Anatomical Characterization of Ear and Kernel in Maize (*Zea mays* L.)

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ABSTRACT
Objective: To evaluate the physical quality of ears and kernels of hybrids and varieties cultivated in the municipality of San Luis Acatlán, Guerrero, Mexico. Methodology: Six white-kernel hybrids, two yellow-kernel hybrids, and two blue and white landraces were used. The maize was grown during the Spring-Summer 2020 growing cycle under rainfed conditions. Physical traits of the ear and kernel anatomy were evaluated.
Results: VS-Tuxpeño and Azul exhibited the greatest ear length among the evaluated varieties (18.70 and 18.56 cm, respectively), whereas H-565 showed the highest ear weight (204.40 g). H-515 and H-Tuxpeño presented a width-to-length index (WLI) of 0.81, corresponding to a round kernel type, whereas H-565 exhibited a more elongated kernel shape (0.65). All genotypes, except Ocotito, showed an endosperm proportion greater than 70%.
Limitations of the study: Given the edaphoclimatic conditions of the municipality of San Luis Acatlán and the increasingly pronounced effects of global climate change, adaptive strategies for this type of crop should be further investigated.
Conclusions: Hybrids H-565 and VS-Tuxpeño exhibited superior performance in most ear and kernel components, which makes them suitable for commercial production, whereas the Azul variety showed comparable performance with the additional advantage of natural pigmentation. H-562 and Ocotito presented higher proportions of endosperm and germ, respectively, underscoring their potential for the masa and tortilla industry. Overall, the results reveal significant differences among genotypes and support their selection according to the intended grain use in San Luis Acatlán, Guerrero.

Keywords: Grain, Hybrids, Maize (*Zea mays* L.), Morphology, Creole varieties.

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INTRODUCTION

Maize (*Zea mays* L.) is a grass species belonging to the family Poaceae, and Mexico is recognized as the center of origin and diversification of this cereal (Wellhausen *et al.*,

1951). It is considered the most important crop worldwide because of its high consumption and its relevance to industry, as the grain is used in the production of products such as oils, starches, proteins, and food sweeteners; furthermore, it serves as a supplement in animal feeding and as forage for livestock (Fernández-Suárez *et al.*, 2013). It is cultivated in two agricultural cycles, spring-summer and autumn-winter, adapting to diverse climatic conditions, soil types, and water availability (Luna Mena *et al.*, 2012). The selection of the best seed is a fundamental component of its improvement, and the principal traits to be considered include ear and kernel length and width, number of kernels per ear, number of rows, kernels per row, and kernel weight (Magdaleno-Hernández *et al.*, 2016; Delgado-Ruiz *et al.*, 2018). In addition, native or creole maize varieties present certain advantages in terms of adaptation to the diverse edaphoclimatic conditions found in Mexico (Magdaleno-Hernández *et al.*, 2016). Delgado-Ruiz *et al.* (2018) reported that, of 100% of rural producers, 37.2% cultivate hybrids, whereas 32.6% sow both creole varieties and hybrids, using the former for household consumption and the latter for commercialization.

Among the components of seed quality, factors such as the anatomical and nutritional characteristics of the kernel must be considered, since these are regarded as essential parameters required by the food industry at both small and large scales (Cortés Soriano *et al.*, 2010; Retes Mantilla *et al.*, 2014). The main structures are the pericarp, endosperm, germ, and pedicel. The endosperm accounts for the largest proportion of kernel weight; this structure is composed of starch, which may be vitreous (floury) or horny (hard), and the amylose-to-amylopectin ratio is responsible for these endosperm types. The pericarp protects the kernel from external environments and is composed of fiber. The germ (embryo) is the living structure of the kernel and is characterized by a high fat and protein content. The pedicel is the anchoring structure and consists of tubular cells that allow the transfer of nutrients from the cob to the kernel. The relationship among these structures confers characteristics that make the grain useful for the food industry (García-Lara *et al.*, 2019; Singh *et al.*, 2019). In the Costa Chica region of Guerrero, particularly in the municipality of San Luis Acatlán, maize is one of the crops of greatest importance, with an annual production of 50,546.72 t (SIAP, 2024), mainly cultivated under rainfed conditions. The objective of this study was to evaluate the physical quality of ears and kernels of hybrids and creole varieties cultivated in the municipality in order to select the best genotypes and achieve higher grain yield.

