SUSTAINABLE AND INTEGRAL EXPLOITATION OF AGAVE

Editor

Antonia Gutiérrez-Mora

Compilers

Benjamín Rodríguez-Garay

Silvia Maribel Contreras-Ramos

Manuel Reinhart Kirchmayr

Marisela González-Ávila

Index

Citation example:

Gutiérrez-Aguilar, P.R., Gil-Vega, K.C. and Simpson, J. 2014. Development of an *Agrobacterium tumefasciens* mediated transformation protocol for two *Agave* species by organogenesis. In: A. Gutiérrez-Mora (Ed.), B. Rodríguez-Garay, S. M. Contreras-Ramos, M. R. Kirchmayr, M. González-Ávila (Comps.), *Sustainable and Integral Exploitation of Agave*. Retrieved from: http://www.ciatej.net.mx/agave/1.7agave.pdf

ISBN: 978-607-96619-1-5

Published online: December 22, 2014

CONACYT

CIATEJ

Tequila and mezcal distillation technology: Similarities and differences

Rogelio PRADO-RAMIREZ*

Centro de Investigación y Asistencia en Tecnología y Diseño del Estado de Jalisco, A. C.
Normalistas 800. Colinas de la Normal. Guadalajara, Jalisco. México, 44270.

The goal of tequila and mezcal distillation is to concentrate and to separate ethanol and chemical compounds that impart to each product its characteristic sensory character. Tequila and mezcal elaboration processes have similar stages: raw material preparation, agave cooking, fermentable sugars obtaining, fermentation, distillation and finishing processes but for every step there are specific conditions that determine the production of chemical compounds that cause differences between they.
Distillation of these alcoholic spirits can be carried out by using differential and/or continuous fractionation with different conditions such as reflux, cutoffs of heads and tails, utilizations of equipment manufactured with copper or with stainless steel and heat supply rate, for instance. To know concentrations profiles of regulated compounds along distillation and relevance of heads and tails cutoffs is important in order to control the process and to meet official specifications, to keep sensory character and to improve process efficiency. These factors are reviewed as well as a thermodynamic factor, the activity coefficient, which can help us to understand the behavior of concentrations of regulated compounds along distillation. The role of materials of construction of distillation equipment on quality of distillates is analyzed because of the effect of copper as a catalyst of favorable reactions and finally is showed profiles of concentrations of regulated chemical compounds along distillation of mezcal, which can be considered to establish the size of heads and tails.

Palabras clave: tequila, mezcal, distillation, alembic, continuous column.

INTRODUCTION

Making of tequila and mezcal, both Mexican distillates with designation of origin and with international acceptance, includes some stages characterized by its technological advancement which for tequila is higher than for mezcal process. Both processes include agave cooking (wet for tequila and dry for mezcal), sugars extraction, fermentation and distillation. Tequila production is regulated by official norm NOM-006-SCFI-1994 and mezcal by norm NOM-070-SCFI-1994.

*Corresponding author: rprado@ciatej.mx

To carry out a distillation of fermented agave juice or from any fermented substrate, it is necessary to involve the following principles (Stichlmair and Fair, 1998): a) Creation of a two phase system, b) Mass transfer between both phases, c) Phases separation to obtain a different composition in each one. Developing of these steps demands a determined energy amount that is supplied like heat which is after removed by the condenser. Distillation needs an intimate contact between liquid and vapor phases, in such a condition, the chemical compounds in liquid phase transfer to vapor phase.

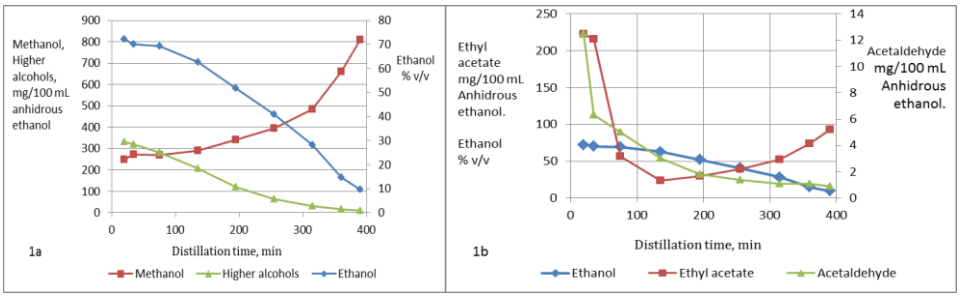
When we want to separate the less volatile components of a mixture, the distillation is called *stripping* and the separation of the more volatile compounds is called *rectification* or *enriching*. Separation of liquid mixtures with an important amount of volatile compounds, similar to those found in alcoholic spirits, involves mass transfer phenomena and thermodynamics of solutions, related to vapor-liquid equilibria, which is essential to solve and to estimate the efficiency of separation and the concentration of some compounds that are sensory significant. Fermented must and ordinario in tequila and mezcal processes are complex multicomponent mixtures because of the big amount of polar chemical compounds and can be considered nonideal mixtures and from a thermodynamic point of view calculations can be corrected introducing the dimensionless *activity coefficient*.

