Biotecnia
Revista de Ciencias Biológicas y de la Salud
www.biotecnia.uson.mx
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SENSORY ANALYSIS AND MINOR VOLATIL COMPOUNDS OF DISTILLED FROM *Agave angustifolia* HAW (BACANORA)

ANÁLISIS SENSORIAL Y DE COMPUESTOS VOLÁTILES MINORITARIOS EN DESTILADOS DE *Agave angustifolia* HAW (BACANORA)

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ABSTRACT

The aims of this study were to evaluate sensory profile of 44 bacanora drinks elaborated in the area of origin denomination for bacanora, and the sensory analysis of preference with regular consumers of the beverage. The trained panel could distinguish eight different profiles and described various attributes for aroma, flavor, taste and trigeminal sensations. The samples showed differences in the sensory attributes to A-smoke, A-smoky, A-citric, A-leather, A-straw, F-citric, F-leather and F-straw examined by the trained panel ($P \leq 0.05$), this is related to the type of processing, which is very rudimentary. We could not determine more significant variations in the attributes, since the samples were highly variable among the area with origin denomination, and even among the same producer. Some minor compounds are related to the raw material (aroma and flavor of agave and green agave) and others to the fermentation process (fruity, alcohol, etc.). It is possible that these compounds have an important role in the impact of the flavor and authenticity of this drink. The consumer sensory analysis showed that the profile represented by sample 72 (Huepac municipality), was preferred by 41 % of the consumers and it was described as a soft drink with smell, flavor and body.

Key words: bacanora, *Agave angustifolia* Haw, sensory attributes, volatile compounds.

RESUMEN

En este trabajo se evaluó el perfil sensorial de 44 bebidas de bacanora elaboradas en el área con denominación de origen bacanora (ADOB), y se correlacionaron los perfiles sensoriales obtenidos con algunos compuestos minoritarios encontrados en las bebidas. Adicionalmente se realizó un análisis sensorial de preferencia de los diferentes perfiles de bacanora con consumidores. El panel entrenado pudo diferenciar ocho perfiles diferentes y se describieron diversos atributos de olor, aroma, gusto y sensaciones trigeminales. Las muestras mostraron diferencias en los atributos sensoriales de olor y aroma de: O-humo, O-ahumado, O-cítrico, O-cuero, O-paja, A-cítrico, A-cuero y A-paja examinados por el panel entrenado ($P \leq 0.05$), relacionándose éstos con el tipo de elaboración, la cual es muy rudimentaria actualmente. Algunos compuestos están asociados a la materia prima (olor y aroma a agave, a agave verde) y otros al proceso de fermentación (frutal, alcoholizado, etc.), que posiblemente tengan una participación importante en el impacto del aroma y tipicidad de esta bebida. El análisis con consumidores mostró que el perfil del municipio de Huépac fue la preferida con un 41 % y se describió como una bebida suave, de buen olor, sabor y con cuerpo.

Palabras clave: bacanora, *Agave angustifolia* Haw, atributos sensoriales, compuestos volátiles.

INTRODUCTION

In México there are different agave distilled beverages, which are having a boom internationally as tequila, mezcal and bacanora. The principal differences between the drinks comes from the type of agave used as raw material, which contains fructans (graminans and branched neo-fructans) as storage material of the plant (Mancilla-Margalli y López, 2006; Lappe-Oliveras *et al*., 2008).

The bacanora is a traditional drink of the state of Sonora, México, which is made by artisanal methods in the Area of Origin Denomination for Bacanora (AODB), that include 35 municipalities, located mostly in the mountains of Sonora (Gutiérrez-Coronado *et al*., 2007; Álvarez-Ainza *et al*., 2009). The elaboration of bacanora begins with the collection and *jima* of the pineapples of wild agave. Later, a cooking of the pineapple in rustic and underground ovens needs to be performed in order to hydrolyze the stored carbohydrate and facilitated the crushed of the pineapple. During cooking, it has been observed that some important compounds involved in the sensorial characteristics of the final product are formed, like some aldehydes and Maillard compounds (Muñoz-Rodriguez *et al*., 2005; Lappe-Oliveras *et al*., 2008). Once the pineapples are ready, these are crushed and shredder and subjected to a natural fermentation for se-

