The objectives of this research were to evaluate the physical and chemical characteristics and tortilla quality for maize improved genotypes developed for the humid tropic in Mexico

Methodology

Localization. The tropical area in Mexico, according with García [2004], the climatic group A, that correspond to humid and subhumid warm conditions [Aw0, Aw1, Aw2, Am y Af] is located in the coast region in the Gulf of Mexico and the pacific ocean. This region corresponds to the influence area on which the maize hybrids and varieties have been generated, evaluated promoted and are located the producers of improved seed; The genotypes evaluated were produced in Cotaxtla Experimental Station INIFAP, in Veracruz, located at the km 34 through the public road from Veracruz-Córdoba in the municipality of Medellín de Bravo, Veracruz, in the 18° 56’ North Latitude and 96° 11’ West longitude and altitude of 15 masl. García [2004]. The soil is in Cotaxtla is Vertisol, with medium texture trough the profile and slightly acid pH [6.6] [INEGI, 2020].

Germplasm used. H-518, H-520, V-537C, V-540, SINT 4B, V-537CxVS-536, SINT 4BxVS-536, commercial and experimental genotypes derived from the Tuxpeño race and developed at Cotaxtla experimental station which belongs to the National Institute of forestry, agricultural and livestock research [INIFAP]. [Sierra *et al.*, 2019]

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Description of grain production. During 2024 were evaluated seven maize genotypes from Cotaxtla experiment station, INIFAP; These genotypes were produced during the fall winter season 2023/24 under irrigation conditions in plots of 4 rows 5 m long and 80 cm wide in plant density of 62,500 plants ha^{-1}; The weeds were controlled based on Atrazine in preemergent application and were controlled pests in leaves during developing crop [Reyes, 1990]. In fertilization was utilized the formula 161-46-00, applying all the phosphorus and 30% of the nitrogen at planting date, the rest of nitrogen was applied 35 days from planting date using urea as nitrogen source. The agronomic management have influence in the presence of the Lysine and Trytophan aminoacids [Vera *et al.*, 2012]

Physical characteristics. There were evaluated the physical characteristics as follow: humidity of grain, hectoliter weight [PH], flotation index, [IF], weight of 100 grains [PCG] and percentage of the grain structures [pedicel [PD], pericarpic [PR], germen [G], endosperm farinose [EH] and cornea endosperm [EC]] according with the norm NMX-FF-034/1 [SE, 2020].

Chemical components and proteína quality. In complete grain and using equipment INFRATEC, there were quantifying protein, oil, and starch. In flouring of grain without treatment, there were quantifying protein, Lysine and Tryptophan using equipment NIRS, in both cases were followed the methodologies described by Palacios [2018]. The quality protein index [ICP] was calculated using the relation: percentage of de tryptophane /percentage of protein]*100 [Twumasi *et al.*, 2016]. All these variables were gotten by duplicated.

Tortilla quality. The maize genotypes were nixtamalizated following the traditional method described by Vázquez *et al.*, [2023] and Salinas *et al.*, [2017].

Consist in cooking 500 g of maize grain in a solution of 1000 mL of water and 10 g of lime [1.0% according with the maize grain quantity]. Time of cooking is assigned based on flotation index [IF] [SE, 2020].

The nixtamal was keeping repose during 16 hours and then was rinsed with 1000 ml of water.

The next step was to grind the nixtamal in a Stone grind Fumasa® Mod. de 5 HP. MN-80 Universal [Fumasa S.A., Méx.] for getting the dough. The dough was molded forming disks of 20 cm diameter and 1.5 mm of thickness, and there were cooking in a machine for making tortillas Villamex, Model V-14C/R, provided of three comales, heated at 310, 280 and 270 °C respectively, on which each disk of dough kept 45, 30 and 35 minutes

In the liquor of cooking [nejayote] there was evaluated the loss of dry matter [PMS]; in the nixtamal, the pericarp retained [PR] and the humidity [HN] [SE, 2020]; in grain and tortillas recently elaborated [30'], packed and stored during 24 h to 4°C, there was evaluated the humidity, the color, the force of compression and the elongation, these two last variables were measured with a texturometer Brookfield® [Model CT3, Middleboro, Massachusetts, EUA] utilizing a punch finish in a globe of 10 mm of diameter. The results were expressed in grams-force [gf] and mm respectively. The yield was evaluated in tortillas recently elaborated and was expressed in kg of tortilla by kg of processed grain.

