Article

Practical and theoretical knowledge of corn and beans in the triqui high region, Oaxaca

Liliana Martínez-López[1]
Emma Zapata-Martelo[1§]
María del Rosario Ayala-Carrillo[1]
Beatriz Martínez-Corona[2]
Gricelda Vázquez-Carrillo[3]
Carmen Jacinto-Hernández[3]
Alejandro Espinosa-Calderón[3]

[1]Postgraduate College-*Campus* Montecillo. Mexico-Texcoco Highway km 36.5, Montecillo, Texcoco, State of Mexico, Tel. 01 (595) 9520200, CP. 56230. (lilian.marlopez@gmail.com; madel@colpos.mx). [2]Postgraduate College-*Campus* Puebla, Mexico-Puebla Federal Highway 125.5 km, Santiago Momoxpan, San Pedro Cholula, Puebla. CP. 72760. Tel. 01 (222) 2851442 (beatrizm@colpos.mx). [3]Valley of México Experimental Field-INIFAP. Highway Los Reyes-Texcoco km 13.5. Coatlinchan, Texcoco, State of Mexico, CP. 56250. Tel. 01 (800) 0882222, ext. 85328. (vazquez.gricelda@inifap.gob.mx; jacinto.carmen@inifap.gob.mx; espinosa.alejandro@inifap.gob.mx).

[§]Corresponding author: emzapata@colpos.mx.

Abstract

The objective of the article is to contrast the practical knowledge that women and men possess about the quality and use of corn and beans, with the theoretical knowledge to evaluate the quality of these grains in the laboratory. There were 27 semi-structured interviews and two participatory workshops, in the mother tongue ‛triqui’, in Santo Domingo of the state, region triqui high, Oaxaca. The hectolitre weight (PH) and flotation index (IF) were evaluated in 20 corn collections. In beans, cooking time (TC), water absorption capacity during soaking (CAA) and percentage of solids in the cooking broth (PSC) in 15 accessions were evaluated. The results were analyzed with a completely randomized design, comparison test of tukey means and correlations. The interviewees indicated preference for white corn, with hard grains (IF= 0-12) and intermediate grains (IF= 38-62), followed by blue, pinto, yellow, red was less preferred. All the pigmented maize was hard grain (IF= 13-37). The pH was between 74-81 kg hl^{-1}. In beans, the species *Phaseolus vulgaris* L. (common) and *Phaseolus coccineus* L. (ayocote) were identified, the one with the longest tradition and preference for consumption was the ‛dry bean’ (ayocote) which requires 317 min for cooking. The practical knowledge of men and women of Santo Domingo del Estado on the quality of corn and beans, showed an association with the theoretical trends of quality in corn; in the bean there was an association with the cooking time.

Keywords: beans, corn, genus, milpa, traditional knowledge.

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Introduction

The milpa in Mexico is of prehispanic origin, it is currently the base of the food of the peasant and ethnic groups, it includes the cultivation of corn with different species of beans, pumpkins and weeds. The breeds and varieties of maize change according to the weather conditions, customs and culinary tastes of each human group (Kato *et al*., 2009). In the state of Oaxaca due to the presence of numerous ethnic groups, the high climatic variation, topography, types of soils and ease of cross-linking of maize it is possible to find up to 35 breeds and diverse landraces (Aragón *et al*., 2006), with different uses such as tortillas, toasts, tamales, tlayudas, pozole, atoles, etc (Alarcón *et al*., 2001).

Delgado and Gama (2015) point out that at the national level there are five species of beans: common bean (*Phaseolus vulgaris* L.), lime or comba *(P. lunatus*), ayocote or botil (*P. coccineus* L.), tepari or escumite (*P. acutifolius*) and acalete or fat (*P. dumosus*). Despite efforts to know the genetic diversity of beans, it has not been fully achieved (Perez *et al*., 1995; Pliego *et al*., 2013).

It is vital to rescue the traditional knowledge possessed by women and men about the diversity and uses of corn and beans, or run the risk of losing them due to genetic erosion, the use of improved varieties, crop diversification, abandonment of the field, migration, high cost of supplies, etc. According to Chambers and Momsen (2007) women not only have different knowledge than men, but the emigration trend continues and they are increasingly responsible for the milpa, so their knowledge and participation in decision-making guarantees the protection and conservation of genetic resources (Millan *et al*., 2016).

