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Article

Characterization of bean seeds from Ñäñho communities of Amealco, Querétaro

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Abstract

Beans are one of the main components of traditional Mexican gastronomy. Mexico is the center of origin, domestication, and diversification of *Phaseolus vulgaris* and *P. coccineus*. These are cultivated in the Ñäñho communities of Amealco, Querétaro, Mexico; however, their characteristics are unknown. The work aimed to determine inter and intraspecific seed diversity based on morphological characteristics and chemical composition. The study was conducted in 2024 at the Faculty of Natural Sciences of the Autonomous University of Querétaro. Twenty-one accessions (eight of *P. coccineus* and 13 of *P. vulgaris*) held in safekeeping at the Germplasm Bank-UAQ, which were collected in 2021 and 2022 in San Miguel Tlaxcaltepec, San Ildefonso and Santiago Mexquititlán, communities of the municipality of Amealco, Querétaro, were analyzed. Four quantitative morphological variables and 11 qualitative variables of each accession's seeds were measured. In addition, chemical analysis was carried out, determining ash, moisture, crude protein, ethereal extract, crude fiber and nitrogen-free extract contents. Statistically significant differences were found in size, weight and protein contents between the two species. Intraspecific diversity was identified in the two species, mainly defined by seed color and size, as well as by percentages of ethereal extract and crude fiber. The Ñäñho communities of Amealco, Querétaro, present inter- and intraspecific diversity in both species, with a higher protein content in *P. vulgaris* than in *P. coccineus*.

Keywords:

P. coccineus, *P. vulgaris*, chemical, morphology.

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Introduction

Beans (*Phaseolus* spp.) are the second most important crop in Mexico and are a relevant source of protein, starch, vitamins and fiber (Aquino-Bolaños *et al*., 2021). The genus *Phaseolus* is native to the Americas and comprises 77 species (López-Báez *et al*., 2018). Of the species recorded in Mexico, five have been domesticated, including *P. vulgaris* L. (common beans) and *P. coccineus* L. (ayocote beans) (Ayala-Garay *et al*., 2021).

P. vulgaris is considered to have been domesticated in Mesoamerica and the Andes (Castillo-Mendoza *et al*., 2006), whereas for *P. coccineus*, Mexico is considered the only center of domestication (Vargas-Vázquez *et al*., 2014). In the state of Querétaro, 12 bean species are found (Quiroz-Sodi *et al*., 2018). In the Ñañho communities of the municipality of Amealco, Querétaro, Hernández-Sandoval *et al*. (2023); Hernández-Puente *et al*. (2025) mention the presence of *P. coccineus* and 18 common names of *P. vulgaris*.

Crop diversity is essential for their adaptation to the effects of climate change and for meeting different human needs (Vargas-Vázquez *et al*., 2014). In studies of populations of *P. vulgaris* and *P. coccineus* in Puebla, State of Mexico, Guerrero and Tlaxcala, based on morphoagronomic characterization, it was possible to identify interspecific and intraspecific diversity (Castillo-Mendoza *et al*., 2006; Vargas-Vázquez *et al*., 2014; Espinosa-Pérez *et al*., 2015). Specifically, seed-related traits enabled the grouping of 75 populations from south-central Mexico (Espinosa-Pérez *et al*., 2015).

Statistically significant differences were recorded between *P. vulgaris* and *P. coccineus* in the chemical composition of seeds, including the contents of proteins, sugars, phenols and secondary metabolites (Quiroz-Sodi *et al*., 2018; Pérez-Herrera *et al*., 2002; Aquino-Bolaños *et al*., 2021).

There is also intraspecific diversity in both species. Fernández-Valenciano and Sánchez-Chávez (2017) found significant differences in the physicochemical properties of improved varieties of *P. vulgaris* in fiber, protein and iron contents. In this same species, Granito *et al*. (2009) noted differences in nutrient content between raw and cooked samples. A study by Teniente-Martínez *et al*. (2006) found differences in the protein content of black (23.8%) and purple (21.9%) *P. coccineus* from the Northern Sierra of the state of Puebla. Nonetheless, purple beans contain higher levels of ash, fat and carbohydrates.