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Recibido: 11 de febrero de 2015
Aceptado: 27 de noviembre de 2015

veral days, which is performed by the microbiota present in the must, time varies depending on the region, temperature and water conditions. Finally, the fermented must is distilled twice, thereby a product of 38-55 % of alcohol is obtained (Gutiérrez-Coronado *et al*., 2007; Lappe-Oliveras *et al*., 2008; Álvarez-Ainza *et al*., 2009; D.O.F, 2004). Some studies based in agave beverages, showed that different compounds are involved in the aroma and flavor: alcohols, fatty acids, esters, aldehydes, terpenes, phenols, lactones, sulfur compounds, etc. (Álvarez-Ainza, *et al*., 2013; Vallejo-Córdoba *et al*., 2004; de León-Rodríguez *et al*., 2008). The alcoholic beverage has a primary aroma, which comes from the raw material used, in the agave-distilled beverages comes from the type of agave. A second scent comes from the fermentation, distillation and maturation of the product (Peña-Álvarez *et al*., 2004).

The aroma is constituted by various volatile compounds such as aromatics, which are found in relatively high concentrations called majority compounds, some of them are toxics (like methanol), in this way the process must be verify and subjected to evaluation and compared with official standards. There are also compounds in lower concentrations, called minority compounds. These include esters, aldehydes, ketones, organic acids, fatty acids, furans, terpenes, naphthalene and alkenes, which have a major impact on the aroma and flavor of the beverages, thanks to the harmony that their combination presents (Peña-Álvarez *et al*., 2004; de León-Rodríguez *et al*., 2006; de León Rodríguez *et al*., 2008; Vera-Guzmán *et al*., 2009). However, the quality of beverages is not only to satisfy the specifications of official standards, but also to other factors, the most important is the consumer acceptance, according to the sensory characteristics perceived. These are associated with the composition of the drink, because of volatile compounds interaction among themselves and the consumer´s palate are going to produce the sensation of taste and scent (Tesevic *et al*., 2005). Nowadays there are no reported studies for most of the Mexican beverages obtained from agave distillation. In addition, there is a lack of information for sensory analysis data. Particularly for tequila, several characterization studies have been performed, however due to industrial policies just a few of them are published, whereas for other distilled beverages no studies have been performed since they are still artisanal products. Is currently unknown which is the sensory profile of the bacanora and what the consumer preference is on the elaborated beverage in AODB. Therefore, the aims of this study were to determine the sensory profile of bacanora produced in AODB and its correlation with some minor compounds, as well as sensory analysis of preference of the different profiles from the bacanora distilled with regular consumers of the drink.

MATERIALS AND METHODS

Bacanora Samples

Forty-four white bacanora samples were used in this study, all obtained from the area with origin denomination for bacanora, the major compounds are described in the study of Álvarez-Ainza *et al*. (2013), and all the samples comply with the official standards for this beverage (D.O.F., 2004).

Analysis of gas chromatographic-Spectrometry (GC-MS). The analysis was conducted at the Analytical Laboratory of Casa Herradura S.A. de C.V. The determination of minority volatile compounds was performed in a gas chromatograph (6890N UF10208014 Agillent Technologies) using a capillary column HP-FFAP (25 m, 0.20 mm i.d., 0.33 mm film thickness; Agilent Technologies Inc., Wilmington, DE., USA), coupled to a mass spectrometer and a flame detector (FID) (5973N NS US104482288, Agillent technologies). The determinate compounds were: propanol, 2-methyl-1 propanol (isobutanol), hexanoate, octanoate, ethyl, ethanoic acid (acetic acid), trans-2-nonenal, propionic acid, 5-methyl-fufural, butyric acid, isovaleric acid, α-terpineol, phenyl ethyl acetate, ethyl dodecanoate, hexanoic acid, 5-methoxy-phenol (guaiacol), phenethyl alcohol, tetradecanoic acid, octanoic acid, 2-isopropyl-2-methylphenol (carvacrol), hexadecanoate ethyl decanoic acid and isoeugenol from 44 bacanora samples obtained from AODB. To determinate the concentrations of all compounds a curve standard were used and 2-pentanol was used as internal standard (all from sigma Aldrich, St. Louis, MO., USA). No more details of the methodology can be described due to confidentiality reasons of the company.