Therefore, the objective of this research is to characterize the genetic diversity of corn and bean samples, and to establish whether the traditional knowledge of men and women about the uses and characteristics of both products, coincide with the results obtained in the laboratory.

Materials and methods

Qualitative methods

Semi-structured interviews were conducted in the triqui mother tongue, translated and transcribed into Spanish. Of the 19 women interviewed: nine married, the rest widows, heads of the domestic unit. Of the eight men interviewed, all married and heads of the domestic unit. The age range of women, 37 to 70 years and for men from 40 to 76 years. Two participatory workshops were held, the first attended by 10 women and the second by five men.

Quantitative methods

It began with a collection of 20 samples of corn and six of beans, obtained in the domestic unit of the interviewees. The analysis was carried out in the corn and bean quality laboratories of the Valle de México Experimental Field (CEVAMEX), belonging to the National Institute of Forestry, Agriculture and Livestock Research (INIFAP), located in Texcoco, State of Mexico. In the corn, six ears of each sample were used for the analysis and in the beans the grains that represented the highest percentage within the compounds were used.

Physical characteristics of corn grain

The apparent density or hectolitre weight (PH), expressed as kg hl^{-1} and the flotation index (IF), was evaluated as an indirect measure of the hardness of the grain, following the methodologies described by Salinas and Vazquez (2006). The results of PH and IF were obtained in duplicate.

Culinary quality in beans

Of the total, five samples were collected in grain: two were composed of common bean (*Phaseolus vulgaris* L.), of different colors, sizes and in each sample a different color predominated; the three remaining samples consisted of a combination of common bean and ayocote bean (*Phaseolus coccineus* L.). The last sample was of ayocote beans in dry beans.

To know the contribution of each of the colors to the culinary and sensorial quality, they were classified into subsamples by color. In each subsample the tests were carried out: cooking time, percentage of solids in cooking broth, and water absorption capacity during soaking. Determined according to the methodology described by Guzman *et al*. (1995).

Water absorption capacity during soaking (CAA)

It was evaluated in duplicate, soaking 20 seeds in 50 ml of distilled water for 18 h. The grains were weighed before and after soaking, and the increase in weight was considered as the amount of water absorbed. To estimate the percentage, the following formula was used:

$$\text{CAA} = \frac{(\text{Peso de muestra después del remojo} - \text{Peso inicial de la muestra})}{\text{Peso inicial de la muestra}} x\ 100$$

Percentage of solids in the cooking broth (PSC)

It was determined in duplicate, placing an aliquot of 10 ml of cooking broth in beakers with a capacity of 50 ml, previously brought to constant weight. Weighing the glass with the aliquot, it was placed in an oven at 60 °C for 24 h, until the evaporation of the liquid, once it was dry, it was weighed with the solids. The percentage was estimated by weight difference by the formula:

$$\%\ \text{sólidos en caldo de cocción} = \frac{(\text{peso de vaso c/sólidos} - \text{Peso de vaso vacío})}{(\text{peso de vaso c/líquido} - \text{Peso de vaso vacío})} x\ 100$$

Cooking time (TC)

It was determined with samples of 20 grains. They were previously soaked for 18 hrs in 50 ml of distilled water. The cooking time was recorded when 60% of the beans reached a smooth granular texture, which is suitable for the beans to be consumed as food.

For the statistical analysis of the results in both maize and beans, a random design was used in the SAS program (Statistical Analysis System 9.0 for Windows). To determine the statistical differences, the analysis of variance were performed and Tukey's mean test (α= 0.01).

Results and discussion

Corn diversity

Based on the relevant distinguishing characteristics of the material obtained; shape, size and color of ear, texture and color of grain and with the support of M.C. Flavio Aragón Cueavas were identified four pure races: Conic, Mushito, Conical Elotes and Nal-tel of height. The Elotes Conic race was represented in the colors; white blue and red; Mushito in white, blue and pinto (white with blue), Conic had samples of color, white and yellow, while the two samples of Nal-Tel of height were yellow. The following crosses (combination of races) were identified: Conical x Serrano, Mushito x Pepitilla, Tepecintle x Nal-tel tall, Conical x Mushito, Mushito x Conical, Elotes conical x Mushito and Mixteco x Conical.