MATERIALS AND METHODS

Experimental establishment and biological material

The experiment was established during the Spring-Summer 2020 growing cycle at the experimental field of the Centro de Bachillerato Tecnológico y Agropecuario No. 178, located in the municipality of San Luis Acatlán, Guerrero. The predominant climate is warm sub-humid (Aw2), at an altitude of 250 m, with an average temperature of 25.9 °C and a mean annual precipitation of 1,309 mm (INEGI, 2024). Eight hybrids were used, six obtained from Universidad Autónoma Chapingo, one hybrid and one synthetic variety from Reycoll Seeds®, and two creole varieties from the municipality of San Luis Acatlán (Table 1). The harvested ears were transported to the Laboratory of Agri-Food Technology

Table 1. Characteristics of the corn seed used in the experiment established in the town of San Luis Acatlán, Guerrero, Mexico.

Name	Genotype Grain Color	Genotype Grain Color
H-515	White Hybrid	White Hybrid
H-516	White Hybrid	White Hybrid
H-562	White Hybrid	White Hybrid
H-563	White Hybrid	White Hybrid
H-565	White Hybrid	White Hybrid
H-568	White Hybrid	White Hybrid
H-337	Yellow Hybrid	Yellow Hybrid
VS-Tuxpeño	Yellow Synthetic	Yellow Synthetic
Ocotito	White Creole	White Creole
Blue	Blue Creole	Blue Creole

and Innovation of the Regional Center for Higher Education of the Costa Chica of Universidad Autónoma de Guerrero.

Ear Quality Components

Ear weight

Fifteen ears were randomly selected, free of disease symptoms and physical damage. They were weighed using a VeLab-500 digital balance, and the results were expressed in g (Salinas-Moreno & Aguilar-Modesto, 2010).

Ear length and diameter

Ear length was measured with a ruler from the base to the last viable kernel (large, defect-free kernel). Diameter was measured at the middle section of the ear, and the results were expressed in cm (Salinas-Moreno & Aguilar-Modesto, 2010).

Number of kernels per ear

The number of rows and kernels per row in each ear was determined visually. Rows were counted in the middle section of the ear, whereas the number of kernels per row was counted from the base of the ear to the last kernel in four sections of the ear (Salinas-Moreno & Aguilar-Modesto, 2010).

Kernel weight per ear

The ears were shelled, keeping the kernels from each ear separately, and the obtained results were expressed in g (Salinas-Moreno & Aguilar-Modesto, 2010).

Kernel depth

Kernel depth was reported as the difference between ear diameter and cob diameter (Salinas-Moreno & Aguilar-Modesto, 2010), using the following equation:

$$KD = ear\ diameter - dcob\ diameter$$

Row-to-ear diameter and ear diameter-to-length indices

The row-to-ear diameter index (REDI) and the ear diameter-to-length index (EDLI) were calculated according to Salinas-Moreno and Aguilar-Modesto (2010), using the following equations:

$$REDI = \frac{(number\ of\ rows\ per\ ear)}{(ear\ diameter)}$$

$$EDLI = \frac{(ear\ diameter)}{(ear\ length)}$$

Physical grain quality

Kernel size

Fifty viable seeds were selected in triplicate, and the length, width, and thickness of each seed were measured using a digital caliper (Truper®). The results were expressed in cm, and the kernel width-to-length index (WLI) was calculated according to Pérez Mendoza *et al*. (2006) and Rivera-Castro *et al*. (2020), using the following equation:

$$WLI = \frac{(kernel\ width)}{(kernel\ length)}$$

Thousand-kernel weight (TKW)

One thousand viable seeds were selected in triplicate and weighed using a digital balance (VeLab-500). The result was calculated and reported in g (Rivera-Castro *et al*., 2020).

