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Sensory perception of *pulque* using free sorting method

Percepción sensorial del pulque usando el método de clasificación libre

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Technological innovation: Sensory characterization of *pulque* using a technique based on similarities.

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Resumen

El pulque es una de las bebidas alcohólicas fermentadas no destiladas más tradicionales de México. La clasificación libre es un método basado en similitudes que se fundamenta en la percepción analítica de productos y en la traducción de sensaciones en palabras. Además, este método permite obtener rápidamente una medida global de las similitudes y diferencias percibidas en un conjunto de productos. La percepción sensorial del pulque se estudió a través del método de clasificación libre utilizando dos grupos de jueces: consumidores y productores, con la finalidad de determinar diferencias debidas a la región de origen. Doce muestras de pulque proveniente de dos regiones productoras del estado de Hidalgo, México (Altiplano y Valle del Mezquital) fueron evaluadas por todos los jueces participantes. La prueba se realizó en una sola sesión, todas las muestras se presentaron de forma simultánea y aleatoria sobre una mesa. Los datos se analizaron con pruebas de Escalamiento Multidimensional (EMD) y Análisis Factorial Múltiple (AFM). Se determinaron dos configuraciones de dimensiones de EMD (valor de estrés de Kruskal = 0.229 y 0.261). El 82% de los participantes en el estudio fueron hombres. El grupo de consumidores eran más joven (26 a 48 años de edad) que el grupo de productores (34 a 68 años de edad). Este último grupo ha consumido pulque desde su niñez. Se observó una tendencia para clasificar el pulque de acuerdo a

su region de origen por parte de ambos grupos. El mapa sensorial obtenido proporcionó una discriminación adecuada de las muestras, separando el pulque de la región del Valle del Mezquital del pulque de la región del Altiplano. En general, los consumidores mencionaron más términos (68 en total) comparados con el grupo de productores (55 en total). Del mismo modo, los consumidores también utilizaron un mayor número de descriptores que los productores (13 y 9, respectivamente) para caracterizar las muestras de pulque. Las principales diferencias percibidas fueron en el sabor y en la textura. A diferencia de los consumidores, los productores usaron términos relacionados con parámetros de calidad asociados con la fermentación. En general, el pulque del Valle del Mezquital presentó un sabor fuerte y menos viscoso, mientras que, el pulque del Altiplano presentó un sabor diluido y un olor fuerte. Este experimento contribuyó a la caracterización sensorial del pulque de dos regiones productoras distintas mostrando diferencias entre ellas. En este caso particular, conocer (o no) el pulque, tuvo un efecto significativo en su percepción. En general, existen muy pocos trabajos sobre el pulque y actualmente no existen publicaciones sobre caracterización sensorial. Por lo anterior, se requieren investigaciones futuras sobre este tema, así como sobre la aceptación de esta bebida a través de pruebas hedónicas que involucren un gran número de consumidores habituales.

Palabras clave: bebida fermentada, características sensoriales, consumidores, método de clasificación, *pulque.*

Abstract

Pulque is one of the most traditional non-distilled alcoholic fermented beverages in Mexico. Free-sorting is a similarity-based method that rely on an analytic perception of products and in the translation of sensations into words. In addition, it allows to quickly obtain an overall measure of the perceived similarities and differences in a product set. Sensory perception of *pulque* using free-sorting task was studied in two groups of judges: consumers and *pulque* producers to determine differences due to region of origin. Twelve samples from two producing *pulque* regions in Hidalgo State, Mexico (Altiplano and Valle del Mezquital) were evaluated for all the judges. The test was performed in a single session, all samples were presented simultaneously and randomly displayed on a table. The data were analyzed with Multidimensional Scaling (MDS) and Multiple Factor Analysis (MFA) tests. Two MDS dimensions configurations were determined (Kruskal´s stress value= 0.229 and 0.261). Eighty two percent of the judges were men. The group of consumers was younger (26 and 48 years old) than the group of producers (34-68 years old). Producers have consumed pulque since childhood. A trend to classify pulque according to its region of origin was observed. The sensory map obtained proportionated an adequate discrimination of samples, separating the *pulque* from Valle del Mezquital region of Altiplano region. In general, consumers mentioned more terms (68 in total) compared to the group of producers (55 in total). In the same way, consumers also used a larger number of descriptors than the producers (13 and 9, respectively). The main differences perceived were in flavor and texture. Unlike consumers, producers used terms related to quality parameters and associated with fermentation. In general, the *pulque* from Valle del Mezquital region presented a strong flavor and lower viscous, while the *pulque* from the Altiplano region presented a diluted flavor and a strong smell. This experiment contributed to the sensory characterization of *pulque* from two different producing regions showing differences between them. In this particular case, being familiar or not with *pulque* have a significant effect on its perception. In general, there are very few studies on *pulque* and currently, there are no publications on sensory characterization. For this reason, future research is encouraged