Some samples showed variation in the color of the grains on the cob, which is due to the combination of corn colors in a single field. According to the interviews, this decision is influenced by women, although men plant corn. The high percentage of mixture of colors, is indicative of the intercrossing between different varieties. This autochthonous practice implies the gene flow of characteristics from one race to another, being a way to increase genetic diversity, which is combined with the selection of seeds (Aragón *et al*., 2012).

This work contributes to the previous investigations (Aragón *et al*., 2006 and Aragón *et al*., 2012) seven additional races (Conic x Serrano, Mushito x Pepitilla, Tepecintle x Nal-tel of height, Conic x Mushito, Mushito x Conic, Conical elotes x Mushito and Mixteco x Conic). The greatest diversity was found in the white grain accessions (the most numerous), the red accessions were those with the least diversity, both were of the Western Elotes race (Table 1).

Table 1. Classification by color of corn, Santo Domingo del Estado, region triqui high, 2016.

Name in Spanish	Races	Grain of corn (name triqui)	Cob (name triqui)
White corn	Cónico (9, 14), Mushito (3), Elotes Cónicos (18), Cónico x Mushito (12), Cónico x Serrano (4), Mixteco x Cónico (17), Mushito x Pepitilla (5)	*´nín gatsìi*	*Tan´ gatsìi*
Black corn (blue)	Elotes cónicos (1, 8, 11), Mushito (19), Mushito x Cónico (13)	*´nin marùu*	*Tan´ marùu*
Pinto corn (blue with white)	Mushito (16), Elotes Cónicos x Mushito (15)	*´nin guala*	*Tan´ guala*
Yellow corn	Cónico (10), Nal-Tel de altura (2), Texpecintle x Nal-Tel de Altura (7)	*´nin serrano*	*Tan´ mahiaj a*
Red corn	Elotes Cónicos, (6, 20)	*´nin màre*	*Tan´ màre*

Fuente: elaboración con información obtenida en muestras de maíz colectadas en campo, 2016.

In the interviews it was identified that 100% of the interviewees plant white corn, followed by pinto (blue with white), black (blue), yellow and red. Similar results were found by Servia and Flores (2011) in the Tlaxiaco Region, where the sowing of white grain corn predominates, followed by yellow, black, red and pinto (red-white, black-white, red-white-blue). Of the races, the conical ears stand out in three of the five colors, followed by the conical ones and Mushito.

According to traditional knowledge, the inhabitants manage to differentiate the corn by colors and not by breeds. Generally the white colored maizes are of longer cycle, with respect to the yellow ones, and these in turn of the other colorations, thus it is explained that they have been maizes with combinations of colors, and even mixtures of races, since they coincide in flowering. One interviewee mentions it: “the black corn milpa dries faster and it looks green where the white corn milpas are” (Josefina, 2016).

The analysis of variance for the PH and IF variables showed significant difference between the races. Both variables were significantly correlated (p< 0.01) (Figure 1), which coincides with Vázquez *et al.* (2012). The average hectolitre weight was 77.7 kg hl^{-1}, a value that is considered high, especially because it is native corn. He highlighted the collection of the Nal-Tel breed tall (yellow) with 81.1 kg hl^{-1} (Figure 1). According to the Mexican norm for white corn destined to the nixtamalization process (NMX-FF-034/1-SCFI-2002), the corn must have a minimum density of 74 kg hl^{-1}. With the exception of sample 12 (Conic x Mushito of white color), all comply with this Standard: the native maize of the community of Santo Domingo del Estado has the hardness for the elaboration of tortillas, on an industrial level.

