

# Creole corns from the Yucatan Peninsula as an alternative in the diet of the Mexican hairless pig

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## ABSTRACT

**Objective:** The Mexican hairless pig (*Sus scrofa*) is a species with high degree of rusticity and environmental adaptation, capable of being included in genetic improvement programs and participant in food sovereignty. As a monogastric animal, its diet is diverse, which could include grains and fodders. However, there are few records about current alternatives used in its diet that are capable of improving the yields and quality of the meat. In the Yucatan Peninsula there are native corns with fodder potential, capable of being used in animal feed. The objective of this review was to show the potential of native corns, and their capacity to be used in the diet of the Mexican hairless pig.

**Design/Methodology/Approximation:** A systematic review of the literature from the period 2000 to 2020 was carried out, where the potential of Creole corns to be used in animal feed was documented, both because of their yields in grain and their plant biomass production.

**Results:** Based on the information analyzed, the use of San Pableño, Dzit bacal, and Nal Tel breeds is recommended, for their inclusion in the diet of the Mexican hairless pig due to their nutritional, mineral and antioxidant value.

**Study Limitations/Implications:** There are studies pending to allow understanding the form and quantity to supply them in the diet.

**Findings/Conclusions:** Creole corns that are present in the Yucatan Peninsula present high rusticity and agroclimatic adaptation, with productive potential to compete with the commercial varieties and hybrids, in the production of corn grain and fodder, reason why they can be used in the diet of the Mexican hairless pig, since it is an animal species of great adaptation.

**Keywords:** nutrition of *Sus scrofa*, corn breeds and varieties, corn ensilage, Ibero-American pigs, nutritional content of Creole corn.

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## INTRODUCTION

Mexico is considered to be the center of origin of corn, due to the existence of a broad diversity of native breeds and varieties (Massieu-Trigo and Lechuga-Montenegro, 2002). These have propagated to other countries of Latin America, such as Guatemala, Colombia, Peru and Brazil (Alemán-Pérez *et al.*, 2020).



In Mexico, Creole corns occupy the first place in agriculture (Hortelano-Santa Rosa *et al.*, 2012), since they represent close to 75% of national corn production (Tadeo-Robledo *et al.*, 2015) and there is the presence of more than 61 endemic breeds (Arias *et al.*, 2007). This is despite the existence of commercial hybrids produced by government institutions and by large international companies (Monsanto, Pioneer, Syngenta), which lead the global seed market (Tadeo-Robledo *et al.*, 2015). The productive potential of corn breeds is due to its capacity for environmental adaptation, which has allowed the development of the diversity of species present in Mexico, which have guaranteed the supply of foods among the vulnerable population (Hortelano-Santa Rosa *et al.*, 2012), and can be used in animal nutrition, through the inclusion of these in the diet of monogastric animals.

The Mexican hairless pig is a species with great potential to be included in food security projects. This is due to its characteristics of environmental adaptability, in addition to high rusticity and productive capacity, added to the quality of its meat. Likewise, since it is a monogastric species, it presents great tolerance to diets rich in fiber, such as fodders, which can represent an option in animal nutrition (Ramos-Canché *et al.* 2020).

In the Yucatan Peninsula, there are genetic materials of high yield in production of grain and fodder, which have not been used in their totality in areas such as the agriculture and livestock sector (Villalobos-González *et al.*, 2019) as in the case of animal nutrition. The objective of this article is to present an updated review on the fodder potential of native corns and their inclusion in the diet of the Mexican hairless pig (*Sus scrofa*), to provide knowledge that can help to improve the sustainable production and the genetic conservation of both species.

## MATERIALS AND METHODS

A systematic review of national and international articles and publications was conducted, about the corn breeds and varieties present in the Yucatan Peninsula and their potential in fodder production, as well as their capacity to be used in the diet of the Mexican hairless pig.

**Sources used.** The search for information was performed through the indexed databases: Google Scholar, Scielo, Dialnet and Redalyc. Only articles from indexed journals were considered as sources of information, considering mainly primary sources.