Kernel density

One hundred kernels were selected and placed in a 100 mL graduated cylinder; sample weight and displaced volume were recorded (Pérez Mendoza *et al*., 2006). Kernel density was calculated using the following equation and expressed in g mL^{-1}:

Kernel anatomy

Fifty viable seeds were selected and soaked for 24 h; subsequently, the endosperm, pericarp, pedicel, and germ were separated using a scalpel. Thereafter, the structures were dried in a forced-air oven; once dried, they were weighed, and the results were calculated using the following equation (Figueroa Cárdenas *et al*., 2013):

$$Anatomical\ part\ (\%) = \frac{weigth\ of\ the\ anatomical\ part}{total\ seed\ weight} \times 100$$

Experimental design

The experiment was conducted under a completely randomized design, in which each genotype was considered a treatment, with three replicates for each evaluated variable. The obtained results were subjected to analysis of variance (ANOVA), and a multiple comparison of means test was performed using Tukey's test (α=0.05) with the statistical package MINITAB® 19.

RESULTS AND DISCUSSION

Ear quality components

Table 2 shows that all variables, except kernel weight ($p \geq 0.05$), exhibited statistically significant differences ($p < 0.05$), thereby confirming the existence of functional genetic variation among the evaluated materials. The greatest ear length observed in VS-Tuxpeño (18.70 cm) and the largest diameter recorded in H-562 (5.10 cm) suggest differences in reproductive architecture, possibly associated with photosynthetic efficiency and the availability of photoassimilates during kernel filling. These results fall within the ranges reported by Huerta *et al.* (2008), who indicated mean values of 14.90 and 4.78 cm for ear length and diameter, respectively, and by Ángeles-Gaspar *et al.* (2010), who reported intervals of 12.4 to 15.2 cm for length and 4.09 to 4.76 cm for diameter. The superiority of H-565 in the number of rows and kernels per ear reinforces the notion that this trait is strongly governed by genetic control, although it may also be modulated by environmental and management factors.

In contrast, kernel weight did not show statistically significant differences, suggesting that, despite the morphological variation among genotypes, there was physiological compensation in the distribution of assimilates to the kernel. This may be attributed to the adaptation of the landrace materials to local conditions, which favors a more stable response among genotypes, even in the presence of differences in ear architecture. This interpretation is consistent with Remache *et al.* (2017), who stated that light intensity, climate, and soil quality directly influence kernel filling. The values recorded for thousand-kernel weight and cob diameter were comparable to those reported by Jiménez-Juárez *et al.* (2012) and Ramírez Reynoso *et al.* (2020), whereas the similarity in kernel depth and morphological indices reflects adaptation and plasticity, even in comparison with hybrids, which partially agrees with the findings of Castellanos Reyes *et al.* (2017). Overall, the results reinforce the observations of Sánchez-Toledano *et al.* (1949), who proposed that differences among genotypes allow for specific uses and differentiated technological utilization.

The differences observed among the evaluated genotypes may also be explained by the level of phenotypic plasticity, particularly in landrace materials, which have coevolved with traditional agricultural practices and heterogeneous environments. This enables them to maintain stability in yield-associated variables, even when they differ in morphological ear traits. Several studies have indicated that, in native maize populations, coadaptation to local factors such as altitude, light intensity, soil type, and moisture availability promotes a physiological balance that is reflected in kernel filling and in the expression of quantitative traits, despite the existence of evident genetic contrasts among materials (Wellhausen *et al.*,

Table 2. Ear characteristics of maize genotypes cultivated in the municipality of San Luis Acatlán, Guerrero, Mexico.