on this topic, as well as on the acceptance of this beverage through hedonic tests involving a large number of habitual consumers.

Key words: consumers, fermented beverage, *pulque*, sensory properties, sorting method.

1. Introduction

Pulque is one of the most traditional non-distilled alcoholic fermented beverages in Mexico. It is produced by spontaneous fermentation of fresh sugary sap (*aguamiel*) extracted from several species of *Agave* plants. The resultant fermented product is a milky white, with strong smell, viscous and slightly acidic beverage with an alcoholic content between 4 and 7° GL (1).

The production and consumption of *pulque* dates back ~1,500 years (2). It was consumed mainly in religious ceremonies due to its alcoholic content, but also because of its nutritional and health promoting properties (2) which have led to consider this beverage as a potential functional beverage. *Pulque* has also been used in traditional medicine since ancient times and it has been documented that its consumption, in a daily moderate basis, provides energy, vitamins, essential amino acids as well as other nutrients (3,4) and also prebiotics and probiotics (1, 5). The main probiotic microbiota reported in this beverage is dominated by lactic acid bacteria (*Lactobacillus* sp., *Leuconostoc mesenteroides*, and *L. mesenteroides subsp. dextranicum*) and the yeast *Saccharomyces cerevisiae* (1).

Pulque is consumed in two forms: natural (alone) or mixed with macerated fruits, vegetables, seeds, nuts or condiments. In its mixed form, *pulque* is known as *curado* (cured) and in recent years, it represents the most popular way of *pulque* consumption, especially for young people (6, 7, 8).

The main production of *pulque* is at Central Mexico plateau (1) being Hidalgo state the main producer, followed by Tlaxcala and State of Mexico (3). Most producers of *pulque* operate in a small scale, using traditional production under no standardized conditions and parameters which leads to a wide variability of the final product (3, 9). The majority of *pulque* produced is for self-consuming or it is sold through agri-food fairs, farmer markets and independent small stores near the area of production.

Despite the historical and socio-cultural importance of *pulque*, a significant decrease in consumption (10) and production (up to 60% in 2018) (11) has been observed. Some of the reasons to explain such decrease include *pulque*'s perception as a low-class, consumed mainly by the elderly beverage (12). In the same way, fluctuations in sensory quality of *pulque* as well as some properties such as viscosity and smell affect severely consumers' perception.

Nowadays, the information available on sensory properties or sensory characterization of *pulque* is scarce or inexistent. Two reports related to *pulque* consumers' perception (an exploratory study) as well as the identification of consumers' profile and factors associated with its valorization, both in Central Mexico have been recently published (7, 13). In this context, additional sensory information about *pulque* is needed.

There are several methods to study sensory perceptions of food products. In this research, Free Sorting Method was selected to investigate *pulque* consumers and producers' sensory perceptions and to elicit the language associated with this beverage. Sorting is relatively simple and less time consuming compared to other

similarity data producing methods (14). It consists of grouping samples according to their similarities allowing to evaluate a large number of samples simultaneously (15).
Sorting task has been successfully used to obtain sensory information of a variety of complex food products such as cheese, beer, wine, yogurt (16), drinking water (17) and coffee (18).

To be able to promote consumption, consumers' engagement as well as to generate new opportunities for commercialization of *pulque*, new sensory information about this beverage is required. Due to this fact, this research aimed to determine differences in consumers' sensory perception between *pulque* from two regions of origin using the sorting task method.