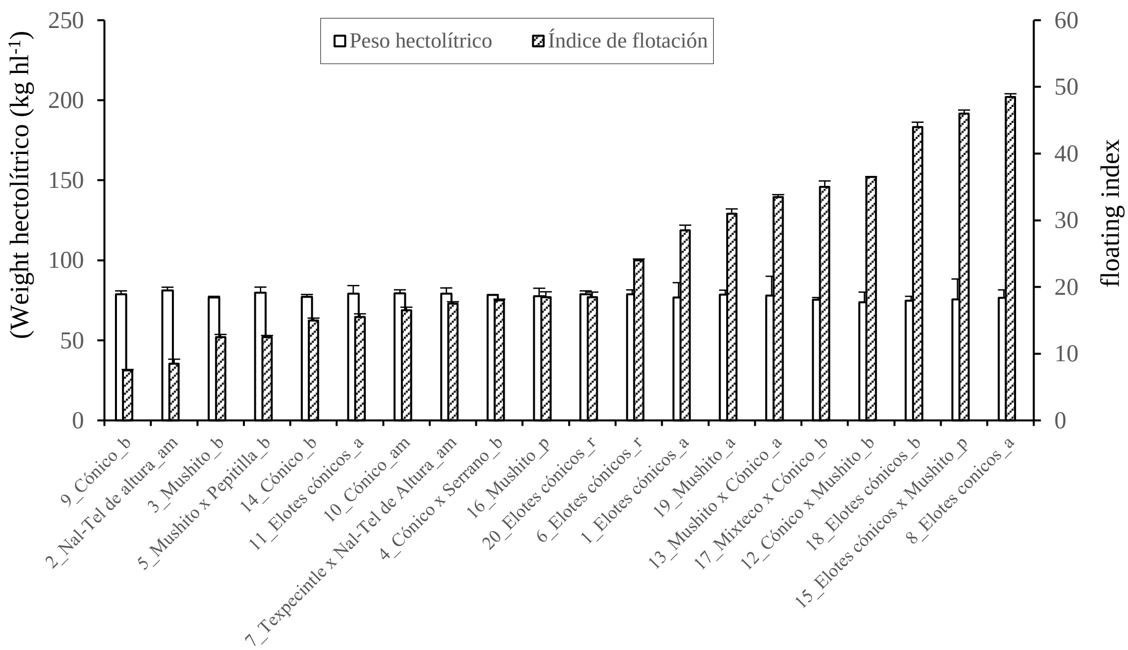

Figure 1. Test weight (kg hl^{-1}) and flotation index (0-100) of corn grains, Santo Domingo del Estado, high triqui region, Oaxaca, 2016. Elaborado con datos obtenidos en laboratorio (CEVAMEX), 2016. a= azul; am= amarillo; b= blanco; r= rojo; p= pinto. Coeficiente de correlación: 0.73.

According to the flotation index, 75% of the collections were hard endosperm (IF= 13-37 floating grains), three collections (numbers 8, 15 and 18) (15%) were intermediate endosperm (IF= 38-62 floating grains) and only collections 2 and 9 (10%) were very hard grains (IF= 0-12 floating grains). Similar results were reported for maize from the Sierra Sur de Oaxaca (Aragón *et al*., 2012), characteristics that according to Agama *et al*. (2013) is due to the biosynthesis, organization and distribution of the chains of pectin in the starch granule, as well as the protein matrix that surrounds the starch granule.

The differences found between what was reported by other authors for some of the races of the 'triqui high' region is attributed to different agroclimatic conditions, which could affect the biosynthesis of the endosperm components (Agama *et al*., 2013) and the search of the producers of this region of Oaxaca, to increase yields and reduce losses in the warehouse, as expressed by some interviewees, in Santo Domingo, Oaxaca state: "I plant more blue or pinto corn than white corn as it is softer then the moths come in" (Dominga, 2016).

Samples 8, 15 and 18 were those with the highest flotation index (48.5, 46 and 44); that is, of intermediate hardness. Samples 8 and 18 belong to the conical Elotes and are blue and the sample 15 belongs to the cross of conical Elotes x Mushito. The interviewees relate to the blue conical Elotes with shorter cooking time, greater ease of grinding and molding the dough, and point out that the tortillas are softer and taste better than the maizes of other colors: "I like it plus the blue corn, since at the time of making the tortillas they do not burn, the tortilla is not hard and they have more flavor" (Dominga, 2016).

The yellow corns (Collects: 2, 7 and 10) were very hard and hard grain, so they require longer cooking time, aspects identified empirically by the people interviewed. This is consistent with the uses that are given to corn in the community.