Sensorial analysis with trained panel and consumers

Trained panel

The sensorial panel (30 judges) for the bacanora beverage analysis previously trained for the sensorial analysis, belong to the Tequilera Casa Herradura Company. Group sessions were used with the purpose of unify the attributes terms, and a profile sensorial was described by the 30 trained judges with commercial bacanora, where the judges described each of the attributes with major mention.

Sorting. This sensory evaluation was conducted with 44 drinks of white bacanora, the samples tested met the specifications of the official standards (D.O.F., 2004). First, the samples were diluted to 20 % alcohol and presented to the judges in cups of glass with watch glasses and identified with a three digit code at random numbers, water and cookies were available to clean the mouth between each sample, and the assessments were carried out in individual booths under red light. The samples were given to the judges using an incomplete Latin Squares. 6 samples were repeated in order to have a total of 50 samples and it had 5 blocks of 10 samples per session and 5 sessions. Then each judge evaluated the same number of samples and each sample was assessed the same number of times. In this analysis, the trained panel of judges grouped the samples by similitude and differences criteria and gave qualitative description of each group of samples.

Descriptive Analysis (DA). The DA tests were performed using a list of attributes pre identified by 30 trained judges, each attribute was measured with an intensity scale from 0 to 15, where 0 is nothing, 5 is light, 10 is moderate and 15 is strong. The samples were diluted at 20 % alcohol and presented to the judges in glass cups covered with watch glasses and identified with a three digit code at random numbers. Water and cookies were available to clean the mouth between samples and the assessments were carried out in individual booths under red light.

Consumer's sensorial Analysis. The consumer analysis was performed by using a hedonic scale to enhance the data, some question for comments from the consumer were included. The samples were presented as they were obtained from the producers without standardization (same production proof), and presented in glass cups covered with a watch glass and identified with three digit at random numbers. Water and cookies were available to clean the mouth between samples.

Statistical Analysis. Sorting analysis was done using multidimentional scaling technique (MDS) and STATISTICA (data analysis software system), version 6. These technique develop a spatial representation of similarity between samples. This means that the objects are represented as points in a multidimensional vector space. Data from the DA of the sensory attributes were normalized by the formula observed value-media/standard deviation. Subsequently, an analysis of variance (ANOVA) was conducted to estimate differences among the selected samples by each sensorial attribute. The means comparison was performed using the Tukey-Kramer test. The significances were considerate to a level of 0.05 in error type I. Additionally in order to estimate correlations between measured variables and reduce the dimensionality for interpretation it was carried out a principal component analysis (PCA). Finally, correlations were made between the minor compounds and sensory attributes. All analysis data were performed in the NCSS statistical package (Ve. 2007, Kaysville, Utah, USA).

RESULTS

Analysis of gas chromatography Spectrometry (GC-MS)

The concentrations were obtained by CG-MS for the 44 samples of bacanora (data not show). Table 1 show the representative concentrations of the minor compounds for each profile defined by the trained panel, for the sam-

Table 1. Concentrations of the minor compounds (ppm) of the different profiles described by the trained panel.
Tabla 1. Concentración de compuestos minoritarios (ppm) de los perfiles de bacanora descritos por el panel entrenado.