2. Materials and Methods

2.1 Regions of study and sampling

Two traditional *pulque* producing regions of the state of Hidalgo were studied: Altiplano and Valle del Mezquital. The studied communities were Epazoyucan, Singuilucan and Zempoala belonging to the Altiplano region. From Valle del Mezquital region, Atotonilco de tula, El Arenal and Actopan were the participant populations. *Pulque* samples (Table 1) were obtained in March 2020 from two different *tinacales* (closed rooms with small windows where the *pulque* fermentation is performed in wood, clay or plastic containers) of three communities in each region. Samples were collected directly by the producers of each region studied and placed in plastic bottles of 1.8 L of capacity. The 12 samples were collected on the same day, 24 hours before the sensory analysis and they were transported at 4 ± 1 ºC.

Table 1. Codes and origin of *pulque* evaluated.

Pulque code	Community	Region
A.E1 A.E2	Epazoyucan	Altiplano
A.S1 A.S2	Singuilucan	
A.Z1 A.Z2	Zempoala	
VM.AT1 VM. AT2	Atotonilco de Tula	Valle del Mezquital
VM.EA1 VM.EA2	El Arenal	
VM.A1 VM.A2	Actopan	

2.2 Sample preparation

Pulque was kept at 4ºC until sensory analysis. Before evaluation, samples were maintained at room temperature for one hour. Then, from 35 to 50 mL of *pulque* were poured into clear plastic cups identified with a random three-digit number.

2.3 Participants

Twenty-eight people participated in the research and were divided into two groups. The first group consisted of 15 *pulque* producers from the State of Hidalgo (13 men and 2 women, between 34 and 68 years old), while the second group was integrated by 13 frequent *pulque* consumers (10 men and 3 women, between 26 and 48 years old). As a first step, all the participants individually answered a questionnaire of eight questions related to their habits and frequency of *pulque* consumption. Subsequently, each participant received the 12 *pulque* samples simultaneously for their evaluation.

2.4 Sorting procedure

The classification method (sorting task) was carried out in a single session divided in two stages. The indications for both stages were given verbally and in writing. In the first stage,

the participants performed a classification task, in which they were asked to taste each *pulque* and classify them into mutually exclusive groups based on perceived similarities and differences. The direction given was to group the products into at least two groups and at most n-1, where n is the number of products to be evaluated.

In the second stage, the participants performed the verbalization task, in which they were instructed to freely describe, in their own words, the attributes of each group of *pulques* previously formed by them (19).

The experiment was carried out in two places, the Sensorial Analysis Laboratory of the Universidad Autónoma del Estado de Hidalgo (test with consumers) and a conditioned space, located in a community where one of the studied *tinacales* was located (test with producers).

2.5 Statistical analysis

The results of each group of participants were analyzed separately. The methods of analysis used are briefly described below.

The data obtained from the grouping task (stage 1) were organized in a matrix, where the rows corresponded to the participants and the columns to the *pulques* evaluated. Each cell indicates in which group each *pulque* was placed by each participant. From this matrix, a similarity matrix was generated. Using the latter, a Multidimensional Scaling (MDS) analysis was run (20, 21). This analysis creates an approximate graph from the observed similarities which allows the visualization of the perceptive dimensions of evaluators (22, 23).

Before the analysis of the data obtained from the verbalization task (stage 2) and to avoid overlaps, the terms mentioned describing *pulque* were qualitatively analyzed. Similar terms were unified and those mentioned only once were removed. After the qualitative analysis was completed, the number of times each term was used to describe each of the samples was counted. With these data, a 12-row matrix (*pulque* samples) with two groups of columns (descriptors used by both groups of participants) was obtained. The data organized in the aforementioned matrix was analyzed through Multiple Factor analysis (MFA) (24), obtaining a comparison of the descriptors used by consumers and producers. The similarity coefficient Rv, which is interpreted analogously to a correlation coefficient (24), was used as a quantitative measure to compare the similarity of the configurations obtained for each group (22). All statistical analyzes were performed using the Xlstat software version 2014.

3. Results and discussions

3.1 Description of the participants and pulque consumption habits

The highest proportion of participants in this research where men (82%), confirming that similarly to other alcoholic beverages such as beer, *pulque* consumption and production is dominated by male gender (13, 25, 26).