The color in grain and tortillas recently elaborated [30'] and stored was qualified using a colorimeter Hunter Lab MiniScanXE Plus® [Reston, VA, EE. UU.]. There was registered the luminosity [L*], a* and b*, with these last variables there was calculated , the angle of tone hue [$hue = \arctan[\frac{b}{a}]$] and the purity index [$chroma = [a^2 + b^2]^{1/2}$] [Sant'Anna *et al.*, 2013].

Results and discussion

Physical characteristics. The grain humidity varied from 10.5-12.2 %, this humidity is an advantage for storage because reduce the risk of fungus proliferation. The improved maize genotypes, were characterized for small grain weight of 100 gr less than 33 g [NMX-034 [SE, 2020], Is important to mention that GRUMA is buying big grain preferring [PCG > 38 g]. All seven genotypes registered hectoliter pound between 75 and 78.6 kg hL^{-1}, with hard and intermediate endosperm, both characteristics into the norm specifications NMX-034/1 [SE, 2020] and the GRUMA demand [Table 1]. These genotypes can be processed by the traditional Nixtamalization and floury industries.

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Box 1

Table 1

Physical variables and structural components of improved maize grains for the Mexican tropic. Cotaxtla, Ver. Fall Winter season 2023-2024.

Genotypes	Grain Humidity [%]	Hectolitric Weight [Kg hL^{-1}]	Weight of 100 grains [g]	Flotation Índex [%]	Hardend Grain §
H-518	10.5±0	75±0.28	23.7±0.01	53±2.83	I
H-520	11.3±0.35	78.2±0.28	28.3±0.02	28±2.12	D
V-537 C	11.4±0.57	75.4±0.28	24±0.01	41±3.54	I
V-537CxVS-536	11.6± 0.78	78.6±0.28	27.2±0.01	35±0.71	D
V-540	11.3±0.42	77.2±0	26±0.01	34±1.41	D
Sintético 4B	12.2±0.92	78.6±0.28	25.8±0.01	29±7.07	D
Sint 4BxVS-536	11.9±0.78	79±0.28	22.6±0.01	23±0	D
NMX-034[1] 2020	> 73			010-45	
GRUMA [2020]		> 73	> 38	< 48	

Source: Own elaboration

In the structural components, the maize hybrid H-520 and the experimental Synthetic 4B, had percentages of pedicel above stablished by GRUMA. Except the experimental varietal cross SINT4BxVS-536, which percentage of germen was above 13 % accepted by GRUMA, the rest of genotypes, compliment the cumplen las specifications of this enterprise. In the sum of: pedicel, pericarp and germen, we can see that all genotypes were into specifications of GRUMA [Table 2].

Box 2

Table 2

Physical variables and structural components of improved maize grains for the Mexican tropic. Cotaxtla, Ver. Fall Winter season 2023-2024

Genotypes	Pedicel	Pericarp	Germen	Endospermo		SUM
				Fluory	Flint	
	[%]					ΣP+Pe+Ger]
H-518	1.01±0.12	4.75±0.07	11.83±0.31	23.71±8.75	58.7±9.11	17.6±0.35
H-520	2.67±0.3	4.98±0.10	9.36±0.31	53.19±4.9	29.8±4.81	17.0±0.09
V-537 C	0.9±0.03	5.18±0.46	12.96±0.36	42.17±0.41	38.78±1.21	19.0±0.79
V-537CxVS-536	1.14±0.18	5.16±0.8	12.67±0.12	36.29±2.6	45.23±3.71	18.5±1.1
V-540	1.14±0.01	5.49±0.14	12.46±0.40	29.47±4.64	51.43±4.38	19.1±0.26
Sintético 4B	2.4±0.08	6.0±0.12	10.9±0.40	33.6±0.54	47.2±0.91	19.3±0.37
Sint 4BxVS-536	0.92±0	5.45±0.52	13.43±0.16	27.64±1.94	52.56±2.30	19.8±0.35
GRUMA [2020]	< 1.2	< 5.5	< 13.0	< 32	> 48	< 21.5

Source: Own elaboration

Chemical components and quality protein. The protein was between 7.3-11.4 % with a mean value of 8.9 %.