RV	Genotypes									
	H-515	**H-516**	**H-562**	**H-563**	**H-565**	**H-568**	**H-377**	**VS-Tux**	**Ocotito**	**Azul**
EL (cm)	16.5±2.3ab*	14.6±1.1b	13.8±2.4b	16.2±2.3ab	16.0±0.8ab	15.1±1.4ab	17.4±1.9ab	18.7±1.4a	15.0±1.8ab	18.6±1.6a
ED (cm)	4.7±0.3abc	4.7±0.2ab	5.1±0.4a	4.4±0.2bcd	4.4±0.2bcd	4.6±0.2abcd	4.7±0.5ab	4.0±0.2d	4.7±0.2ab	4.1±0.1cd
RE	15.2±1.64ab	15.2±1.8ab	15.2±1.3ab	16.4±1.7a	16.8±1.a	14.4±2.2abc	14.8±1.1abc	12.8±1.1bc	15.6±0.9ab	12.0±0.7c
KR	33.7±4.24a	31.2±3.3a	32.2±5.1a	36.1±3.7a	38.2±3.1a	38.8±1.6a	37.9±2.7a	39.3±5.2a	35.2±6.7a	38.2±2.5a
EW (g)	177±45.74ab	163±28ab	187±25.2ab	142.6±24.4b	204.4±24.9a	170.6±23.5ab	208.2±27.7a	180.8±6.8ab	172.4±37.3ab	201.2±19.1ab
CD (cm)	2.9±0.4ab	2.9±0.2ab	3.2±0.2a	2.9±0.1ab	3.1±0.1a	2.7±0.2ab	2.9±0.3ab	2.4±0.2b	2.8±0.2ab	2.8±0.3ab
KW (g)	150.0±26.8a	138.4±25a	118.4±66.8a	131.2±43.8a	175.6±19.9a	146.3±19.8a	174.7±20.4a	150.2±15.4a	146.0±34.7a	186.7±25.9a
CW (g)	39.1±6.4a	24.8±3.9b	26.4±3.9b	27.2±10.5ab	29.2±5.5ab	23.5±4.4b	33.8±8.2ab	24.1±0.9b	26.6±5.2b	26.4±4.1b
KD (cm)	1.8±0.4ab	1.8±0.2ab	1.9±0.2a	1.6±0.2ab	1.3±0.2b	1.9±0.2ab	1.8±0.4ab	1.6±0.1ab	1.9±0.3a	1.3±0.3b
EDLI	0.28±0.02bcd	0.32±0.02ab	0.38±0.09a	0.28±0.04bcd	0.27±0.01bcd	0.30±0.03abc	0.3±0.05bcd	0.22±0.02d	0.3±0.03ab	0.2±0.03cd
REDI	3.3±0.3abc	3.2±0.3abc	2.9±0.3c	3.7±0.3ab	3.9±0.4a	3.1±0.4bc	3.1±0.3bc	3.2±0.3bc	3.3±0.29abc	2.9±0.1c
TKW (g)	295±4.8c	278±9.9c	319±8.2b	201.9±8.5d	280.7±19.2c	276.0±8.6c	329.5±8.2b	331.4±14.9b	283.7±2.6c	376.9±6.0a

(± standard deviation of the mean). *Different letters within rows indicate statistically significant differences according to Tukey's test ($p \leq 0.05$). RV: response variable; EL: ear length; ED: ear diameter; RE: rows per ear; KR: kernels per row; EW: ear weight; CD: cob diameter; KW: kernel weight; CW: cob weight; KD: kernel depth; EDLI: ear diameter-to-length index; REDI: row-to-ear diameter index; TKW: thousand-kernel weight; CV: coefficient of variation.

1951; Pressoir & Berthaud, 2004). This may explain why, in the present study, genotypes with greater ear length or diameter did not differ significantly in weight-related variables, thereby revealing a compensatory mechanism associated with the flow of photoassimilates toward the kernel.

Likewise, the results demonstrate that some landrace materials possess agronomic potential comparable to that of hybrids, not only because of their stability in key variables, but also because of the ear architecture observed. This behavior is consistent with recent reports highlighting the value of native maize as a strategic resource for genetic improvement schemes, particularly because of its adaptive capacity under biotic and abiotic stress, as well as its quality attributes and productive resilience (Ávila *et al.*, 2019; Arteaga *et al.*, 2021). In this regard, the similarity in kernel weight among genotypes in the present study, despite marked morphological differences, reinforces the relevance of landraces as a productive alternative in regions where hybrids do not always maximize their potential because of climatic or management conditions.

Physical grain quality

Table 3 presents the results obtained for kernel anatomy (Figure 1), in which statistically significant differences ($p<0.05$) were observed in the pedicel, germ, and endosperm, but not in the pericarp. The latter constitutes the grain's first line of defense against the external environment, and its hardness is one of the principal criteria used to define its suitability for the food industry (Wolf *et al.*, 1952).