Uses of corn

Women know more uses of corn, due to gender roles, especially knowledge in food preparation. To prepare tortillas, they put the corn to nixtamalize, they rest it all night, the next day they wash it and they take it to grind from 5:00 to 6:30 am. In the morning, they make the tortillas that they will consume during lunch, at noon they elaborate the ones that they will taste in the food and the little nixtamal that remains, they process it during the dinner.

The most commonly used maize is white (Conic, Mushito, Conic x Serrano, Mushito x Pepitilla, Conic x Mushito, Mushito x Conic, and Mixteco x Conic). Blue corn (Elotes Conics), due to its sweeter flavor, cook it with chilacayote or consume it as corn. The above agrees with Salinas *et al*. (2010) who reported that blue corn from Valles Altos (> 2 200 m) have more sugar than whites, so it tastes more pleasant. The pinto corn is used to make tortillas, atole de bean (*nakinj runee*) and caldillo de bean (*nee nínj*).

Red corn is used to make tortillas but it is the least used: "I have not planted red here, the tortilla is very pretty and it has a very nice color, but the problem is when the women take it to the nixtamal mill, sometimes people who carry white corn do not like to mix with that red or blue corn (Adolfo, 2016)". Besides that there are some mythical beliefs that limit its use: "I do not plant red corn because the belief of the elderly says that it is a sin to consume or sell, and if it is sold one of us loses our luck, so we do not I sow it" (Dominga, 2016).

Table 2 summarizes the uses of the maize, according to the gender of the interviewee. Women identify more uses than men. Within the triqui gender and ethnic identity, it is unseemly for men to carry out domestic activities and even less, to prepare food, so that their knowledge to the respect is more limited.

Table 2. Uses of the grain of corn by type and color, according to women and men, Santo Domingo del Estado, region triqui high, Oaxaca, 2016.

Corn by color	Mens	Women
White corn	Pozole, tortillas, tamales	Tortillas, pozole, masita, atole picoso with meat and sweet white atole, tamales, corn.
Blue corn	Tortillas	Tortillas, incorporated in chilacayote, corn
Pinto corn	Tortillas	Tortillas
Yellow corn	Tortillas	Tortillas, masita
Red corn	Tortillas	Tortillas

Fuente: elaborado con información de campo, 2016.

The women also mentioned the uses in the festivities of the community: “I use corn to make nixtamal and make tortillas. When I am in some stewardship I use it, i carry a drawer to make pozole, and from there the tortilla also comes out when I need it. But you can make masita, sometimes atole spicy meat. When i’m from the women’s stewardship, i have to carry a liter or two to make it a sweet white atole” (Angela, 2016).

The men recognize that the women carry out the food preparation activities, while they assume the responsibility of planting the milpa: “Because when we want to eat something, they prepare pozole or put tortillas and they will leave it for us to eat or from the house we take it to the milpa, because it is too far for women to walk every day, that's why we take the tortilla and make fire there and warm them up” (Miguel, 2016).

According to the type of food to prepare they choose the corn race. Their empirical knowledge has led them to characterize the grains by their color and hardness, thus they choose some softer ones for atoles, pozole, masita, among others; the harder ones, which they classify as resistant to pests, prefer them for tortillas or tlayudas; and those that qualify as sweeter to consume them fresh. The observations and knowledge of the women interviewed, shows how empirical-ancestral knowledge, transmitted by tradition to Triqui women, has scientific foundations, proven in the laboratory, so it is necessary to safeguard and value it.

Diversity, culinary quality and uses of beans

Two bean species were identified: common bean (*Phaseolus vulgaris* L.) of yellow, black, pink, dark pink, beige, black spotted beige, and black and reddish (*Phaseolus coccineus* L.) black beans (Table 3).

Table 3. Bean species, form of consumption and names in Triqui of the samples obtained in Santo Domingo del Estado, triqui high region, Oaxaca, 2016.