The average content of oil registered was 5.22 %, corresponding to highest value for V-537C maize variety [Table 3], besides this variety registered among the highest percentage of germen [x=13.0 %]. The content of starch was similar in all evaluated genotypes with an average value of 70.91 %.

The protein content in the floury, measured in the equipment NIRS, varied slightly with respect to obtained by Infratech equipment, which can be attributed to lost that can be occur during milling that can permit concentration or dilution in components. Thus, the hybrid H-518 and open pollinating maize variety V-537C, that registered intermediate endosperm and were that registered less protein and more oil. The amino acids Lysine and Tryptophan registered values between 0.404-0.310 and 0.069-0.057% respectively. Except H-518 that registered Lysine values, like normal endosperm, the rest of genotypes the rest presented high percentages of Lysine, like QPM maize [Table 3]. The reduced differences among the genotypes may be due to interchange of pollen, with the quality protein maize V-537C and the varietal cross V-537CxVS-536, where the female parent is V-537C.

According with Vera *et al.*, [2012] the clime conditions and the management of crop by farmers, contribute in the content of the amino acids. In average for Tryptophan was 0.062 %, value below than 0.075 % established for QPM genotypes [Twumasi *et al.*, 2016]. The highest content of protein, Lysine and Tryptophan was for V-540, besides, registered less starch [Table 3]. The high ICP of H-518, is due to reduced content of protein and the percentages of Lysine and Tryptophan were smaller than the QPM maize variety. As a conclusion we can see that none of these genotypes reach a quality index ICP of 0.8 stablished for QPM maize [Twumasi *et al*., 2016]. The results of Lysine indicate that we should continue sampling this amino acid.

Box 3

Table 3

Chemical components and quality protein improved maize for Mexican tropic

Genotypes	Humidity	Protein €	oil €	Starch €	Protein £	Lysine £	Tryptophan £	ICP
	[%]				[%]			
H-518	11.5±0.0	7.3±0.07	5.6±0.14	71.4±0.28	7.2±0.32	0.310±0.004	0.057±0.002	0.80
H-520	10.1±0.07	9.6±0.0	5.0±0.0	70.3±0.35	10.5±0.12	0.403±0.023	0.065±0.0008	0.61
V-537C	12.6±0.07	8.0±0.14	5.7±0.07	71.3±0.57	9.3±0.33	0.378±0.005	0.063±0.0008	0.68
V-537CxVS-536	13.9±0.0	8.3±0.0	5.0±0.07	71.2±0.21	9.5±0.24	0.375±0.003	0.060±0.0007	0.63
V-540	10.7±0.0	11.4±0.42	5.1±0.07	69.4±0.28	12.1±0.11	0.404±0.022	0.069±0.0005	0.57
Sintético 4B	14.0±0.07	8.6±0.21	5.3±0.0	71.6±0.21	9.1±0.12	0.404±0.003	0.059±0.003	0.65
Sint 4BxVS-536	13.6±0.07	8.9±0.14	5.0±0.14	71.4±0.07	10.1±0.55	0.382±0.005	0.060±0.001	0.60
Twumasi-Afryie *et al.*, [2016]					QPM	> 0.35	> 0.075	0.8

£In fluory grain without process [measured in the NIRS].

Source: Own elaboration

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Quality of tortillas. The lost of solids in the liquor of cooking [nejayote] was between 4.8 to 3.3 % with an average value of 4.3 %, similar values were reported by Salinas *et al.,* [2017] for improved genotypes in the tropic. The percentage of pericarp retained for the nixtamal was between 43.8 and 16.0%, particularly V-537C, was the variety that less pericarp retained in nixtamal [Table 4]. Thus, V-537C was among the genotypes with high lost of solids [x=4.6%]. On the contrary genotypes with high retention of pericarp [V537CxVS536, SINT4BxVS536], were those with less detriment of solids registered [Table 4]. The significative correlation between these two variables [r=0.71; P< 0.01] was reported by Vázquez *et al.,* [2018].