**Strategies for the search.** The consultation of information was conducted with the words “razas de maíz” + “forraje” + “Península de Yucatán”, “razas de maíz” + “caracterización” + “Península de Yucatán”, “maíces nativos” + “potencial forrajero”, “ensilaje de maíz” + “ganancia de peso” + “en cerdos”, “características” + “cerdo pelón mexicano” + “investigación” (“corn breeds” + “fodder” + “Yucatan Peninsula”, “corn breeds” + “characterization” + “Yucatan Peninsula”, “native corns” + “fodder potential”, “corn ensilage” + “weight gain” + “in pigs”, “characteristics” + “Mexican hairless pig” + “research”). A range of 20 years (2000-2020) was considered in the publications, and titles in Spanish and English were taken into consideration, published within this range of years in the search engines.

**Criteria of inclusion and exclusion.** Only scientific articles were considered, while reviews, theses and gray literature were excluded.

**Extraction of the data and data analysis.** The literature review resulted in a total of 219 publications related to corn breeds, corn varieties and use of fodder in pigs in Mexico, in the Yucatan Peninsula and outside the country. The abstracts and complete documents were taken into consideration to select the information, and a total of 58 scientific articles were obtained, which were considered in this review. Results of the documental review were organized into sub-themes to ease their analysis and discussion.

### **Corn breeds and varieties present in the Yucatan Peninsula**

In the Yucatan Peninsula, among the principal corn breeds that have been recorded and which are still conserved until today, the following stand out: Naál Xóy, Xnúc Naál Blanco, Gallito Amarillo, Dzit Bacal, Mejeén Naál, Rosa San Juan, Cháck-Chóp, Teél Cháck, Sáck Teél, San Pableño, Ejú-Criollo Morado, Xmején Naál Tsitbacal and Clavo Chia-paneco (Villalobos-González *et al.*, 2019). Likewise, the following breeds and varieties are recognized: San Pableño amarillo, blanco, rojo, Nal Xoy amarillo, Nal Xoy blanco, palomero amarillo, tablancillo, Nal Tel (Sak Nal Tel, Kan Nal Tel, Chac Nal Tel), X'mején Naal (Sak X'mején naal, K'an X'mején naal, Chac X'mején naal), pix cristo, Sak tux (González-Valdivia *et al.*, 2016). The breeds Nal t'eel, Xmejen naal, T'sít bakal and Xnuuk naal are the most representative and with highest presence in the states that make up the Yucatan Peninsula (Cázares-Sánchez *et al.*, 2015). In this sense, Villalobos-González *et al.* (2019) evaluated local varieties present in the Yucatan Peninsula, highlighting the breeds Naál Xóy and Dzit Bacal as the ones with the highest grain yield, of 4,751 and 4,417 kg. Likewise, studies performed by Ku-Pech *et al.* (2020) mention the persistence in the use of the breeds Nal Xoy, Xnuk Nal which is due to their characteristics of resistance and rusticity, and the use of the breed Nal Tel because of its precociousness, together with Dzit Bacal, because of its high yields.

### **Fodder potential of native corns**

Sánchez-Hernández *et al.* (2011), when comparing the fodder potential of corn genotypes with different sowing densities (50,000; 62,500 and 83,333 plants ha<sup>-1</sup>), showed the superiority of Creole corns with a yield of 57 t ha<sup>-1</sup> of green matter at a density of 83,333 plants, in comparison with the hybrid H-520 which contributed 36.4 t ha<sup>-1</sup> of fodder and the control variety VS-536 with a yield of 36 t ha<sup>-1</sup>, both managed at 62,500 plants ha<sup>-1</sup>. These results highlight the importance of understanding the fodder potential of the Creole materials that are useful in the agriculture and livestock sector.