It was observed that H-568 (6.51%) and Ocotito (6.47%) exhibited the highest proportion of pedicel. This structure functions as the site of kernel attachment to the cob and is responsible for nutrient supply during kernel development; moreover, during nixtamalization, the pedicel, together with the pericarp, contributes to the formation of natural gums that confer an optimal texture to tortillas (Wolf *et al.*, 1952). Regarding the germ, differences among genotypes were minimal, with H-377 standing out at 22.5%. The germ represents the living part of the kernel and serves as the principal reserve

Table 3. Percentage of the main structures that make up the corn kernel of the evaluated genotypes.

Genotype	Pedicel (%)	Pericarp (%)	Germ (%)	Endosperm (%)
H-515	3.84 ± 0.64^{c}*	5.34 ± 1.22^{a}	13.49 ± 1.70^{bc}	77.33 ± 1.63^{ab}
H-516	5.12 ± 1.07^{b}	5.27 ± 0.25^{a}	11.54 ± 0.80^{c}	78.07 ± 1.15^{a}
H-562	3.89 ± 0.32^{c}	4.61 ± 0.31^{a}	13.70 ± 2.74^{bc}	77.81 ± 2.73^{a}
H-563	4.05 ± 0.68^{c}	5.29 ± 0.76^{a}	18.77 ± 0.77^{a}	71.89 ± 1.28^{bc}
H-565	3.36±0.26d	5.43 ± 0.20^{a}	19.50 ± 0.68^{a}	71.72 ± 0.95^{c}
H-568	6.51 ± 1.45^{a}	4.94 ± 0.96^{a}	18.10 ± 2.71^{ab}	70.45 ± 3.07^{cd}
H-377	2.64±0.56d	4.40 ± 0.55^{a}	22.50 ± 1.67^{a}	70.46 ± 1.88^{cd}
VS-Tuxpeño	4.99 ± 0.48^{b}	5.16 ± 0.34^{a}	19.79 ± 1.17^{a}	70.06 ± 1.35^{cd}
Ocotito	6.47 ± 0.68^{a}	5.95 ± 0.69^{a}	22.46 ± 0.92^{a}	65.11 ± 2.09^{d}
Azul	4.52 ± 0.11^{c}	4.57 ± 0.11^{a}	20.60 ± 1.43^{a}	70.31 ± 1.62^{cd}

±: standard deviation from the mean. *Different letters in the same column are statistically different (Tukey, $p\leq0.05$). CV: Coefficient of variation.

of lipids, containing approximately 78% of the mineral content, with phosphorus as a key nutrient for initiating seedling emergence mechanisms (Agama-Acevedo *et al.*, 2013; Serna-Saldívar, 2019).

Regarding the endosperm, H-516 (78.07%) and H-562 (77.81%) exhibited the highest proportions (Table 3). The endosperm constitutes the principal source of carbohydrates and is subdivided into two types: 1) horny or vitreous, characterized by a higher amylopectin content and lower moisture, primarily destined for the flour industry (Luna Mena *et al.*, 2012); and 2) floury, characterized by a higher amylose content and greater moisture, and used in the production of masa and tortillas (Salinas-Moreno & Aguilar-Modesto, 2010).

Salinas-Moreno *et al.* (2013) reported, in hybrid maize produced in Oaxaca, values of 0.7-2.0, 0.63-5.4, 1.25-13.1, and 79.5-97.42% for pedicel, pericarp, germ, and endosperm, respectively. Corona-Terán *et al.* (2017) reported pedicel values ranging from 2.92 to 5.16%, germ values from 6.4 to 9.59%, pericarp values from 4.32 to 6.78%, and endosperm values from 78.47 to 86.36%. Rivera-Castro *et al.* (2020) reported, in kernels of native maize from the Costa Chica region of Guerrero, pericarp and endosperm values of 4.35-6.20 and 79.65–84.25%, respectively. The differences with the present study may be attributed to cultivation conditions, varietal background, and the type of irrigation used, as noted by Gaytán-Martínez et al. (2013).