The average for nixtamal humidity [HN] was 44.5 %, V-537 C registered the highest value, nevertheless, less time of cooking [40 min] respect to hard grain genotypes, that had 45 minutes. Besides, V-537C registered 1.63 kg of tortilla for each kg of maize grain and presented intermediate hard endosperm and there were produced soft tortillas, Finally, V-537C presented the highest content of Lysine but not for Tryptophane.

Box 4

Table 4

Quality nixtamalero-tortillera of improved genotypes for mexican tropic

Varieties	% lost	% Pericarp	Humidity [%]					Yield Tortill
	Dry matter	Retained	H Nixtamal	H dough	HT [30´]	HT [24 h]	HT [48 h]	[kg/Kg maize]
H-518	3.9 ± 0.7	39.3±1.27	45.0±0.25	0.2±0.11	45.8±0.85	40.6±0.45	44.1±0.18	1.58±0.007
H-520	4.8±1.0	26.01±2.0	44.3±0.23	0.6±0.19	45.0±1.03	44.3± 0.35	43.9±1.02	1.55±0.014
V-537C	4.6±1.4	16.0±0.98	45.8±0.32	2.2±0.27	45.2±0.91	43.9±0.51	44.0±0.29	1.63±0.042
V537CxVS536	3.3±0.8	42.3±1.71	42.9±1.7	7.5±0.23	42.2±0.35	42.5±0.1.1	43.3±0.6	1.5±0.007
V-540	4.7± 0.5	30.0±1.3	44.6±1.45	8.9±0.31	45.1±0.53	44.4±0.41	44.1±0.35	1.5±0.015
SINT 4B	4.3±0.9	41.2±1.90	45.1±0.83	9.8±0.18	43.2±1.01	43.8±0.43	41.2±0.12	1.47± 0.028
SINT4BxVS536	3.6±0.0	43.8±1.21	44.5±1.21	8.2±0.28	43.1±0.82	43.9±0.48	41.1±0.41	1.44±0.0

Source: Own elaboration

The softer tortillas, recently elaborated, 24 and 28 h after of stored were made with V-537C [Table 5]. The varietal crosses V537CxVS536 and SINT4BxVS536 were those which retained the highest pericarp retention [x=43.1 %], produced tortillas with less humidity [x= 42.6%], besides these crosses were that required more force for breaking [x=3.0 N], especially after 24 h of stored [Table 5].

Box 5

Table 5

Force of breaking and elongation of tortillas recently elaborated [30´] and storaged [24 and 48 h] to 4°C, of improved genotypes for the humid tropic in México

Genotypes	Force of breaking [N]			Elongation [mm]		
	30 min	24 h	24 h	30 min	24 h	24 h
H-518	2.1±0	1.9±0.1	1.8±0	6.7±1.2	4.2±0.1	6.5±1.1
H-520	1.9±0.1	3±0.2	2±0	5.4±1.1	7.7±0.4	5.1±0.4
V-537 C	1.7±0	1.6±0	1.5±0.1	5.6±0.4	5.5±0.6	5.8±0.2
V537CxVS536	1.8±0.1	3.2±0.1	2.7±0	7.7±0.1	9.7±3.1	8.5±1
V-540	2.2±0.1	1.8±0	2.8±0	7.1±0.6	8±0	8.6±0
SINT 4B	2±0	2.6±0	2.7±0.3	6.9±0.5	7.8±0.9	7.3±1.3
SINT4BxVS536	1.9±0.1	2.8±0	1.8±0.1	6.5±0	7.4±0.5	6.7±1

Source: Own elaboration

Color in grain and tortillas. The average luminosity in grain was 69.7%, value increased in tortillas [x= 73.9%], this is because of the dilution of pericarp by effect of the nixtamalization and the predominance of the white starch in endosperm. The grains of V-540 and V-537C were those that presented the clearest tone and highest color purity [chroma], while H-520 had grains with creamier tones and lower color purity [Table 6].