In 2023, bean production was 724 000 t (SIAP, 2024), the lowest reported in the last 30 years. The genetic richness of beans faces serious problems due to changes in consumption habits, industrialization, which affects the countryside and the substitution of food for fast food. The use of monocultures has reduced the use of varieties associated with native corn within the milpa. Given the above, the present study performed a morphological and chemical characterization of native seeds of *P. vulgaris* and *P. coccineus* from the Ñañho communities of Amealco, Querétaro, to identify the inter- and intraspecific diversity that farmers conserve and select.

Materials and methods

Biological material

The morphological characterization and proximate chemical analysis were carried out in 2024 at the Faculty of Natural Sciences of the Autonomous University of Querétaro (UAQ). Seeds held in safekeeping at the Germplasm Bank-UAQ were used. Collections of *P. vulgaris* and *P. coccineus* from three Ñañho indigenous communities, corresponding to San Miguel Tlaxcaltepec, San Ildefonso Tultepec and Santiago Mexquititlán in the municipality of Amealco de Bonfil, Querétaro, Mexico, were selected.

The most recent collections, corresponding to the years 2021 and 2022, were selected. A total of 21 accessions were characterized, of which eight belonged to the species *P. coccineus* (PC) and 13 to *P. vulgaris* (PV). The common names for the PC accessions stated in the passport data were bayocote, frijol grande and burro. In the case of PV, some common names are ojo de cabra for accession PV2, cacahuate for PV7, rojo for PV8, san franciscano for PV10 and PV11 and vaquita for PV13.

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Morphological characterization of seeds

For the morphological analysis, 50 seeds per accession were used. Four quantitative morphological variables were evaluated: weight, thickness, width, and length. Likewise, 11 qualitative variables were characterized, with their different trait states, according to the technical guide for varietal description of beans (*Phaseolus vulgaris* L.) (SNICS, 2017) (Table 1).

Table 1. Qualitative traits of bean seeds.

Qualitative traits	
Shape in the longitudinal section (SLS): 6	Distribution of secondary color (DSECCOL): 3
Shape in the transversal section (STS): 5	Distribution of secondary color (DISTRSECCOL): 3
Number of colors (NCOL): 3	Testa brightness (SEEDTESTA): 3
Main color (MAINCOL): 10	Type of seed venation (VEN): 3
Secondary color (SECCOL): 11	Hilum crown color (HILCOL): 2

The number refers to the states of traits considered in the varietal description technical guide (SNICS, 2017).

Color measurements were taken with a colorimeter (Precise Color Reader, WR-10), which provides value in wavelengths L, a and b. To characterize the shape in the longitudinal and transversal sections, half of the material was used, 200 seeds for *P. coccineus* and 325 for *P. vulgaris*, with 25 seeds per accession. A digital vernier caliper (STAINLESS HARDENED.CAT.CA3930) and an analytical balance (OHAUS Item Pa31) were used for all morphometric measurements.

Proximate chemical analysis

The chemical composition of beans was determined according to the Association of Official Analytical Chemists (AOAC, 2000). The bean samples were ground in an electric mill (IKA Works, Inc. A10 52) and then used for the following analyses.

Ash content (A). Ash is the inorganic part of food left after burning it at high temperatures. The analysis was performed by incinerating the samples in a muffle at 550-600 °C for 6 h. The percentage was calculated as the weight difference between the calcined and initial samples, multiplied by 100.

Moisture content (ME). It allowed the water content to be determined. The samples were placed in the drying oven at 105 °C for 4 h. The moisture percentage was obtained by weight difference, where the weight of the crucible with the dry sample was subtracted from the weight of the sample plus the weight of the crucible, then divided by the total weight of the sample and multiplied by 100.

Crude protein (CP) content. It determines the amount of N present in organic and inorganic samples. The Kjeldahl method was used, which consists of three steps: digestion, distillation and titration (AOAC, 2000). The protein concentration was expressed as a percentage, considering a protein factor of 6.25.