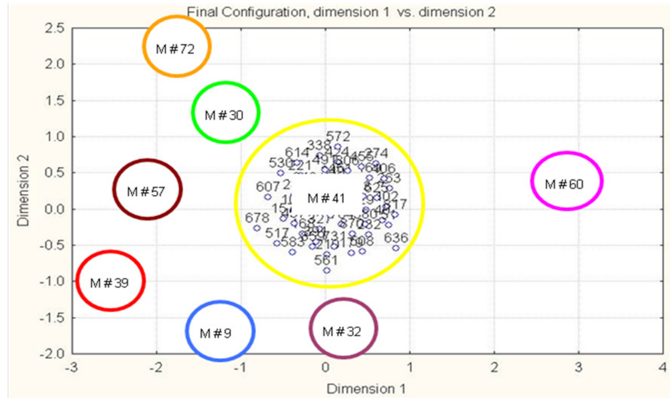
Minor compound	Profile 1 (S # 9)†	Profile 2 (S # 30)†	Profile 3 (S # 32)†	Profile 4 (S # 39)†	Profile 5 (S # 41)†	Profile 6 (S # 57)†	Profile 7 (S # 61)†	Profile 8 (S #72)†
1-Propanol	151.915	113.710	64.685	62.785	47.195	53.180	61.150	31.610
Isobutyl alcohol	229.195	122.500	314.420	308.110	302.885	371.640	294.685	207.315
Hexanoic acid	1.705	0.210	1.780	0.550	1.020	N.D.	1.345	0.675
Isoamyl alcohol	945.595	701.800	1306.890	1135.335	1229.795	1078.960	1177.285	714.065
Ethyl lactate	70.790	85.030	90.545	71.680	72.835	111.790	92.365	75.535
Ethyl caprylate	8.595	0.760	5.095	1.750	3.905	3.095	6.555	2.530
Acetic acid	496.955	356.880	865.055	698.525	1014.745	1305.230	782.290	195.585
Trans-2-nonenal	N.D.	N.D.	N.D.	0.380	N.D.	0.400	0.405	N.D.
Propionic acid	7.950	8.910	N.D.	8.430	7.350	10.130	8.600	N.D.
5-Methyl furfural	0.390	3.840	2.005	1.490	2.090	24.565	10.700	2.610
Butanoic acid	10.755	6.130	6.005	3.990	4.635	4.985	4.150	3.970
Isovaleric acid	1.850	1.680	1.970	N.D.	N.D.	3.785	1.980	1.350
Alpha terpineol	6.025	4.850	4.130	6.850	4.435	5.485	6.255	1.875
Phenethyl acetate	N.D.	0.610	0.165	0.270	0.200	0.095	0.255	0.020
Ethyl laurate	5.230	3.150	2.735	0.670	1.040	2.580	4.140	1.535
Guaiacol	2.140	N.D.	N.D.	N.D.	N.D.	2.620	1.895	N.D.
Pheneteyl alcohol	26.320	48.590	54.805	46.715	43.045	47.870	48.665	22.690
Ethyl myristate	0.680	0.190	0.610	N.D.	N.D	1.000	1.220	0.630
Octanoic acid	11.515	5.760	5.650	4.490	4.620	15.260	5.755	3.270
Carvacrol	0.390	N.D	0.370	0.360	N.D.	0.460	0.395	N.D.
Ethyl palmitate	2.605	0.990	1.730	N.D.	1.805	6.000	3.905	3.675
Decanoic acid	17.005	N.D.	4.905	5.425	3.150	19.840	8.290	2.485
Isoeugenol	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	1.620	N.D.

ples encoded as: 9, 30, 32, 39 41, 57, 60 and 72. The minor compounds detected include chemical groups such as aldehydes, ketonas, alcohols, organic acids, fatty acid ethyl ester, furans and terpenes, as other agave beverage as tequila and mezcal. The presence of these minor compounds is important for each kind of beverage; they will provided the harmony and balance and gives the characteristics unique of each product (de León-Rodríguez *et al*., 2006; 2008). The flavor characteristics are the result of complex interactions among three principal factors: raw material, yeast strains involved and technical conditions of elaboration. The capacity to form aroma depends not only on yeast species but also on the particular strains of the individual species (Torrens *et al*., 2008). Twenty-three minor compounds were determined, but not all of them were detected in the different profiles of the bacanora beverage, the compounds tras-2-nonenal, propionic acid, isovaleric acid, 5-methoxy-phenol and decanoate ethyl ester, where not detected in all the samples; it is possible that this compounds are present at a lower concentrations and they were not detected. As in other beverages obtained from agave an abundant group of ethyl esters were quantified, which are associated with the bouquet and pleasant fruity flavors, these compounds have been detected in other alcoholic beverages such as tequila, mezcal, whiskey and cognac (de León-Rodriguez *et al*., 2006, Ledauphin *et al*., 2004). The terpene compounds are identified in other agave beverages; alpha-terpineol was found in mezcal produced with *A. angustifolia* as bacanora. It has been reported that terpenes are liberated by β-glycosidasas from yeast during the fermentation process.