Concerning the two groups formed (producers and consumers), it was observed that participants of the group of producers were older (34-68 years old) compared to the group of consumers (26-48 years). Regarding the level of education, more than half of producers (62%) had the lowest level (basic level) contrarily to the group of consumers in which the majority of participants (69%) had a technical or superior schooling level.

With respect to consumption, producers' group has been consuming *pulque* for longer and drinks it more frequently than the consumers' group. In this sense, 90% of producers declared consuming *pulque* since childhood. Of this group, 47% of participants indicated that they drink *pulque* one to three times a day while the rest, one to three times a week. For their part,

45% of consumers indicated they have been consuming *pulque* for the last 10-15 years. Besides, 30% reported consuming this beverage only twice to three times per month. A little bit more than half of the participants of consumers' group (54%) indicated buying the *pulque* in sell points called *pulquerías* located in Pachuca city (Hidalgo, Mexico). The remaining mentioned buying it directly from producers.

The results obtained indicate that the participating consumers have maintained a constant consumption of *pulque* in their diet even though recently a decrease in the production of this beverage has been reported (11). This could be associated to the recent emergence of a new culture of *pulque* consumption, mainly in young consumers (25).

3.2 Classification of pulque

The group of producers classified the *pulques* in a range of 2 to 3 groups whereas the group of consumers used 2 to 5 groups. The configuration resulting from the two-dimensional positioning of MDS (Figure 1) reveals the global perceptual proximity structure of the 12 samples of *pulque* for each group (Kruskal's stress = 0.229 and 0.261).

In general, we observed the trend to classify *pulques* according to the region of production for both producers and consumers group. As regards perception of the producers, the *pulques* from Valle del Mezquital region, Atotonilco de Tula (VM.AT1 and VM.AT2) and Actopan (VM.A1) communities were positioned close in the graph (Figure 1). Thus, they were perceived as similar to each other but different from the rest. Another group that was formed consisted of *pulque* from the Arenal community (VM.EA1) and the second sample of *pulque* from Actopan (VM.A2). On the other hand, *pulques* from Singuilucan (A.S1) and Zempoala (A.Z2) communities belonging to the Altiplano region also showed similarity between them. In the case of samples, A.E2, A.Z1, A.S2, and VM.EA2, a little similarity with any of the other *pulques* analyzed was observed.

In the same way, according to the consumers' group (Figure 1), the samples from Valle del Mezquital region produced in Actopan (VM.A1 and VM.A2) and in Atotonilco de Tula (VM.AT1 and VM.AT2), as well as the sample from Epazoyucan community (A.E1), presented similarities. Likewise, the rest of the *pulques* from the Altiplano region (A.Z2, A, Z1, A.S1, A.S2, A.E2) and the Arenal community (VM.EA1 and VM.EA1) also presented similarities but, at the same time, they were more dispersed than the first samples mentioned.