Ethereal extract (EE) content. The total ether-soluble lipid content was specified. A total of 1.5 g of each sample was weighed and placed in the base of the BUCHI fat extractor, where 60-80 ml of petroleum ether was added. The concentration was expressed as a percentage by weight differences.

Crude fiber (CF) content. The contents of cellulose, hemicellulose, and lignin present in the cell walls were determined. For each sample, a filter bag was weighed, 0.5 g was placed in it, the bag was sealed with heat, and then it was placed in a digester. The percentage of fiber was determined by weight difference.

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Nitrogen-free extract (NFE) content. This determination quantifies the content of non-structural carbohydrates. This fraction is calculated by subtracting the sum of the total percentages from 100: 100 - (CP% + CF% + A% + EE% + ME%).

Statistical analysis. To identify the statistical differences between the two species, the U-Mann-Whitney test was applied, as the data did not present a normal distribution. To evaluate intraspecific diversity within each species, multivariate cluster analyses were conducted using the WardD method and Euclidean distance. Non-metric multidimensional scaling (NMDS) ordering analysis was also used to identify the main variables that allow accessions to be grouped. All statistical analyses were performed in R version 4.

Results and discussion

Interspecific diversity of *P. vulgaris* and *P. coccineus* seeds

Statistically significant differences were found between the two bean species across the quantitative and qualitative variables. For the traits of weight, length, thickness and width, *P. coccineus* was statistically larger than *P. vulgaris*. For the color intensity trait, which was determined through wavelengths, no statistically significant differences were found for variable a, while variables L and b showed differences (Table 2).

Table 2. Morphological characterization of *P. vulgaris* and *P. coccineus* seeds.

Species	Statistic	Weight (g)	Length (mm)	Thickness (mm)	Width (mm)	L	a	b
P. vulgaris (n= 650)	Minimum	0.09	3.78	3.12	4.3	10.41	0.4	1.71
	Maximum	0.6	13.14	11.6	9.39	75.42	23.5	31.9
	Average	0.29^{a}	9.88^{a}	5.14^{a}	7.07^{a}	39.2^{a}	9.17^{a}	14.8^{a}
	CV	31	12	19	13	33	95	49
P. coccineus (n= 400)	Minimum	0.25	8.8	1.01	5.6	7.68	0.01	0.53
	Maximum	2	22.6	17.01	17.4	92.71	27.27	38.84
	Average	0.99^{b}	15.62^{b}	8.62^{b}	11.28^{b}	20.02^{b}	10.4^{a}	16.2^{b}
	CV	51	20	37	20	37	71	41

Different letters in the superscript indicate statistically significant differences.

Differences were found in the qualitative characteristics of the seed. For the shape of the longitudinal section (SLS) in both species, five of the six trait states considered by the SNICS (2017) varietal description technical guide were found. In *P. vulgaris*, the predominant shape was circular with 64 seeds (33%), whereas in *P. coccineus*, it was rectangular with 47 seeds (45%).

Similarly, in the shape of the transversal section (STS), the five trait states considered by the technical guide were present in both species. However, there are differences between the two species; the most common shape was the flattened one, with 73 seeds (47%) corresponding to *P. vulgaris*; for *P. coccineus*, the most predominant shape was the circular one, with 38 seeds (40%).

Regarding the number of colors (NCOL), *P. vulgaris* presented greater diversity, with seven colors and *P. coccineus* showed five colors. The testa brightness and venation are higher in *P. coccineus* than in *P. vulgaris*, but for the color of the hilum crown, the same color as in the testa predominates in both (Figures 1a and 1b).