Sensorial analysis with trained panel and consumers

Sorting. The sensory analys was carried out using sorting with a trained panel which helps to classify the samples by grouping them with similar characteristics. From this analysis 8 groups or profiles were obtained (Figure 1). From these, 7 were composed of a single sample, and the majority group, was composed of 37 samples. Surely bacanora samples are very similar among them, possibly because of the way that craftsmanship is always done. The profiles with only one sample belonged to the municipalities of Moctezuma (two samples), Cumpas (two samples), Opodepe (one sample), Tepache (one sample) and the last one from Huépac. The sample represented the eighth group that was also produced in Opodepe, so we can assert that the judges were able to discriminate between samples of the same municipality.

Also, in the sorting analysis, the judges were asked to describe the attributes they perceived in the samples, they coincide in most samples. The perceived attributes were distinguished by the nose directly (aroma); retro-nasally to test the samples (flavor), and those perceived by the taste and trigeminal sensations (both perceived by tongue). For aroma (A) and flavor (F) the judges description notes were of: Heartburn, cooked agave, green agave, smoked, citrus heads, menthol, straw, oil, drunk, floral, leather, herbal, metal, moisture, smoke, mold, ordinary, plastic, burnt, solvent, wet earth



Each circle represent a profile identified by the training panel, the number indicate the sample used for analysis of post-sorting (DA and consumer analysis).
Cada circulo representa un perfil identificado por el panel entrenado, el número índica la muestra que fué utilizada en el análisis post-sorting (Análisis descriptivo y con consumidores).

Figure 1. Bacanora Sensory analysis by sorting with trained panel of 44 samples of various municipalities from AODB.
Figura 1. Análisis sensorial por Sorting de 44 muestras de Bacanora de diferentes municipios del ADOB.

and tufts. For taste (T) notes were: sweet, sour and bitter; as of for the trigeminal sensations (TS) the attributes of astringent, spicy and burning. The attributes found in the drink are due to the raw material (green agave, cooked agave, smoked, smoke, etc) and the fermentation process (fruity, alcohol, etc.), especially the last one, which is when the compounds produced aroma by the yeasts present (de León-Rodríguez *et al*., 2006; Díaz-Montaño *et al*., 2008; Lachenmeier *et al*., 2006).

Descriptive Analysis (DA). Figure 2 show the scores assigned by the judges to aroma, taste and trigeminal sensations only. Flavor was omitted to see the chart better, which is still difficult to appreciate due to the number of samples and

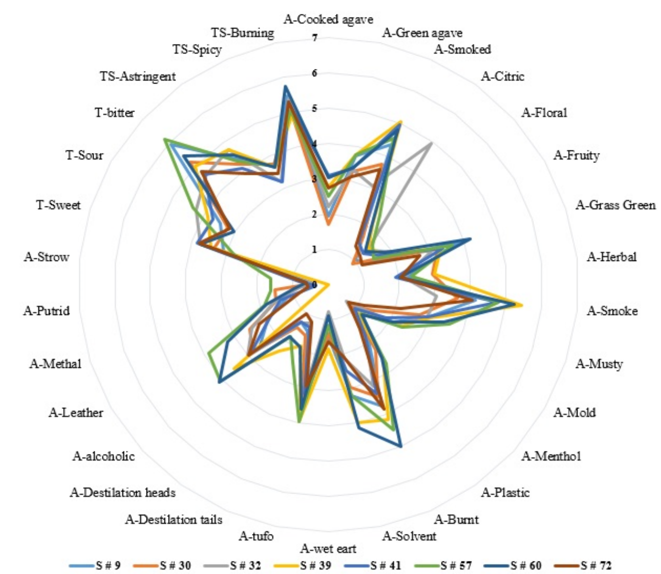


Figure 2. Descriptive analysis attributes of the eight profiles identified by the trained panel (each color represents a profile).
Figura 2. Análisis descriptivo de los ocho perfiles identificados por el panel entrenado (cada color representa un perfil).