Vázquez-Carrillo *et al.* (2010) indicated that a kernel of good nixtamalization quality should exhibit a pedicel proportion of less than 2% and a high pericarp proportion ($p \geq 5\%$), since the latter is responsible for generating the gel that confers texture to the tortilla. Rivera-Castro *et al.* (2020) demonstrated that there is a proportional relationship between germ size and fat content; that is, a higher germ percentage implies a greater lipid content. The results of the present study meet two desirable characteristics for the masa and tortilla industry: 1) a pericarp proportion greater than 3.2%, and 2) a germ proportion higher than 10.75%. These traits ensure that tortillas produced from these maize types will exhibit good texture and a high fatty acid content.

Table 4 shows significant differences ($p < 0.05$) in all evaluated variables. Azul and H-568 exhibited the highest values for length (12.84 and 12.66 mm, respectively) and width (9.29 and 9.54 mm, respectively), whereas H-563 showed the lowest values (length, 10.91

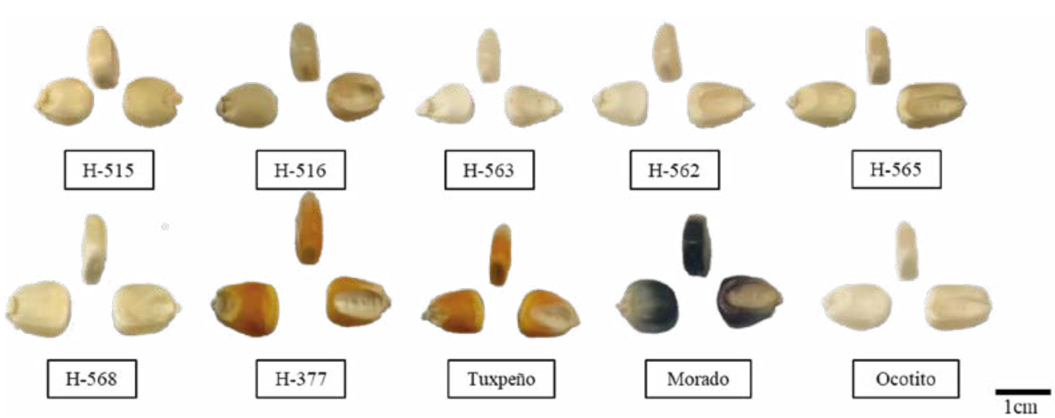

Figure 1. Morphology of the maize grain of the genotypes cultivated in the locality of San Luis Acatlán, Guerrero, Mexico.

Table 4. Physical characteristics of the grain of the evaluated maize genotypes that are grown in the municipality of San Luis Acatlán, Guerrero.

Genotype	Pedicel (%)	Pericarp (%)	Germ (%)	Endosperm (%)
H-515	3.84 ± 0.64^{bc}*	5.34 ± 1.22^{a}	13.49 ± 1.70^{bc}	77.33 ± 1.63^{ab}
H-516	5.12 ± 1.07^{ab}	5.27 ± 0.25^{a}	11.54 ± 0.80^{c}	78.07 ± 1.15^{a}
H-562	3.89 ± 0.32^{bc}	4.61 ± 0.31^{a}	13.70 ± 2.74^{bc}	77.81 ± 2.73^{a}
H-563	4.05 ± 0.68^{bc}	5.29 ± 0.76^{a}	18.77 ± 0.77^{a}	71.89 ± 1.28^{bc}
H-565	3.36 ± 0.26^{bc}	5.43 ± 0.20^{a}	19.50 ± 0.68^{a}	71.72 ± 0.95^{c}
H-568	6.51 ± 1.45^{a}	4.94 ± 0.96^{a}	18.10 ± 2.71^{ab}	70.45 ± 3.07^{cd}
H-377	2.64 ± 0.56^{bc}	4.40 ± 0.55^{a}	22.50 ± 1.67^{a}	70.46 ± 1.88^{cd}
VS-Tuxpeño	4.99 ± 0.48^{ab}	5.16 ± 0.34^{a}	19.79 ± 1.17^{a}	70.06 ± 1.35^{cd}
Ocotito	6.47 ± 0.68^{a}	5.95 ± 0.69^{a}	22.46 ± 0.92^{a}	65.11 ± 2.09^{d}
Azul	4.52 ± 0.11^{abc}	4.57 ± 0.11^{a}	20.60 ± 1.43^{a}	70.31 ± 1.62^{cd}