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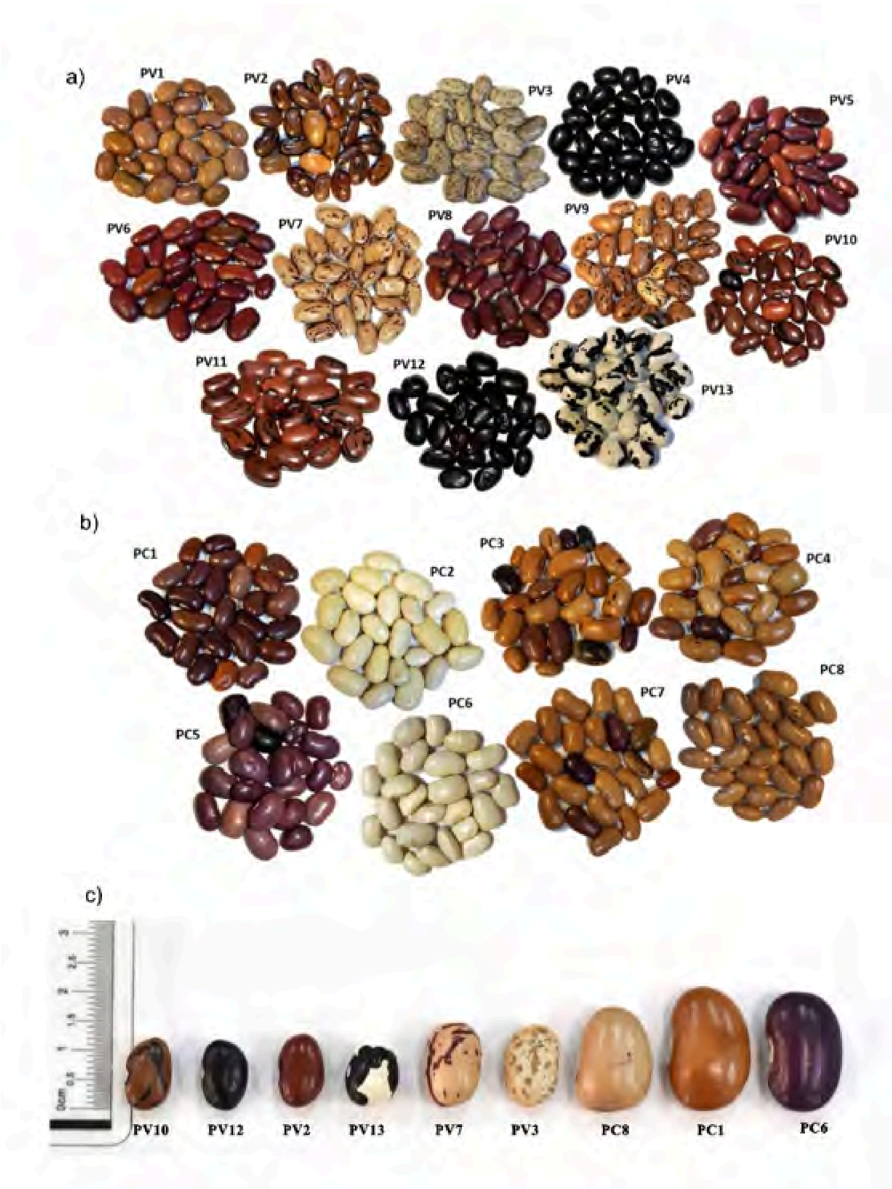
Figure 1. Seed accessions analyzed: a) *P. vulgaris* (PV); b) *P. coccineus* (PC); and c) sizes of different bean seed samples (cm).



A greater diversity of colors was found in *P. vulgaris* than in *P. coccineus*, similar to that reported by Castillo-Mendoza *et al*. (2006) in the study of the morphological diversity of beans in northern Morelos and the east of the State of Mexico; the predominance of certain colors may depend on the region and use.

Intraspecific morphological diversity of *P. vulgaris* and *P. coccineus* seeds

As observed in Table 2, *P. coccineus* has greater intraspecific diversity. In terms of weight, length, thickness, and width, this species has higher CV values than *P. vulgaris*. In weight, *P. coccineus* has a minimum of 0.25 g and a maximum of 2 g (CV: 51%); on the other hand, *P. vulgaris* shows values of 0.09 to 0.6 g (CV: 31%). In length, *P. coccineus* has values of 8.8 to 22.6 mm (CV: 20%), and *P. vulgaris* has values of 3.78 to 13.14 mm (CV: 12%).