attributes. The ANOVA showed statistical differences between the attributes of aroma A-smoke, A-smoky, A-citric, A-leather, A-straw and flavors F-citric, F-leather and F-straw (P ≤ 0.05, see Table 2). Given the differences in this notes of aroma and flavor or attribute it can be distinguish different profiles with particular attributes, also there are showed some attributes that are directionally significant like A-smoke, A-metal and A-oil (P ≤ 0.1). It´s possible that the way of brewing is still very similar among the producers, since there were no major differences between the other attributes, and talking about the A-smoky the difference in this attribute indicates that the type of cooking is a very important factor in bacanora development. Also the fermentation process could be an important step due with the cooking in the procedure given to the difference in citric and straw attributes. The rudimentary ovens used without temperature control, nor the wood used in the cooking, could cause the differences in this aromatic note. It has been reported in other drinks, that the smoke notes are given by guaiacol and this compound also could be produced by some non-*Saccharomyces* yeast (Been y Peppard, 1996; de León-Rodríguez *et al*., 2006; Molina-Guerrero *et al*., 2007; Vera-Guzmán *et al*., 2009). The fermentation procedure is carried out by native yeast, this means that inoculum is not used, and this may be an important factor to the difference in the profiles identified by the judges. The citric character of the profiles can be due to the production of organic acids in the fermentation procedure, it is known that non-*Saccharomyces* yeast produce a lot of compound, different to the ethanol and provides different attributes to the drink. This kind of yeast had an important participation in the fermentation procedure of the bacanora (Gallardo-Valdez *et al.*, 2008).

The mezcal from the state of Michoacan has been reported to have significant sensory differences with the smoked and green mezcal notes from the raw material and type of processing which is also handcrafted. Distiller beverages are complex mixtures of many individual aroma compounds in an ethanol-water matrix. These compounds originate from both the raw material and production processes of mashing, fermentation, distillation and maturation. In all distilled beverages the same compounds are generally present but in different amounts and ratios contributing to the final perceived aroma. Traditional distilled beverages are divided into two groups, those in which the flavor is derived essentially from the raw materials and the particular conditions of process (Scotch whisky, Cognac, Grappa, Rum), and those using a neutral alcohol source into which selected flavoring materials are incorporated (Gin, Acquavite and those containing high levels of sugar such as liqueurs) (Mc Donnell *et al*., 2000).

Principal components analysis (PCA). The different profiles were analyzed using principal compounds (PC) for reducing dimensionalities of the results obtained by the DA for the trained panel. The PCA found four main compounds (PC1, PC2, PC3 and PC4) with an eigenvalue above 1 (Goldner y Zamora, 2007). The four main compounds explains for the approximately 65.07 % of the total variance of the data obtained by the DA (Table 3). The PC1 is a positive component and an average of attributes F-tuff, F-smoke, F-herbaceous, F-smoked, A-alcohol, A-tuff, A-solvent, A-smoke and A-herbaceous.

The PC1 suggest that there are beverages in the AODB with characteristics for these attributes that can be described by them. Many of these attributes are due to the processing of raw materials and even the raw material itself, as well as the fermentation process. The PC2 is a contrasting component, that has positive coefficients for the attributes of F-solvent, A-stuff, A-solvent and with the negative coefficients for the attributes of the A-agave, A-smoked, F-green agave. This component suggest that there is a group of bacanora drinks

Table 2. Analysis of variance of some attributes present in the different profiles of bacanora found by the trained panel.
Tabla 2. Análisis de varianza de algunos atributos presents en los perfiles de bacanora descritos por el panel entrenado