DISTILLATION PROCESSES IN TEQUILA PRODUCTION.

Batch distillation.

Tequila and mezcal can be distilled using a batch, or continuous scheme or under a combined arrangement batch-continuous or continuous-batch. In Jalisco, the main tequila producer state, most of companies use batch distillation but today increases the number of companies that make stripping or rectification or ethanol recovery from bottoms stream (vinasses) by using continuous columns. In batch distillation, the aim of the stripping is to obtain a distillate called *ordinario*, with 25-30% ethanol v/v. Some companies separate the first volume of distillate, called *heads*, and this cutoff is recycled to fermented must or pumped to the heads and tails storage tank. Stripping finishes when stream distillate has an ethanol content of 5-6% v/v. Goal of ordinario distillation is to increase the ethanol content up to 55% v/v and the product of this stage is called *rectificado*, which has most of the sensory compounds. In this step are also separated heads and the distillation continues up to the distillate has an ethanol content around 25% ethanol v/v. The distillate obtained after this cutoff is called *tails*.

Energy supply rate to alembic determines distillation time and ethanol concentration profile in distillate stream and the latter the profile of regulated compound as methanol, isoamyl alcohol, ethyl acetate and acetaldehyde. See Figures 1a and 1b. These profiles can be used to establish cutoffs of heads and tails remarking that acetaldehyde, ethyl acetate and isoamyl alcohol are found mainly in heads and higher methanol concentrations are found in tails.



Figures 1a, 1b. Regulated compounds along tequila batch distillation.

Continuous distillation.

Only few researches on tequila distillation using continuous column (CC) have been published. Prado (2002) evaluated continuous distillation using ordinario and feeding a 8 inches diameter and 20 trays copper CC. Experimental treatments included to feed at tray 17, after changing to tray 14. Alembic distillation with same ordinario was taken as reference. Rectified products were obtained with a 64.7%, 84.3% and 56.0% ethanol v/v content, respectively. GC-MS analysis were carried out and chemical groups of congeners in rectified products were identified I, see Table 1.

Table 1. Groups of chemical compounds identified in rectified products.

Compound	Treatment			
	Ordinario	Alembic	Column run 1	Column run 2
Ethanol	23.6	56.0	84.3	64.7
Higher alcohols	207.0	209.4	199.2	201.9
Methanol	286.0	263.2	343.8	248.3
Acetaldehyde	18.5	1.6	17.2	5.6
Ethyl acetate	87.4	44.5	65.1	47.2
Furfural	1.5	1.2	2.5	1.3

Small differences in number of congeners are attributed to the low amount of trays used in the enriching section of the column however was confirmed the feasibility to use of a CC to rectify ordinario without some reflux stream. Dávila (2004) evaluated continuous distillation by using a pilot packed column. Results showed an increase from 12.3 up to 64.4 and 74.5% ethanol v/v and concluding that this technique is feasible to recover heads and tails as well. Castro (2014) studied regulated compounds by using a 50 trays CC and feeding fermented must. Sampled trays in enriching section showed it is possible to draw off product with a similar ethanol content to the obtained using alembic. These results are congruent to obtained at pilot plan level. Concentration profiles of regulated compounds in enriching section of CC showed acetaldehyde and ethyl acetate have highest values in top trays; methanol increases slightly its concentration as increases ethanol content and isoamyl alcohol is concentrated at trays with an ethanol content about 70% v/v, underlying here the effect of an important thermodynamic factor as the activity coefficient, which was determined for every chemical compound using ternary mixtures at different v/v ethanol content (35%, 55%, 75 %), see Figure 2. The behavior of activity coefficient is useful to explain profiles of chemical compounds concentrations along distillation column trays.

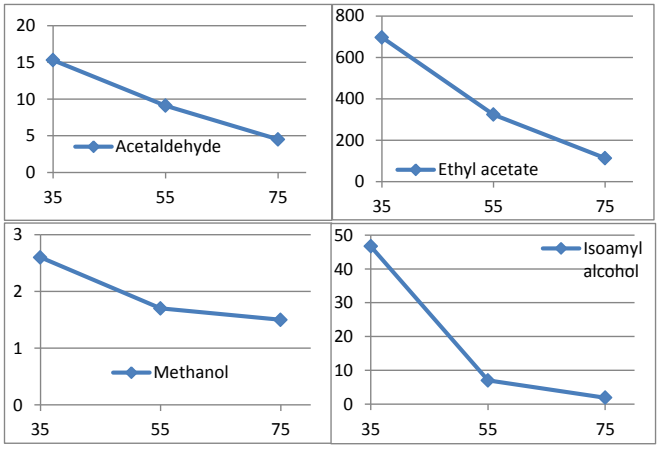


Figure 2. Activity coefficients for regulated compounds in ethanol-water mixtures.