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Different morphological characterization studies in *P. vulgaris* and *P. coccineus* showed that some of the main traits that allow the grouping of the different populations are the characteristics related to the color, size, weight, and geographical origin of the seed (Castillo-Mendoza *et al*., 2006; Espinoza-Pérez *et al*., 2015; López-Báez *et al*., 2018). This may be because, during domestication, the main selection criteria are seed size, color and earliness (López-Báez *et al*., 2018).

In the case of the diversity of colors present in both species, it depends on the region and the uses of the seed, whether in traditional gastronomy or in cultivation (Vargas-Vázquez *et al*., 2012). Intraspecific morphological differences may be due to the ranges of adaptation to different environmental conditions and to biological aspects of the species, since *P. vulgaris* is autogamous and has lower CVs than *P. coccineus*, an open-pollinated, allogamous species (López-Báez *et al*., 2018; Ayala-Garay *et al*., 2021).

Diversity of chemical composition between *P. vulgaris* and *P. coccineus*

No statistically significant differences were found in the contents of moisture, ash, ethereal extract, crude fiber and nitrogen-free extract between *P. vulgaris* and *P. coccineus*. Nevertheless, they differed significantly in the percentage of crude protein (Table 3).

Table 3. Chemical composition of *P. vulgaris* and *P. coccineus* seeds.

Species	Statistic	Moisture (%)	Ash (%)	Crude protein (%)	EE (fat) (%)	Crude fiber (%)	NFE (%)
P. vulgaris (n= 13)	Minimum	7.96	3.73	15.26	0.67	0.49	59.23
	Maximum	9.42	4.92	22.37	2.78	7.86	66.41
	Average	8.58^{a}	4.29^{a}	18.41^{a}	1.66^{a}	4.34^{a}	62.71^{a}
	CV	4	7	10	28	28	1
P. coccineus (n= 8)	Minimum	7.78	3.58	13.85	0.31	3.03	60.69
	Maximum	8.653	5.03	19.61	2.12	9.48	67.89
	Average	8.21^{a}	4.35^{a}	16.82^{b}	1.33^{a}	4.96^{a}	64.1^{a}
	CV	4	10	10	43	28	1

EE= ethereal extract; NFE= nitrogen-free extract. Different superscript letters indicate statistically significant differences.

Intraspecific chemical diversity in *P. vulgaris* and *P. coccineus*

As shown in Table 3, the percentages of moisture, ash, crude protein and nitrogen-free extract have CVs equal to or less than 10 in both species. Therefore, the contents are similar across the different accessions, as indicated by the minimum and maximum values obtained.

On the contrary, in the percentages of ethereal extract and crude fiber, CVs range from 28% to 43%, so there is intraspecific diversity in both species. In the case of *P. vulgaris*, accession PV9 had the lowest ethereal extract content at 0.67%, and accession PV11 (san franciscano) had the highest at 2.78%.

In the case of *P. coccineus*, the accession with the lowest value was PC2 (white bayocote) at 0.31%, and the highest was PC6 (purple bayocote) at 2.12% (Figures 2a and 2c).