Form of consumption	Name in Spanish	Species	Name in Triqui
Bean	Thick coarse beans	*Phaseolus coccineus* L.	*Natan sikìj i*
	Soft bean	*Phaseolus vulgaris* L.	*Natan ‘ninaj a*
Grain	Donkey or reddish beans	*Phaseolus vulgaris* L.	*Runee kuaj a*
	Black or large beans	*Phaseolus coccineus* L.	*Runee ga’nïn’ïn*
	Scrambled beans	*Phaseolus vulgaris* L.	*Runee gitsi*

Culinary quality of beans

Figure 2a shows the cooking time (TC) in minutes, which requires beans in the laboratory and the capacity to absorb water during steeping (CAA) and in Figure 2b the percentage of solids in cooking broth is observed (PSC).

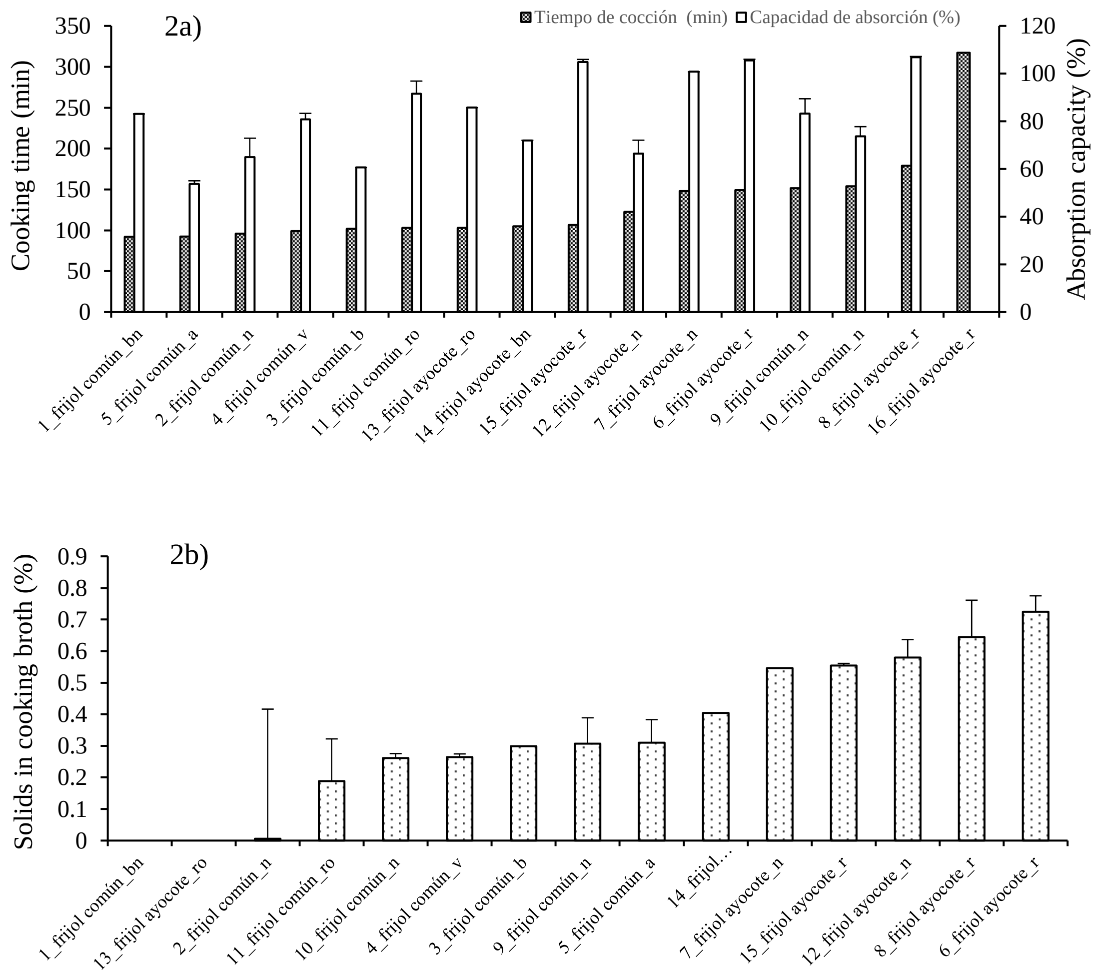

Figure 2. a) cooking time (min) and absorption capacity (%); and b) percentage of solids in cooking broth (%), bean samples, Santo Domingo del Estado, Oaxaca. Eaborado con datos de laboratorio de frijol CEVAMEX, 2016. bn= beige manchas negro, n= negro, b= beige, v= vino, a= amarillo, r= rojizo, ro= rosa obscuro.