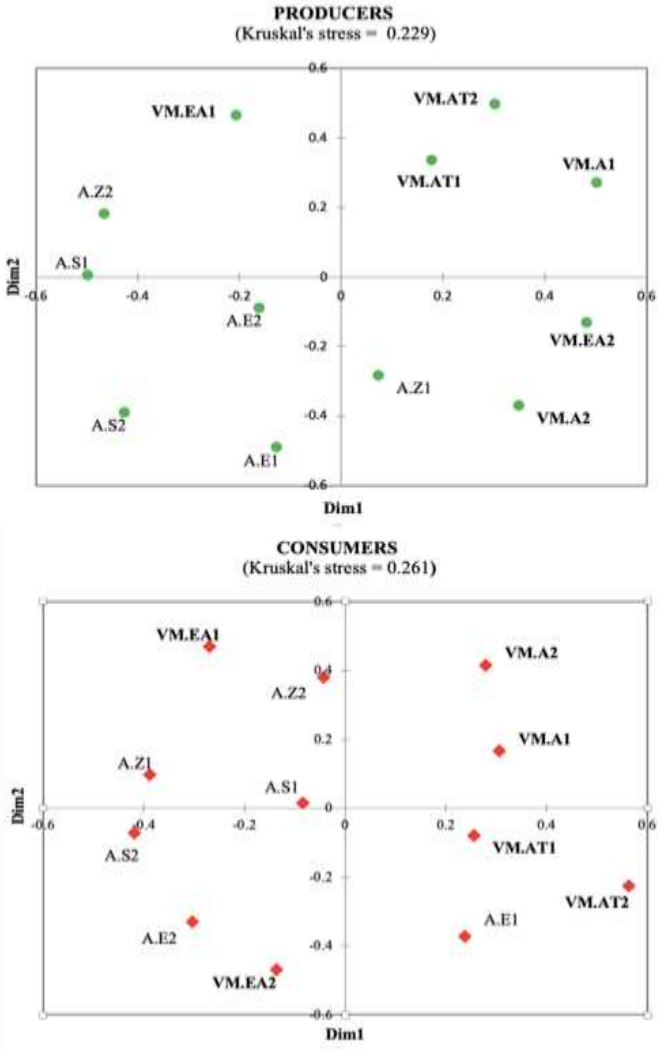


Figure 1. Representation of the 12 pulques on the basis of the first two MDS axes, for the producer group (upper) and consumer group (lower).
M: Region of Valle del Mezquital, EA: El Arenal, AT: Atotonilco de Tula, A: Actopan; A: Region of Altiplano, S: Singilucan, Z: Zempoala, E: Epazoyucan.

Even though *pulque* producers are much more familiar and experienced with the product compared to consumers, both groups were able to produce perceptual maps using the free sorting task. Our results are in agreement with those reported by several authors (15, 21, 27), who have shown that the positioning of products using the sorting method is comparable between trained panels and naive subjects. Specifically, sorting has been applied to create perceptual maps of cheeses (21), to classify wines through smell (27), beer (28) and for the classification of non-food products such as plastic pieces through their visual description (15). Moreover, other descriptive methods (Descriptive Analysis, CATA questions) have shown similarities on the sensory profile generated by trained judges and by consumers for artisan cheeses (29) and for different fish species (30).

3.3 Description of pulque

In the verbalization task, the group of consumers generated a total of 68 terms (5.2 terms on average) to describe *pulques*, whereas

the producer group generated a total of 55 (3.6 terms on average). After homogenization of similar words and after discarding the less mentioned ones, it was seen that producers used fewer terms (9 attributes) to describe the samples, compared to the consumers (13 terms, Table 2). The terms used to describe *pulque* were classified in characteristics of taste, smell, appearance and texture in the mouth (mouthfeel).

In the case of consumers, it is noteworthy that the attributes used for them to describe *pulques* taste and aroma were related to basic tastes (sweet, acid taste, bitter taste, slightly acid) which are easy to identify and recognize in food (31) due to the familiarity with these attributes.

With respect to smell, consumers were not able to identify its nature but rather indicated its absence (without smell). Our results differ from those reported by Rivas-Hilario (6) in which participants evaluating *pulque* mentioned terms related to smell such as fermented, wood, dairy and acetic. The smell of *pulque* is a relevant characteristic considered by consumers as a critical point of acceptance or rejection of this drink (25, 32).

Table 2. Terms used by consumers and producers to describe *pulques*.

Attributes	Consumers	Producers
Taste and smell	Sweet Acid Bitter *Penca* Slightly acid Without smell Strong flavor Diluted flavor	Sour Mild-taste *Aguanoso* Without taste Strong smell
Appearance	White color Light color Thick	Foamy *Estiloso*
Mouthfeel	Slimy Thick	Thick Thin

The term *Penca* (*Penca* means agave leave) also used for the consumers' group to describe *pulque*, refers to a flavor related to *aguamiel* which is a slightly cloudy, thick, very sweet sap, with a fresh and slightly acidic plant flavor (1). Therefore, it is presumed that the presence of this attribute suggests *pulque* with little fermentation. Furthermore, this attribute may be related to the diluted flavor attribute due to fermentation is in an early stage.