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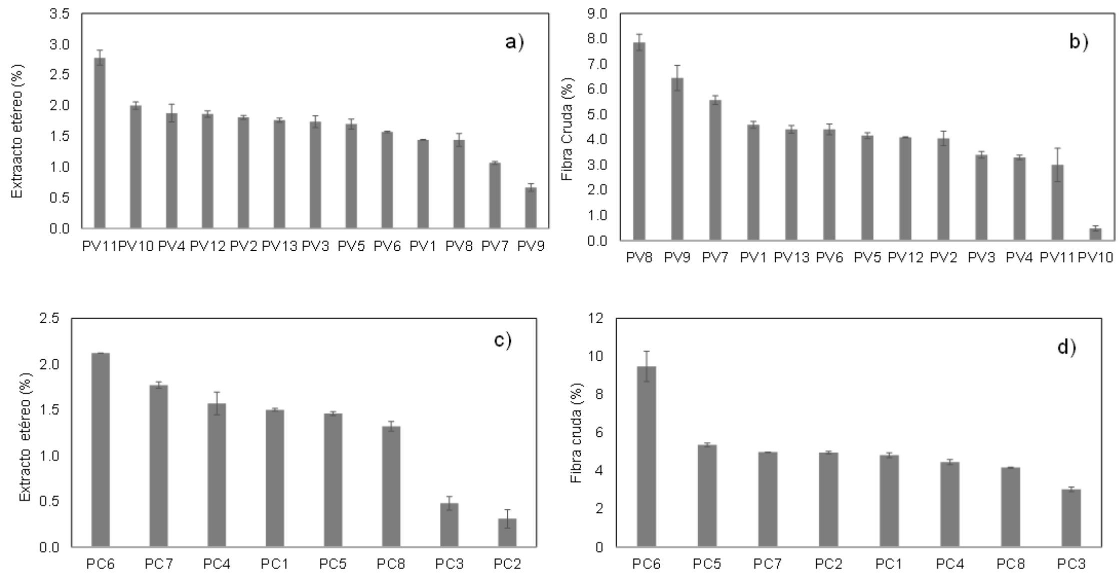
Figure 2. Percentages of ethereal extract and fiber in bean seeds: a and b) *P. vulgaris* (PV); c and d) *P. coccineus* (PC).



In the percentage of crude fiber, the *P. vulgaris* accession with the lowest value was PV10 (san franciscano), at 0.49%, which was statistically different from the content of accession PV8, which had the highest value, 7.86%. In *P. coccineus*, the accession with the lowest percentage was PC3 (3.03%), and the highest was PC6 (purple bayocote) (9.48%), with statistically significant differences (Figures 2b and 2d).

Aquino-Bolaños *et al*. (2021) and Pérez-Herrera *et al*. (2002) also indicate a higher percentage of crude protein content in *P. vulgaris* than in *P. coccineus*. Regarding the content of ethereal extract, Granito *et al*. (2009); Teniente-Martínez *et al*. (2006); Pliego *et al*. (2013) mention that it can range from 1.2 to 3.78% in *P. vulgaris* and *P. coccineus*.

On the other hand, in six improved varieties of *P. vulgaris*, the percentages of crude fiber can be between 5.55 and 11.35% (Fernández-Valenciano and Sánchez-Chávez, 2017). These wide intervals may be due to aspects of farmer selection and management, as well as to the availability of nutrients in the planting areas, as it affects the concentration of some of these compounds (Granito *et al*., 2009).

Interspecific morphological and chemical diversity between *P. vulgaris* and *P. coccineus*

Considering quantitative morphological variables and chemical composition results, the cluster analysis of similarity between the two species yields two groups. However, the two species did not separate. Group one is made up of accessions PC6 and PC2 of *P. coccineus* and accession PV3 of *P. vulgaris*.

Group two has two subgroups, one with four accessions of *P. vulgaris* and four of *P. coccineus*, and the other with eight accessions of the first species and two of the second species (Figure 3). This is because there are morphological differences, but in chemical composition, they are similar. According to the NMDS analysis (stress: 0.09), the variables that allow the grouping of accessions are seed size, seed thickness and seed color.

