

Volatile and anionic composition of Mexican *Agave* spirits (Tequila, Mezcal, Sotol, Bacanora)

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Introduction:

The *Agave* genus with more than 200 species occurs natively in arid and tropical regions from southern USA to northern South America, and throughout the Caribbean. There are around 150 species of *Agave* plants native to Mexico. The most important economic use of *Agaves* is the production of alcoholic beverages such as Mezcal (*Agave angustifolia* Haw., *A. potatorum* Zucc., *A. salmiana* Otto, and other species), Sotol (*Dasylirion ssp.*), and Bacanora (*A. angustifolia* Haw.). All these spirits are obtained from the fermentation of agavins (fructooligosaccharides) from the different *Agave* species. However, the most popular contemporary alcoholic beverage made from *Agave* is Tequila, which is recognized worldwide. The production of Tequila is restricted to the blue *Agave* (*Agave tequilana* Weber var. *azul*, Agavaceae) and also to defined geographic areas, primarily to the State of Jalisco in West-Central Mexico. Following Tequila's appellation of origin, the other *Agave* distilled beverages from the States of Oaxaca, Guerrero, San Luis Potosí, Chiapas, Guajalajara, and Zacatecas (Mezcal), Chihuahua, Coahuila, Durango (Sotol) and Sonora (Bacanora), were granted equal recognition (Figure 1). All these regional drinks are subject to official standards, and their production is supervised by the Mexican government.

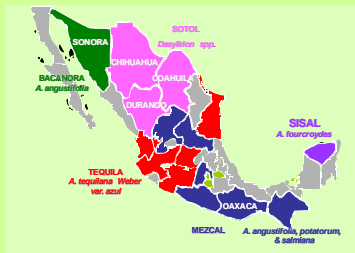


Figure 1. Geographical origins of Mexican *Agave* spirits.

Until now only Tequila and more recently Mezcal have reached international recognition, and especially in the last decade, the consumption of Tequila has tremendously increased worldwide. Tequila and Mezcal are protected under the North American Free Trade Agreement (NAFTA) and an "Agreement between the European Union and the United Mexican States on the mutual recognition and protection of designations for spirit drinks".

Due to frequent fraud (e.g. adulteration with grain spirits), the authenticity control of *Agave* spirits is of a high concern. To establish the authenticity of Tequila, different analytical studies have been performed, which include the detection of volatile compounds using gas chromatography (GC) or sensory techniques as well as SPME-GC-MS, FTIR, SIMCA-NEAR, GC-O, and GC-IRMS. All these studies permitted to set up qualitative and quantitative differences among all Tequila types. However, stable isotope values undoubtedly allowed a positive correlation to determine the plant origin. In this work Ion chromatography (IC) and GC are used for the first time to assess a large collection of Mexican *Agave* spirits.

Results and Discussion:

Anionic profile of Mexican spirits

An often neglected part in the quality control of spirit drinks is the ionic composition of the water used in their production. As a result of different processing conditions, the anionic profile of Tequilas bottled in Mexico showed major differences to those bottled in the importing countries. In this study significant differences were likewise found between Tequila (lower content of anions) and the other Mexican spirits (higher content, especially Sotol) (Figure 2). This finding can be explained by the fact that most Tequila distilleries employ technological advances e.g. water purification by reverse osmosis, whereas the other products are produced by rudimentary production methods.