Materials of construction of distillation equipment.

Alembics and columns have been traditionally manufactured with copper, but today, stainless steel has gained a higher relevance; besides, the role of copper has been understood because of its favorable effect on the sensory character of tequila and mezcal. This effect promotes removal of unpleasant smells (Nedjma, Hoffmann, 1996) due to thiols presence in distillates, however, some products obtained in copper alembic show higher copper concentration than the maximum allowed (2 mg/L, NOM-142-SSA1-1995).

DISTILLATION PROCESSES IN MEZCAL PRODUCTION.

Presently, most of mezcal is produced by using traditional alembics manufactured with copper, with a capacity from 400 to 800 L and distillation in two stages has substituted progressively the one stage distillation in order to meet official regulations. Mezcal distillation is carried out with *agave* bagasse and firewood as heat source. Distinctive sensory notes in mezcal include soil, smoke (Quiroz Marquez, 1997) and acidity. Regulated compounds exhibit a similar behavior than that found in tequila (see Figure 3) but irregular ethanol profile is caused because of the addition of water in the upper pipe of the boiler of alembic, which produces a reflux that increases at the moment the ethanol content in distillate stream.

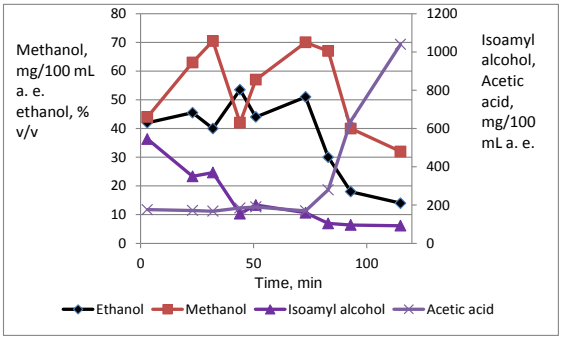


Figure 3. Regulated compounds in mezcal rectification.

CONCLUSIONS

Concentration of regulated compounds along tequila and mezcal distillation show similarities: highest concentrations of isoamyl alcohol, ethyl acetate and acetaldehyde are found in heads volume; methanol and acetic acid are found mainly in tails. Cutoffs of heads and tails are significant to regulate final concentrations in rectified products. Activity coefficient of regulated compounds explains to a great extent, their concentrations profiles along distillation. Alembics and continuous columns copper fully manufactured, produce tequila and mezcal with favorable sensory notes but with higher copper concentrations than those manufactured with stainless steel-copper. Mezcal industry exhibits a distillation process with a large amount of technological improvement opportunities in process and quality control areas.

REFERENCES

Castro P. (2014) Comportamiento del acetaldehído, acetato de etilo, metanol y alcoholes superiores en una columna de destilación. PICYT, Guadalajara, México.

Dávila Soto H. (2004) Recuperación de etanol y compuestos organolépticos importantes en la destilación de cabezas y colas del proceso de obtención del tequila. Universidad de Guadalajara.

Nedjma M., Hoffmann N. (1996) Hydrogen Sulfide Reactivity with thiols in the Presence of Copper (II) in Hydroalcoholic Solutions or Cognac Brandies: Formation of Symmetrical and Unsymmetrical Dialkyl Trisulfides. Journal Agriculture Chemistry. 44 (12) 3935-3938.

NORMA Oficial Mexicana NOM-142-SSA1-1995, Bienes y servicios. Bebidas alcohólicas. Especificaciones sanitarias. Etiquetado sanitario y commercial.

Norma Oficial Mexicana NOM-006-SCFI-1994, Bebidas alcohólicas-Tequila-Especificaciones.

Norma Oficial Mexicana NOM-070-SCFI-1994, Bebidas alcohólicas-Mezcal-Especificaciones.

Prado Ramírez R. (2002) Destilación de tequila y mezcal: factores que afectan la calidad del producto. Universidad de Guadalajara.

Quiroz Márquez J. (1997) El Mezcal, Orígenes, Elaboración y Recetas. Ed. Códice, Oaxaca.
Stichlmair J. G., Fair J. R. (1998) Distillation. Ed. Wiley-VCH. New York.