Attribute	Profile 1 (S # 9)†	Profile 2 (S # 30)†	Profile 3 (S # 32)†	Profile 4 (S # 39)†	Profile 5 (S # 41)†	Profile 6 (S # 57)†	Profile 7 (S # 60)†	Profile 8 (S #72)†	Comp. F	Probability
A-Smoky	4.72 ab	3.81 ab	3.91 ab	4.59 ab	5.83 a	2.29 b	5.34 a	5.53 a	3.28	0.0025 *
A-Citric	1.84 a	1.59 a	1.24 a	1.54 a	2.05 a	6.05 b	2.21 a	1.98 a	11.37	0.0001 *
A-Smoke	3.71	4.33	3.65	4.67	5.26	2.67	4.78	5.24	2.04	0.0515
A-Leather	2.38 ab	2.15 ab	2.52 a	2.16 ab	3.19 a	2.23 ab	4.17 a	0.00 b	4.15	0.0003 *
A-Metal	1.04	1.07	0.81	0.55	1.28	1.46	2.00	0.00	2.05	0.0511
A-Strow	0.52 ab	0.48 ab	0.75 ab	0.81 ab	1.19 ab	0.86 ab	1.97 a	0.00 b	2.64	0.0124 *
A-Oil	0.77	0.84	0.55	0.76	1.61	0.47	1.46	0.00	1.91	0.0695
F-Citric	1.63 a	1.67 a	1.34 a	1.48 a	2.06 a	4.94 b	2.46 a	2.12 a	6.35	0.0001 *
F-Leather	1.96 ab	2.52 a	2.24 ab	1.90 ab	3.23 a	2.47 b	3.87 a	0.00 b	4.66	0.0001 *
F-Putrid	0.98	1.48	0.56	0.35	0.95	0.83	1.60	0.00	1.98	0.0593
F-Strow	0.47 ab	0.47 ab	0.65 ab	0.81 ab	0.61 ab	0.37 ab	1.60 a	0.00 b	2.08	0.0470 *

A= aroma; F= flavor; same letters are not statistically different (Tukey 0.05); *: P ≤ 0.05; †: sample code who represent each profile.
A= aroma; F=olor; mismas literales son no significativamente diferentes (Tukey 0.05); * P ≤ 0.05; †: codigo de la muestra que representa a cada perfil.

Table 3. Component principal analysis of the different attributes of the profiles founded by the trained panel.
Tabla 3. Análisis de components principales de los diferentes atributos de los perfiles descritos por el panel entrenado

Component	Eigenvalor	% variance explained	% cumulative variance explained
PC1	9.09	43.33	43.33
PC2	1.82	8.69	52.02
PC3	1.52	7.25	59.28
PC4	1.21	5.79	65.07
Total	13.64		65.07

with a large amount of positive attributes associated with the fermentation process and small amounts of negative attributes associated with the raw material. The PC3, like the previous component, is also contrasting with attributes with positive coefficients of ST-astringent, TS-tangling, TS-burning and negative attributes of A-herbaceous and F-herbaceous.

Correlations between the sensorial attributes and minor compounds. The correlations between the attributes of the profiles found and the minority compounds of the representative samples are showed in table 4. A significant correlation was found (P≤ 0.05) for the compound terpineol with the attributes of A-green agave (0.82) and A-solvent (0.68), this compound has a descriptor, to delicate odor of flowers, oil pines and conifers. The compound 2-isopropyl-2-methylphenol (carvacrol) correlates with F-green agave (0.69), F-herbaceous (0.77) and T-sour (0.81), this compound has been described with aromatic notes of oregano and spices. Decanoic acid correlated with A-tuff (0.69), F-green agave (0.75), T-sour (0.94) and T-sweet (0.87), whose descriptors are fatty acids, dry, woody and citrus. Acetic acid was correlated with T-acid (0.71) and its descriptor is vinegar. The compound ethyl octanoate was correlated with TS-warm (0.71) and has as descriptor the hot sensation. The compound 5-methoxy-phenol (guaiacol) showed correlation with F-herbaceous (0.73), A-burning, T-bitter (0.85) and has as descriptors smoke and phenolic compounds. Isovaleric acid was correlated with T-sour (0.74) described by the aroma of blue cheese. Octanoic acid was correlated with T-sweet (0.86) and T-sour (0.67), whose descriptors reported for this compound are the rancid butter, milk, dry, stale and hard. Finally, hexanoic acid was positively correlated with ST-warm (0.84) and has as descriptors the aroma of cheese and sweat (Been y Peppard, 1996; De León-Rodríguez *et al*., 2006; Molina-Guerrero *et al*., 2007; Bellon *et al*., 2011).