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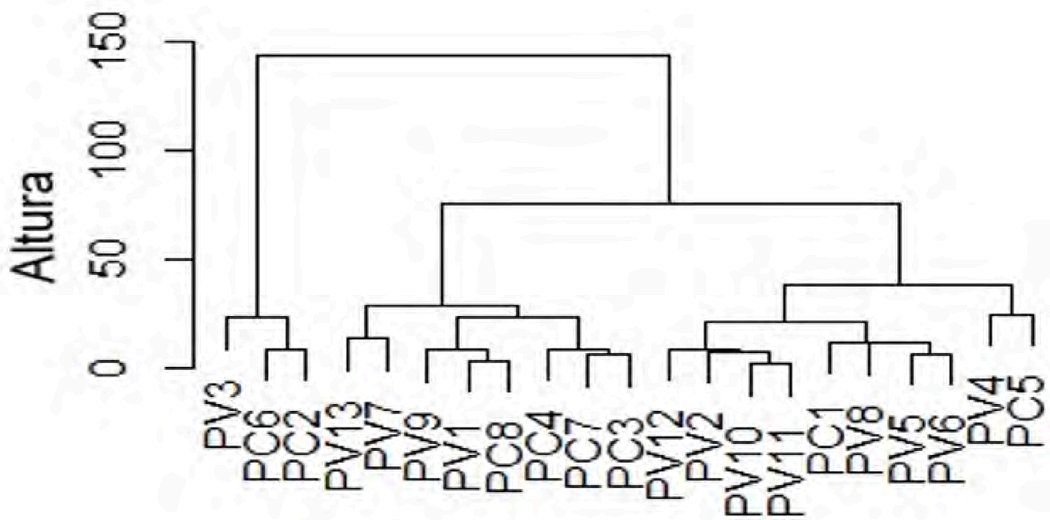
Figure 3. Cluster analysis of *P. vulgaris* and *P. coccineus*.



This intraspecific diversity coincides with studies by Hernández-Sandoval *et al*. (2023); Hernández-Puente *et al*. (2025), who report the presence of different traditional varieties in the study communities. Espinoza-Pérez *et al*. (2015), also based on morphological characterization of the seed, grouped 75 populations of *P. vulgaris* from south-central Mexico into 13 classes.

For this same species, Vargas-Vázquez *et al*. (2012) grouped 200 populations from the INIFAP core collection into five classes. Vargas-Vázquez *et al*. (2014), in the morphoagronomic characterization of *P. coccineus*, grouped the populations into four classes based on their geographical origin, earliness, and seed size.

Conclusions

Inter- and intraspecific diversity was found between *P. vulgaris* and *P. coccineus* from the three Ñañho communities of Amealco, Querétaro. The main traits that grouped the collections were seed color, size and weight, ethereal extract and crude fiber.

A higher protein percentage content and greater intraspecific diversity for *P. vulgaris* stand out. The morphological traits and chemical composition of the seeds allowed us to differentiate groups within both *P. vulgaris* and *P. coccineus*, but without forming different groups between the two.

These materials can be a source of genes for genetic improvement programs to generate highly nutritious varieties.

Bibliography

1 AOAC. Association of Official Analytical Chemist. 2000. Official Methods of Analysis (17th). Ed. AOAC International. Guithersbur, MD, EE. UU.

2 Aquino-Bolaños, E.; Garzón-García, A. K.; Alba-Jiménez, J. E.; Chávez-Servia, J. L.; Vera-Guzmán, A. M.; Carrillo-Rodríguez, J. C. and Santos-Basurto, M. A. 2021. Physicochemical characterization and functional potential of *Phaseolus vulgaris* L. and *Phaseolus coccineus* L. landrace green beans. Agronomy. 11(4):803. Doi: 10.3390/agronomy11040803.

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3 Ayala-Garay, A. V.; García-Lemus, D. E. y Acosta-Gallegos, J. A. 2021. Origen y domesticación del género *Phaseolus*. In: Ayala-Garay, A.; Acosta-Gallegos, J. A. y Reyes-Muro, L. (Eds.). El cultivo del frijol presente y futuro para México. INIFAP, México. 15-27 pp.

4 Castillo-Mendoza, G.; Ramírez-Vallejo, P.; Castillo-González, F. y Miranda-Colín, S. 2006. Diversidad morfológica de poblaciones nativas de frijol común y frijol ayocote del oriente del Estado de México. Revista Fitotecnia Mexicana. 29 (2):111-119.

5 Espinosa-Pérez, E. E.; Ramírez-Vallejo, P.; Crosby-Galván, M.; Estrada-Gómez, J. A.; Lucas-Florentino, B. y Chávez-Servía, J. L. 2015. Clasificación de poblaciones nativas de frijol común del centro-sur de México por morfología de semilla. Revista Fitotecnia Mexicana. 29(1):29-38.