Concerning appearance attributes, color (white and light) and thick consistency were the attributes mentioned by consumers. The latter was also perceived in the mouth, along with the slimy sensation. Viscosity is a characteristic related to *pulque* fermentation (2). The development of viscosity is due to the synthesis of bacterial exopolysaccharides from the endogenous microbiota from *pulque*. This attribute is one of the main criteria to determine the degree of fermentation of this beverage, and it is useful to differentiate fresh from aged product (8, 33).

With regard to the description of *pulque* by the producers, taste and smell terms such as sour, mild, tasteless, strong smell and *aguanoso* were used. The *aguanoso* attribute is considered a quality parameter, which is not desirable in *pulque* since it involves the presence of a sour taste and a thin consistency. This attribute is more evident in hot season as a result of collecting aguamiel after noon leading to the acceleration of the fermentation process (1).

To describe the appearance of *pulques*, the producers used the terms sparkling (foamy) and *estiloso* which is a positive parameter related to the viscosity. This attribute describes a *pulque* with a medium thickness and the fresh taste of the *aguamiel*. It is more common in winter, because due to low temperatures sap stays fresh in agave plant starting its fermentation in *pulque* containers (information from a producer). Finally, the producers used the terms

thin and thick to refer to the thick or light consistency of *pulque*.

According to Ballester *et al.*, (27), knowledge of a product and familiarization with it can influence the generation of attributes for sensometric characterization. As is the case for *aguanoso* and *estiloso*, two relevant quality attributes of *pulque* mentioned by producers but not by consumers.

Comparable to other works (15, 34), in our research, the combination of multidimensional scales with the verbal description of the product, allowed us to obtain perceptual maps with subjects, getting information about the genuine perception of the consumer. This can be seen in Figure 2, which shows the comparison of the distribution of the 12 *pulques* analyzed according to the evaluators (producer and consumers groups) and to the sensory characteristics used to describe them. The regression coefficient value obtained (Rv = 0.60) indicated a good concordance between the two mentioned configurations (15). Hence, the data generated by both groups for *pulque* classification were similar according to sensory perception.

Multiple factor analysis results point out that *pulques* were classified into two groups in the first two dimensions (Figure 2). The first and second dimensions represented (F1) 30.41% and F2) 15.58% of the total variance of the experimental data, respectively.

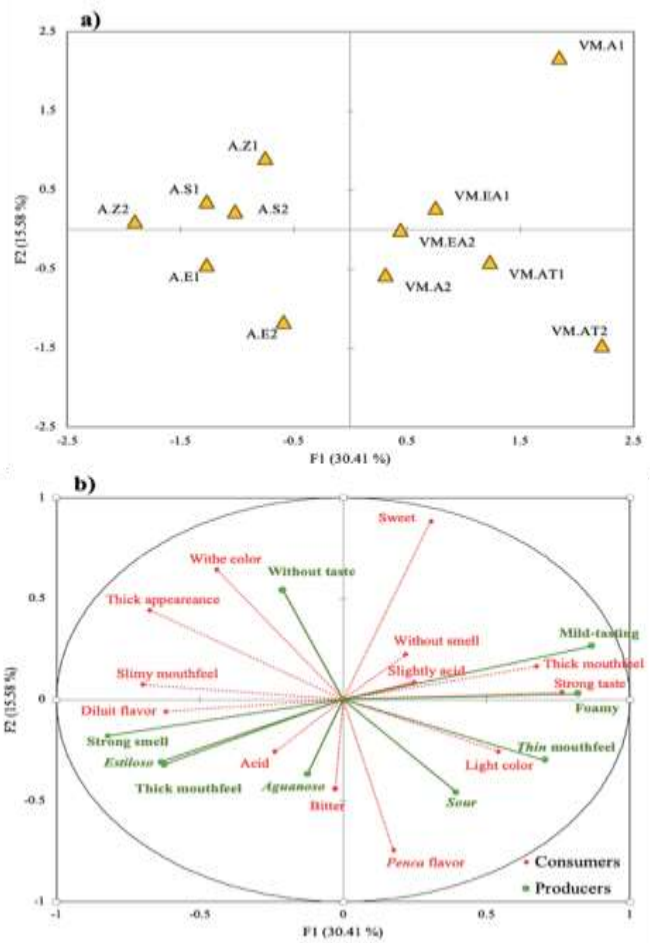


Figure 2. Representation of 12 pulques (a) and terms used to describe the samples (b), in the first two dimensions of the MFA.