In freshly made tortillas [30'] the lightest tone was for SINT4BxVS-536, conversely the lowest purity was in the cream color [x=19.97]. The lower purity of color in tortillas is attributed to the color changes caused by lime [Ca [OH]2] and the cooking of the dough, where the Maillard reaction occurs, which is a color change towards brownish tones, which is produced by the caramelization of sugars or proteins when subjected to heat. As well as the color change due to the cooking of the dough itself. The tortillas stored for 48 hours in refrigeration, from SINT4BxVS36, were the lightest in color [Table 6].

Box 6

Table 6

Parámeters of color in grain and tortillas from improved maize genotypes for mexican tropic.

Variedades	Color en Grano		Tortillas [30']		Tortillas [24 h]		Tortillas [48 h]	
	Hue [°]	Croma	Hue [°]	Croma	Hue [°]	Croma	Hue [°]	Croma
H-518	83.43±0.2	28.57±1.4	85.87±0	21.46±0.1	85.69±0.2	20.5±0.2	90.55±0.1	19.35±0.3
H-520	81.78±0.3	25.96±0.3	86.93±0.2	20.07±0	85.76±0.6	21.09±1	91.33±0.1	19.67±0.2
V-537 C	84.28±0.6	29.69±0	86.53±0.3	21.38±0.2	86.8±0.2	21.76±0	89.95±0	20.82±0.3
V537CxVS-536	82.35±0.2	28.72±0.1	85.93±0.4	21.76±0.2	89.79±0.1	20.36±0.2	89.39±0	20.33±0.2
V-540	84.36±0.9	27.02±0	87.73±0.1	20.85±0.1	91.34±0.4	20.1±1	91.4±0.1	19.51±0.6
SINT 4B	83.07±0.5	31.52±0.7	86.46±0.1	20.6±0.2	89.44±0.1	19.83±0.4	89.74±1.1	20.35±0.4
SINT4BxVS536	83.03±0.5	28.7±0.1	87.97±0.2	19.97±0.9	90.76±1	20.56±0.2	91.2±0	20.25±0

Source: Own elaboration

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Conclusions

The seven improved varieties showed similarities in their physical characteristics; all had small grains and a predominance of hard endosperm. All met the specifications of the NMX-034/1 standard [SE, 2020].

The V-537C, which had intermediate-firmness grains, produced the softest, freshest and most stored tortillas and the highest tortilla yield.

Its lysine content was high, typical of a high-protein corn, but its tryptophan content was not. Neither of these varieties had the tryptophan levels expected of QPM corn.

The varieties evaluated can be processed by the fresh dough and nixtamalized flour industries.

Conflict of interest

Authors declare no interest conflict.

Authors' contribution statement

Sierra-Macías, Mauro: Corresponsable in Project: "Mejoramiento genético y registro de variedades de maíz para el trópico bajo de México y sus nichos ecológicos". Participating in generating maize genotypes y producing the grain for the samples utilized in these Physical, chemical and nixtamalization analysis

Vázquez-Carrillo, María Gricelda: Physical, chemical and nixtamalization analysis for maize hybrids and varieties for the humid tropic.

Ríos-Isidro, Clara: Asistant in the maize program Campo experimental Cotaxtla, colaborated in generating maize genotypes and producing the grain for the samples utilized in these Physical, chemical and nixtamalization analysis, organization of the data and elaborating the information.

Gómez-Montiel, Noel Orlando: Responsable in Project: "Mejoramiento genético y registro de variedades de maíz para el trópico bajo de México y sus nichos ecológicos". Participating in generating maize genotypes organization of the data and elaborating the information

Availability of data and materials

The data and the information that we present in this contribution are data of experiments conducted by INIFAP

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Abbreviations

CONAHCYT	National Council of Humanity Science and Technology
CP	Postgraduate College
INAPESCA	Fishing National Institute
INIFAP	National Institute of Forestry, Agriculture and Livestock Research
SADER	Agricultural livestock and rural development ministry
SIAP	Service of agrifood and fishing information
TECNM	National Technological of México
UACH	Chapingo Autonomous University
UV	Veracruz University

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