6 Fernández-Valenciano, A. M. y Sánchez-Chávez, E. 2017. Estudio de las propiedades fisicoquímicas y calidad nutricional en distintas variedades de frijol consumidas en México. Nova Scientia. 9(18):133-148: Doi https://doi.org/10.21640/ns.v9i18.763.

7 Granito, M.; Guinand, J.; Pérez, D. y Pérez, S. 2009. Valor nutricional y propiedades funcionales de *Phaseolus vulgaris* procesada: un ingrediente potencial para alimentos. Interciencia 34(1):064-070.

8 Hernández-Puente, K. N.; Hernández-Sandoval, L.; González-Santos, R.; Casas, A.; Martínez, M. and Steimann, V. W. 2025. Diversity management and uses of edible plants in a Ñañho community of Southern Querétaro, México. Journal of Ethnobiology and Ethnomedicine 21(1):18. Doi: https://pmc.ncbi.nlm.nih.gov/articles/PMC11899470/.

9 Hernández-Sandoval, L.; González-Santos, R.; Hernández-Puente, K. N. 2023. Catálogo de semilla nativa y naturalizada de tres comunidades indígenas de Amealco, Querétaro. Universidad Autónoma de Querétaro (UAQ). Ciudad de México. 75 p.

10 López-Báez, L. I.; Taboada-Gaytán, O. R.; Gil-Muñoz, A.; López, P. A.; Ortiz-Torres, E.; Vargas-Vázquez, M. L. P. y Díaz-Cervantes, R. 2018. Diversidad morfoagronómica del frijol en altiplano centro-oriente de Puebla. Revista Fitotecnia Mexicana. 41(4-A):487-497.

11 Pérez-Herrera, P.; Esquivel-Esquivel, G.; Rosales-Serna, R.; Acosta-Gallegos, J. A. 2002. Caracterización física, culinaria y nutricional de frijol del altiplano subhúmedo de México. Archivos Latinoamericanos de Nutrición. 52(2):172-180.

12 Pliego L.; López J.; Aragón E. 2013. Características físicas, nutricionales y capacidad germinativa de frijol criollo bajo estrés hídrico. Revista Mexicana de Ciencias Agrícolas. 4(6):1197-1209.

13 Quiroz-Sodi, M.; Mendoza-Díaz, S.; Hernández-Sandoval, L. and Carrillo-Ángeles, I. 2018. Characterization of the secondary metabolites in the seeds of nine native bean varieties (*Phaseolus vulgaris* and *P. coccineus*) from Querétaro, Mexico. Botanical Sciences. 96(4):650-661.

14 SIAP. 2024. Servicio de Información Agroalimentaria y Pesquera. Panorama agroalimentario 2018-2024. Agricultura-SIAP. 207 p.

15 SNICS. 2017. Servicio Nacional de Inspección y Certificación de Semillas. Guía técnica para la descripción varietal. (*Phaseolus vulgaris* L). Servicio Nacional de Inspección y Certificación de Semillas (SNICS). Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA). México, DF. 36 p.

16 Teniente-Martínez, G.; González-Cruz, L.; Cariño-Cortez, R. y Bernardino-Nicanor, A. 2006. Caracterización de las proteínas del frijol ayocote (*Phaseolus coccineus* L.). Investigación y Desarrollo en Ciencias y Tecnología de Alimentos. 1(1):1-6.

17 Vargas-Vázquez, M. L. P.; Muruaga-Martínez, J. C.; Mayek-Pérez, N.; Pérez-Guerrero, A.; Ramírez-Sánchez, S. E. 2014. Caracterización de frijol ayocote (*Phaseolus coccineus* L.) del Eje Neovolcánico y la Sierra Madre Oriental. Revista Mexicana de Ciencias Agrícolas. 5(2):191-20.

18 Vargas-Vázquez, M. L. P.; Muruaga-Martínez, J. C.; Lépiz-Idelfonso, R. y Pérez-Guerrero, A. 2012. La colección INIFAP de frijol ayocote (*Phaseolus coccineus* L.) I. Distribución geográfica de sitios de colecta. Revista Mexicana de Ciencias Agrícolas. 3(6):1247-1259.

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