(± standard deviation from the mean). *Different letters in the same column are statistically different (Tukey, $p \leq 0.05$). C. V. coefficient of variation.

mm; width, 7.99 mm). Regarding thickness, VS-Tuxpeño presented the highest value (4.69 mm), whereas H-562 exhibited the lowest width-to-length index (WLI, 0.71); moreover, VS-Tuxpeño and H-515 showed the highest width-to-length relationship for this trait.

Figueroa Cárdenas *et al.* (2013) reported, in native maize, values ranging from 9.0 to 14.5 mm for length and from 6.2 to 10.9 mm for width, with an average thickness of 4.5 to 5.5 mm. Vázquez-Carrillo *et al.* (2010) reported densities of 29.3 to 35.5, whereas Ramírez Reynoso *et al.* (2020) reported a WLI close to 1, indicating rounder kernels. In the present study, the evaluated kernels were more elongated and flatter. The relationship between kernel depth and kernel length is consistent with that reported by Ramírez Reynoso *et al.* (2020) and Rivera-Castro *et al.* (2020). Wolf *et al.* (1952) emphasized that kernel dimensions are decisive in commercialization, with the sale by volume being more advantageous for larger kernels.

The results obtained reveal considerable variability in the anatomical composition of maize kernels, suggesting genetic adaptation to specific environmental conditions. This variability is consistent with the findings of Zepeda-Bautista *et al.* (2009), who reported significant differences in kernel structure between hybrids and landrace varieties, attributable to genotype-by-environment interaction. Landrace varieties, such as Ocotito, exhibited a higher proportion of pedicel and germ, which could indicate adaptation to local conditions that favor the preservation of essential nutrients during kernel development.

The anatomical composition of the kernel has direct implications for the food industry. According to Pérez de la Cerda (2007), the proportion of vitreous endosperm is related to the physiological quality of the seed, affecting germination and vigor. In the present study, hybrids with a higher proportion of endosperm, such as H-516 and H-562, may be preferred for flour production, whereas varieties with higher germ and pedicel content, such as Ocotito, may be more suitable for masa and tortilla production because of their textural characteristics and nutritional content.

When the present results are compared with previous studies, the proportions of pedicel, germ, and endosperm are similar to those reported by Salinas-Moreno *et al.* (2013) in hybrid maize from Oaxaca. However, the pericarp proportions observed in this study are lower than those reported by Rivera-Castro *et al.* (2020) in native maize from the Costa Chica region of Guerrero, which may indicate differences in agricultural practices and environmental conditions among regions.

Kernel quality also has implications for food security. Nixtamalization improves the bioavailability of essential nutrients such as phosphorus and calcium, while simultaneously reducing phytic acid, thereby enhancing mineral absorption. Varieties with a higher proportion of germ, such as Ocotito, may therefore be preferred for tortilla dough production, as they provide additional nutritional benefits that contribute to a more balanced diet.

Taken together, the results show that the evaluated genotypes possess anatomical characteristics that make them suitable both for the masa and tortilla industry and for specific food applications, thereby underscoring the importance of conserving the genetic diversity of native maize from Guerrero, which offers adaptive and productive advantages under diverse agroecological conditions.

CONCLUSIONS

Hybrids H-565 and VS-Tuxpeño stood out in most ear and kernel components, making them suitable for commercial production, whereas the Azul variety exhibited comparable performance, with the added value of its natural pigmentation. H-562 and Ocotito showed a higher proportion of endosperm and germ, respectively, indicating their potential for the masa and tortilla industry. Overall, the results reveal significant differences among genotypes and make it possible to select hybrids or landraces according to grain use, thereby fulfilling the objective of characterizing their physical quality in San Luis Acatlán, Guerrero.

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