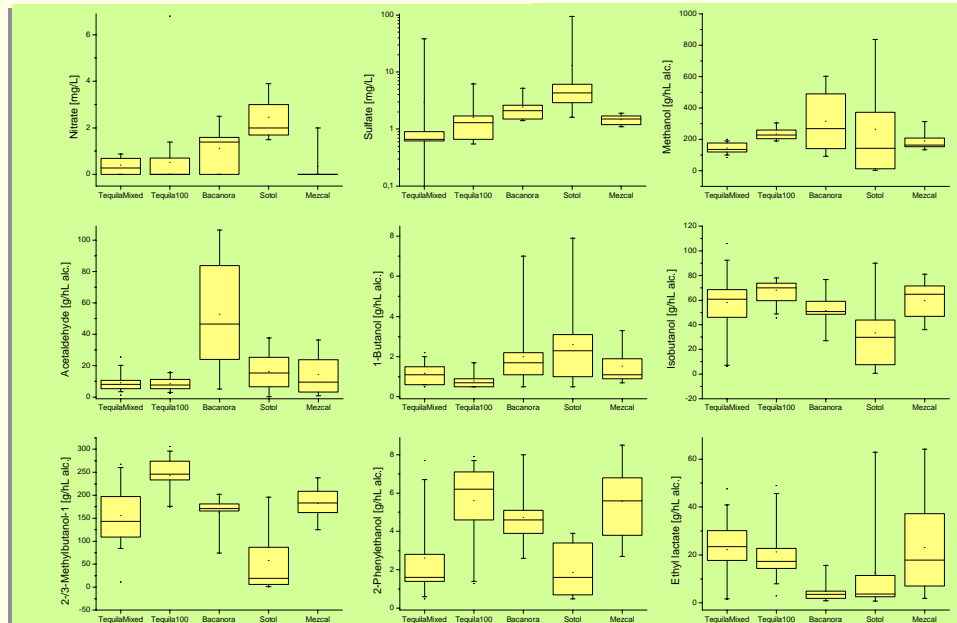


Figure 2: Box charts of analysis results with significant differences between the different types of Mexican *Agave* spirits.

Volatile composition of Mexican spirits

The production process is more rudimentary for Mezcal, Sotol, and Bacanora than for Tequila. A main difference is that the fermentation step is carried out without inoculation, whereas Tequila is normally manufactured using selected yeast strains. Relatively high genetic differences of yeasts isolated from Mexican *Agave* spirits were reported. The yeast strain is the most important factor influencing the amount of higher alcohols produced along with ethanol. Native strains isolated from Tequila were reported to produce higher amounts of such compounds like isoamyl alcohol and isobutanol compared to yeast strains employed in bakeries. The characteristic compound methanol is generated through hydrolysis of methylated pectins present in the *Agave* plant. Other volatile substances (often undesirable ones) might be produced as effect of bacterial contamination of the *Agave* wort.

Due to these different influences, it was not unexpected that the volatile profile of *Agave* spirits varies over a large range (Figure 2). Especially large variances are obvious for the spirits with rudimentary production methods, e.g. the methanol content of Sotol was in the range between 3 and 837 g/hL alcohol. This confirms the previous results that also found a large variance in the volatile composition and no significant differences in the profile of higher alcohols during the analysis of 21 Tequilas and 11 Mezcals. Our study is likewise confirmed by recent analysis results of Mezcals that found most of the compounds of Mezcal to be very similar to those present in Tequila. Only by use of pre-concentration with solid-phase microextraction it was possible to determine minor compounds (e.g. limonene) with differences between the alcoholic beverages.

Our study, however, does not confirm the previous view that Mezcal contains significantly higher contents of acetaldehyde and ethyl acetate than Tequila. Presumably the production methods of Mezcal have been improved since the 1990's when previous studies were conducted. The production of acetaldehyde and ethyl acetate as result of spoilage microorganisms (e.g. *Acetobacter*) is often correlated to production hygiene.

The methanol content was the most problematic compound regarding the Mexican standard. 2 Tequilas (4%), 5 Sotols (31%) and 6 Bacanoras (46%) had levels above the maximum methanol content of 300 g/hL alcohol. For Tequila, the exceedance (methanol: 304 and 308 g/hL alc.) of two 100% Tequilas was not significant. In contrast, Sotol (methanol: 371, 493, 653, 782, and 837 g/hL alc.) and Bacanora (methanol: 318, 483, 489, 502, 581, and 601 g/hL alc.) showed higher deviations than Tequila. It should be noted, that these methanol levels are not yet of toxicological relevance. These findings verify a previous study that described methanol as one of the most important problems for the producers of *Agave* beverages. The standards for higher alcohols were observed by all spirits except 4 Sotol samples (25%), who had concentrations below the minimum of 20 g/hL alcohol.

Conclusion:

The composition of Mexican *Agave* spirits was found to be relatively variable. The contents of methanol and higher alcohols completely comprise the whole range defined in the Mexican Official Standards. The relatively strict limits are exceeded in a significant number of cases (especially Sotol and Bacanora spirits).

The lowest variability showed Tequila, which is regulated strictly to one type of *Agave* and its production processes became technologically advanced after the worldwide success. The higher variability of Mezcal, Sotol and Bacanora can be explained beginning by the raw material used. A large variety of *Agaves* are allowed, the production is more rudimentary and the specifications are not as clear as for Tequila.

References:

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