The correlations suggest that the sensory attributes associated with the different compounds are highly involved in the aroma of the beverage since being minor compounds could be perceived by the judges. It has been observed in other beverages that compounds like terpenes (such as terpineol and carvacrol) are notes desirable of flavor and nice smells, these compounds come from the agave, they are part of the primary aroma. Possibly the guaiacol is formed during the cooking of the agave pineapples, giving aromatic notes of smoke, which has an important impact on the aroma of the beverage, being one of attributes that showed significant differences (Peña-Alvarez *et al*., 2004). Acetic acid is a compound formed from the cooking of pineapples and during fermentation by acetic acid bacteria, as suggested Vera-Guzman *et al.* (2009). Other acidic compounds, alcohols and esters correlated with the attributes identified by the judges in this study, and it might be a result of the yeast metabolism during fermentation. On the other hand, significantly attri-

Table 4. Pearson Correlations* of minor compounds with sensory attributes of Bacanora Alcoholic Beverage.
Table 4. Correlaciones de Pearson* de los compuestos minoritarios con los atributos sensoriales descritos en las bebidas de bacanora.

Minor Compounds	Terpineol	Carvacrol	Decanoic acid	Acetic acid	Ethyl octanoate	Guaiacol	Isovaleric acid	Octanoic acid	Hexanoic acid
A-Green agave	0.82	-----	-----	-----	-----	-----	-----	-----	-----
A-Solvent	0.68	-----	-----	-----	-----	-----	-----	-----	-----
F-Green agave	-----	0.69	0.75	-----	-----	-----	-----	-----	-----
F-Herbaceous	-----	0.77	-----	-----	-----	0.73	-----	-----	-----
T-Sour	-----	0.81	0.94	-----	-----	-----	0.74	0.67	-----
A-Tuff	-----	-----	0.69	-----	-----	-----	-----	-----	-----
T-Sweet	-----	-----	0.87	-----	-----	-----	-----	0.86	-----
T-Acid	-----	-----	-----	0.71	-----	-----	-----	-----	-----
TS-Warm	-----	-----	-----	-----	0.71	-----	-----	-----	0.84
T-Bitter	-----	-----	-----	-----	-----	0.85	-----	-----	-----

*Significant correlations (P<0.05).
*Correlaciones con significancia estadística (P<0.05)

butes were not found on other key compounds, besides the guaiacol produced during fermentation.

Sensory consumers test. Once established bacanora profiles and their differences, these beverages were tested with consumers. A test of preference ranking or ordering was conducted, where consumers showed a preference for any of the profiles. 40 % of the consumers showed a preference in the profile with the sample represented with key 72, belonging to the municipality of Huépac, followed by the profile represented by sample 41 with 33 % belonging to the municipality of Opodepe. Sample 71 was described by the judges with the profile 8 (Table 1), and it shows that values of aroma, taste and trigeminal sensations are centralized respect the others beverages. This sample has few undesirable descriptors, standing out those of smoke and citric aroma and citric flavor. Additionally we obtained some beneficial comments about the sample among people who like Bacanora and they characterized the beverage as good taste, they like the scent of the aroma, the softness, good smell, taste, beverage was not very strong, and it has body. According to these results, each producer must innovate in their process, to define what profile of attributes they prefer for their product.

CONCLUSIONS

Most of the compounds quantified were found in other alcoholic beverages as tequila and mezcal. The trained panel could distinguish eight different profiles among 44 samples from the AODB. They described various attributes of aroma, flavor, taste and trigeminal sensations. Representative samples from each profile showed differences in sensory attributes, for the aroma and flavor A-smoke, A-smoky, A-citric, A-leather, A-straw, F-citric, F-leather and F-straw, related to the type of processing, which is very rudimentary. Possibly the compounds that show statically differences have an important role in the impact of the aroma and authenticity of this beverage. The analysis with consumers showed that sample 72 of the municipality of Huépac was preferred by 41 % and it was described as a soft beverage, with good smell and taste, it was not too strong and it is fully bodied.

ACKNOWLEDGEMENTS

The authors would like to thank and devote this manuscript to Evelia Acedo-Felix† who made this work possible, to the Consejo Nacional de Ciencia y Tecnología, México, (CONACyT), for the scholarship to M. L. Álvarez-Ainza. The authors also thank to the producers involves in the Bacanora production, to Casa Herradura for the technical support (Karina Enriquez, Elba Ochoa) and Gutiérrez-Franco, L. E. by proofreading.

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