Similar results were found by Godina-Rodríguez *et al.* (2020) who, when evaluating the fodder potential of native corns of the central zone of Mexico, found a great potential for the production of total dry matter of genotypes such as Ratón Tuxpeño Norteño, with means of 8.8 ton ha<sup>-1</sup>; these values are higher than those found with commercial hybrids such as A6-069-B with means of 3.1 ton ha<sup>-1</sup>, showing the importance of the improvement and rescue of corn genetic materials for fodder production.

For their part, Villalobos-González *et al.* (2019) evaluated 13 native corn accessions from the Yucatan Peninsula, pointing to the breeds Ejú-criollo Morado, San Pableño and Xmején Naál Tsitbacal, with the best means of plant height (370, 340 and 337 cm,

respectively), and regarding grain yields, Naál Xóy, Dzit bacal and San Pableño (4751, 4417 and 4017 kg ha<sup>-1</sup>, respectively). This allows concluding that there was high genetic variability, which could serve in terms of the rescue and improvement of native breeds with productive purposes.

A distinctive characteristic of native breeds is their adaptation and great rusticity to agroecological conditions, which ensures production compared to commercial hybrids, which totally depend on the agronomic management that is characteristic of technological packages. In this regard, Conceição-dos Santos *et al.* (2019) mention the breeds Dzit bacal, with an efficient use of water and climatic adaptation, as well as the breed Xmejen nal, due to its precociousness, with potential to be used in the Yucatan Peninsula in fodder and grain production, respectively.

### **Nutritional content of native corns from the Yucatan Peninsula**

Studies performed in native corns to know the variation in the composition of the grain have shown to have a high nutritional content in the native precocious breeds, such as Nal t'eel and Xmejen nal, which have presented high concentrations of protein (10.80-11.9% and 10.2-11.9%) and triptophan (0.00080-0.12% and 0.094-0.129%). Meanwhile, the breeds of type T'siit bakal and Xnuuk nal present higher lysine concentration (2.97 g) and lower protein concentration (10.54 and 10.62%). The average of fiber ranged between 1.13 and 1.57%, with Nal t'eel occupying the first place. This variation in the chemical composition of native corn populations is a determining factor for the genetic improvement, and for their inclusion in animal nutrition (Cázares-Sánchez *et al.*, 2015).

For their part, Chí-Sánchez *et al.* (2021) studied the mineral concentration of various native corn varieties present in the Yucatan Peninsula, where the genotypes Xnuuk-nal anaranjado stood out, with ranges of P of 52.66 mg kg<sup>-1</sup>, and concentrations of K of 3693.36 mg kg<sup>-1</sup>, S of 71.99 mg kg<sup>-1</sup>, Mg of 831.91 mg kg<sup>-1</sup> and Na of 1831.94 mg kg<sup>-1</sup>, followed by Xnuuk-nal anaranjado with high concentration of Ca (127.68 mg kg<sup>-1</sup>). Likewise, X'mejen nal anaranjado was outstanding, with a high concentration of Zn (36.8 mg kg<sup>-1</sup>) and Cu (1169.4 mg kg<sup>-1</sup>). Therefore, these native corns can be used in the genetic improvement and in nutritional management programs, both for humans and for animals.

Grain coloring is an important factor in mineral and nutritional content, aspect which is very present in the native corn varieties. The orange grains with high content of carotenoids, flavonoids and anthocyanins stand out, which presently confer antioxidant properties, to be considered in the food industry (Zhirkova *et al.* 2016).

### **Potential use of corn fodder in the diet of the Mexican hairless pig**

In the Yucatan Peninsula, the Mexican hairless pig is bred in three types of production systems (backyard, extensive and intensive), with drove sizes between 9, 56 and 96 animals. The diet in these systems is based primarily on the use of wheat bran, corn and balanced meals, as well as fodder of tree species such as breadnut (*Brosimum alicastrum*). Corn is used in the intensive systems, in proportions of 42% as feed, and 60% as supplement, and the use of fodders occupies percentages of 10 to 70% in pigs' diets (Hernández *et al.*, 2020).