The time for cooking common bean grains is in the range of 92 to 154 min. Bean sprouts took 179 minutes and beans 317 min; that is, it took almost twice as much time compared to the other samples. These cooking times are superior to those found by Muñoz *et al*. (2009) in native beans of the state of Hidalgo.

Despite the time required for cooking dried beans, women prefer this form of preparation because it is traditional in the high triqui region. The atole de bean is a local culinary specialty passed on from generation to generation that is made with the ayocote bean.

In the bean collections, the values of water absorption capacity during soaking (CAA) vary between 54 to 107%, the first value corresponds to a subsample of common bean and the second one to a bean sprouts. It differs with that observed by Muñoz *et al*. (2009), where the range was between 14 and 137%. Beans with CAA less than 70% have a hard testa partially impermeable to the weight of the water, only in the case of three samples did this occur (5, 3 and 15). Hard-coated beans require longer soaking time and consequently, longer preparation time.

The percentage of solids content in cooking broth (PSC) of the reddish ayocote bean with values (0.72 and 0.64) stands out. It means that the broth is thicker than that of the common bean, the testimonies of the women affirm that black and red ayocote beans are the ones with the best flavor that is why they are part of the traditional dishes. Similar results were found by Ramírez *et al*. (2012). The traditional knowledge of the interviewed women coincided with the cooking test, arguing that the ayocote bean takes longer time to cook as a dry bean, but they did not indicate the time it takes them to cook it.

Uses of beans

Two forms were identified to consume the common bean (*Phaseolus vulgaris* L.): green bean and dry bean, and grain. This bean is used to prepare a black bean broth; previously the beans are ground in metate, then water is added and mixed with epazote leaves forming a traditional dish called *nee nínj*.

The ayocote bean (*Phaseolus coccineus* L.), is used to make atole de bean (*nakinj runee*), one of the typical dishes of the high triqui region, it can be consumed in the day of the dead and in the wakes. With the pinto corn is made atole, the dough that is taken to the mill, mixed with water to form a broth, boiled and finally add the beans that were previously cooked. Table 4 summarizes the uses mentioned by the interviewees, again women are the ones who know the greatest variety of uses; although also the men showed to know some.

Table 4. Uses of bean grain in Santo Domingo del Estado, triqui high region, Oaxaca.

Specie	Men	Women
Phaseolus coccineus L.	Atole of bean	Cooked, bean gruel (*nakinj runee*), bean caldillo (*nee nínj*)
Phaseolus vulgaris L.	Cooked	Cooked in green bean and dry, cooked in grain, fried and with chili

Source: prepared with field information, 2016.

In the preparation of green beans or green beans, the green beans are cooked with water and salt for about two hours, and depending on the tastes, some seasoning can be used. Later they are fried in oil and with it they have better flavor according to the local taste.

Conclusions

In Santo Domingo del Estado the maize with hard grain (75%), very hard grain (10%) and intermediate (15%) and with a hectolítrico weight superior to 74 kg hl^{-1} and index of flotation predominates (8-46). The 100% of the interviewees plant white corn in addition to planting other colorations, which they use to prepare different dishes (tortillas, pozole, masita, atole picoso with meat, sweet white atole, tamales and corn).

Two bean species were identified: common bean (*Phaseolus vulgaris* L.) and ayocote (*Phaseolus coccineus* L.). The dry bean (ayocote) is the preferred form of consumption, mainly for women. The reddish ayocote bean presented higher PSC (0.72 and 0.64), high CAA (105 and 107%), and broth thicker compared to the other samples and therefore is pleasant to the palate, although the cooking time is high (106 at 179 min), associated with grain size.

The practical knowledge of men and women of Santo Domingo del Estado about the quality of corn and beans, showed association with the theoretical trends of quality in corn and beans showed association with the cooking time. Therefore, these traditional knowledges are of great cultural, scientific and culinary value, so it is convenient that they be safeguarded, valued and recognized.

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