The *pulques* from the Altiplano region were located in the negative quadrant of the first dimension (Fig 2a). The group of consumers characterized these pulques with a diluted flavor (diluted taste), slimy mouthfeel, thick appearance, and white color. In contrast, *pulques* from Valle del Mezquital region were located in the positive quadrant of the first dimension and were characterized by light color, strong taste, and thick mouthfeel on the palate.

On the other hand, producers characterized *pulques* from the Altiplano region as *estiloso*, with a strong smell and thick (thick mouthfeel). Moreover, these participants characterized *pulques* from Valle del Mezquital as mild-tasting, foamy, and thin mouthfeel.

Although other authors (35) have revealed better performance by the experts in terms of discrimination, memory or description of products compare to nonexperts, in our research both groups (producers, consider as experts and consumers which are nonexperts) were able to discriminate *pulques* taking into account their sensory attributes. Escalante et al., (1) have reported the most evident attributes of this beverage such as color, viscosity and acid taste.

In recent years, there has been anecdotal evidence from producers and consumers suggesting that *pulques* from Valle del Mezquital region are milder in flavor and thinner than *pulques* from the Altiplano region. The sensory characteristics of *pulque* are the result of the complex microbiota, which is affected by the variety of agave, the manufacturing process, and by the harvesting conditions of the sap (33).

Due to their location, the studied regions present different climatic characteristics. The Altiplano region is the lower part of the basin that is surrounded by the volcanic axis. As a result of the formation of lakes, the land in this region is more fertile than Valle del Mezquital region. Altiplano region is characterized by not very elevated plains and hills. Although its vegetation is sparse, this region is suitable for growing agave plants. The climate is subhumid, not extreme and temperate with rains in summer (36). On the contrary, a large part of Valle del Mezquital region has a dry climate with precipitation less than 600 mm. The communities of Actopan and El Arenal are located in the central area of this region (36).

Therefore, it is reasonable that the *pulques* produced in each of these regions have distinctive sensory characteristics. Besides, most of the national *pulque* production is artisanal without standardized conditions. Under this type of production, the fermentation process changes due to several factors such as geographic and weather conditions and *aguamiel* quality, which lead to a wide variability in the final product (1, 9). The general trend is towards an increase in the consumption of *pulque* (25). Its nutritional and healthy qualities are some of its strengths (1). *Pulque* consumption is marked by local culture, it is emblematic of the diet of some indigenous peoples such as the Otomí culture (hñähñú) (37) and is part of our history and tradition as Mexicans.

It is hard to obtain lots of *pulque* with similar characteristics due to factors that affect its artisanal production. For this reason, it is necessary to have sensory information on *pulques* of different origins to promote them as quality products despite the lack of homogeneity between them.

The sorting task method is useful in the evaluation of complex and difficult-to-standardize samples such as *pulque* since it allows to quickly obtain a general measure of the differences and similarities perceived in the product. This method allowed us to find out that perceptual product discrimination

exists between *pulque* from two different artisanal producer regions. Our results provided a general view about whether *pulque* attributes were relevant to describe this beverage based on perceptions of consumers and producers.

4. Conclusions

The classification of *pulque* from two different regions was possible through the elicitation of the main sensory attributes perceived by producers and by consumers using the sorting method. The region of origin of *pulque* determined the sensory characteristics that allow its differentiation, in this case, flavor and texture. In this research, being familiar or not with pulque had a significant effect on its perception. Producers described pulque with terms related to quality parameters associated with fermentation. For this reason, it would be important to include them in a panel dedicated to the characterization of *pulque* in their context of origin. This would contribute to homogenize the final sensory quality of pulque, which could favor a large-scale production in the medium term. This experiment contributed to the sensory characterization of *pulque* produced in Hidalgo, the main producer state in Mexico. Nevertheless, further research on sensory tasks about this emblematic fermented beverage is needed, especially quantitative studies as well as hedonic tests involving a large number of participants and *pulque* from different geographical zones.

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