An alternative in their diet can be the inclusion of corn ensilage, with which the fodder potential of the native corn species could be exploited, and the production costs in intensive systems can be reduced (Villalobos-González *et al.*, 2019). The fodder potential of the corn breeds and varieties present in the Yucatan Peninsula provides the possibility of being used in the production of corn ensilage, alternative feed in times of low water levels (Villalobos-González *et al.*, 2019). A distinctive characteristics of the native varieties is that races of short, intermediate and long cycle can be found, so that they can be farmed in different regions and under different climate conditions (González-Valdivia *et al.*, 2016).

It is important to consider that the use of fodders and ensilages in pigs' diets should not exceed 20% of the portion (González *et al.*, 2020). Likewise, studies conducted by Weber *et al.* (2008) to understand the effect of the inclusion of different sources of fiber (dry distillery grains with soluble elements, soy husk or citrus pulp), showed that in proportions of 7.5% they are capable of increasing the content of pro-inflammatory and anti-inflammatory cytokinins of the intestinal tissue.

Studies performed with ensilage of a mixture of yucca roots (*Manihot esculenta* Crantz) and corn residues in Yorkshire × Landrace × CC21 pigs showed acceptability to diets with alternative supplements, although significant differences from the inclusion of ensilage were not manifested, and no animal deaths or digestive type disorders were found (Cabrera and Lezcano, 2012).

The inclusion of corn ensilage in pigs' diets have been successfully used by Kanengoni *et al.* (2015) in native breeds of growing South African Windsnyer pigs and in Large White × Landrace crosses, attaining an acceptability of the corn ensilage in high and low proportions, for both pig breeds, both native and in the crosses, influencing the breeds in acceptability of the feed.

Likewise, Capraro *et al.* (2017) showed that the use of corn ensilage improved the quality of the dorsal fat during the seasoning process, without generating effects in the loss of condiments for ham elaboration. In this sense, Sun *et al.* (2018) mention that there was a decreasing line in the final weight and average weight gain with the use of full-plant corn ensilage in proportions of 20, 30 and 40% in the diet of growing pigs (Duroc × Landrace × Large White), with means of fiber between 3.0 and 4.5%, as well as in the apparent digestibility of the nutrients. However, the daily food intake increased linearly, concluding that the inclusion of full-plant corn ensilage, supplied at between 20 and 30%, can ensure the yield and improve the health of growing pigs.

On the other hand, Lyu *et al.* (2020) reported that the use of corn ensilage in the diet of mestizo pigs Duroc A (Landrace × Northeastern Indigenous) did not cause health problems in the pigs' health, which were able to tolerate high concentrations of it (80% in the inclusion of fodders); and contrary to the common idea, the pigs fed with corn ensilage improved the load capacity of the livestock, without causing violent falls in the yield. In addition, the yields reached in final weights with corn ensilage were close to the conventional management with fodders with a difference of 13.2%.

Corn ensilage can represent an option for the diet of the Mexican hairless pig. However, there are no data from studies carried out in Mexico on the inclusion of corn ensilage in pigs' diets, and particularly of the Mexican hairless pig. Therefore, studies are necessary

which allow understanding the behavior of omnivores, as well as the portion and the adequate way of providing these foods. Likewise, studies are necessary on the nutritional contribution of native corn ensilage, due to the effect of the grain color, stage of cutting, and ensilage process, as well as the quality of the corn ensilage. With this, the production and rescue of native corn species is incentivized, which are at risk of genetic loss.

## CONCLUSIONS

Creole corns present high rusticity and agroclimatic adaptation in the Yucatan Peninsula, and there is also a large diversity of them. The ones that stand out are San Pableño, Dzit bacal, and Nal Tel type breeds, which present productive potential to compete with the commercial varieties and hybrids in maize production for grain and fodder, in addition to having nutritional, mineral and antioxidant value. Therefore, they can be used in the diet of the Mexican hairless pig, since it is an animal species with great adaptation. However, there are still studies pending that would allow understanding the form and amount to supply them in the diet. This translates into scientific research areas for the Yucatan Peninsula, and especially for the state of Campeche.

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