



Mechanization process in the production of mezcal

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Received 28 April 2007, accepted 11 August 2007.

Abstract

Mezcal is an alcoholic drink obtained from the fermentation and distillation of the sugary juices extracted from the mature and cooked heads of magueyes, wild and cultivated, of the arid and semi-arid regions of Mexico. The process for mezcal-making begins with the cooking, causing the hydrolysis of the polysaccharides of the maguey, since the inulin is not very soluble in water and not fermentable in direct form. Next, the heads or pineapples go to the mill process, which is carried out in a flour or Chilean mill with the purpose of extracting the juices. The waste pulp still has a high content of sugars after the mill process. For this reason this waste pulp is re-hydrated in a laundry tub together with the effluvia coming from the ovens. This waste pulp is then placed in a press in order to extract even more juice. The juices obtained in this way are taken to the fermentation tubs where diammonic phosphate is added with the purpose of favoring the development of yeast. Next, the wine mezcal resulting from fermentation is taken to the distiller where, according to the different boiling points, is fractionated in heads (methanol), body or heart (ethanol) and tails (propanol or butanol); before being bottled. The objective of this work was to develop knowledge of the techniques and the technologies used in the production of mezcal. The conclusions obtained from the development of this work were: 1) the process of mechanization of mezcal has been increasingly copying schemes which have already been successfully used by the tequila industry; and 2) the modernization of the process of production of mezcal has been increasing as the product wins price and market.

Key words: Mezcal, mezcal-production, mechanization.

Introduction

According to the Mexican National Standard⁵, mezcal is a regional alcoholic drink obtained from distillation and rectification of musts prepared directly and originally from the extracted sugars of the mature heads of the following agave plants: *Agave angustifolia* Haw., *A. asperrima* Jacobi, *A. weberi* former Cels Poissons, *A. potatorum* Zucc. and *A. salmiana* former Otto Salm-Dyck ssp. *crassispina* (Trel.) Gentry.

The mezcal is a liquid with a special color and flavor, according to its type. It is colorless or lightly yellowish when rested or matured in wooden recipients of oak or holm oak or when it is not rested or matured. In each region, in each town and even from one distiller to another, mezcal acquires its own characteristic, according to the type or mixture of magueys used; to the way the maguey is cooked; to the time and the form of fermentation of the honeys and according to the number of times that the product has been distilled. This is the way in which the different mezcales, known to date, were born: tequila, comiteco from Chiapas, the bacanora from Sonora, the raicilla and barranca from Nayarit and Jalisco, the tuxca or quitupán from Colima and the yahuytzingu from the Mixteca region⁷.

The process for elaborating mezcal is performed in three steps or stages, the first one is known as pre-gathering handling, the second is the gathering while the third one is the process performed at the factory. In the first stage, a process known as castration is performed, which consists on preventing that the

maguey continues with its reproduction process (the floral shaft is cut). This process is carried out, in general, when the plant is eight years old or older. The recommended seasoning period is from 18 to 24 months¹. In the gathering stage, three activities are carried out. The first one is the "desvirado" which consists on cutting all the fleshy leaves up to the point where the stem and the base of the leaves are left alone, forming a structure called head or pineapple. This activity is carried out with a bar or "desvirador" iron. The second activity is known as knocking down and is carried out with a knocking bar. It consists on removing the head or pineapple, by cutting it almost at the level of the floor. The third activity is transportation, where trucks are used in order to gather the pineapples or heads which are later transferred to the factory.

Factory process is presented in Fig. 1. Once the pineapples are in the factory, they are cut up and transported to the oven for cooking. Generally, the ovens are raised above the floor and built in stone; some are heated with vapor coming from a boiler, in these ovens the cooking process takes approximately 30 hours and they have a average capacity of 20 tons; others, heated by firewood, requires about one week for the cooking process; these ovens have a capacity of 40 tons and give honeys a better flavor because of a combination of a slower cooking process and the smoky flavor acquired from the firewood. The average temperature reached in the ovens is about 120°C. In the case of the state of

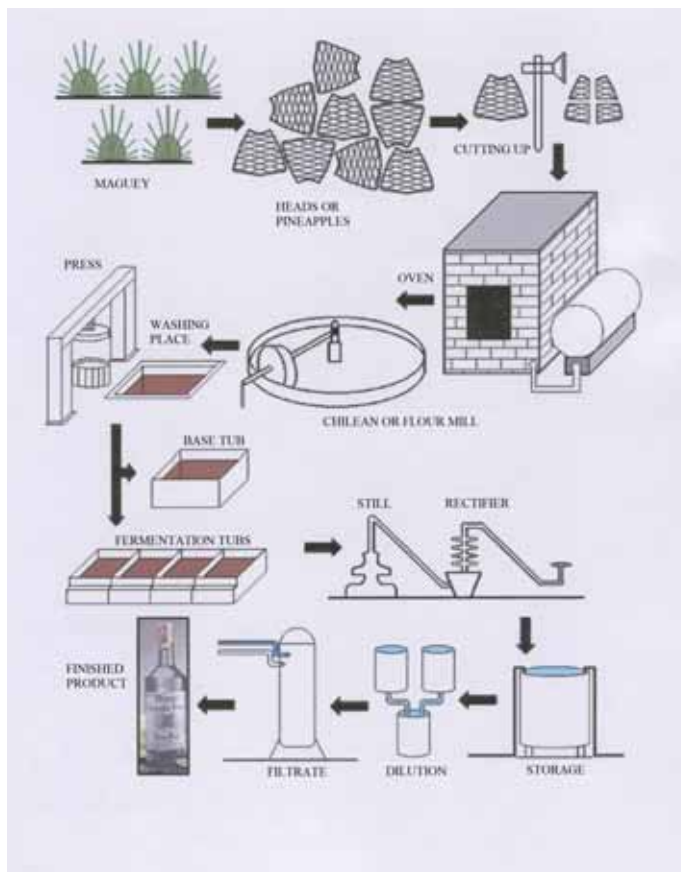


Figure 1. Process for mezcal elaboration.

Oaxaca, Mexico, Sánchez ⁶ mentioned that two types of ovens exist for maguery cooking, depending on whether the work is continuous or discontinuous: raised ovens covered with refractory stone and ovens consisting of simple hollows (these consist of a hole made in the ground, of variable dimensions and with a circular shape that can be covered or not, according to the use or knowledge for producing mezcal). The raised ovens are located where important volumes of mezcal are produced and they are dedicated to continuous use. The same author mentions that the ovens are heated with firewood as fuel. When full firewood combustion is achieved, the oven is covered with special stones until they show a red-hot color (5 to 6 hours after being exposed to flames). The process continues when a bed of humid waste pulp is placed, above which the maguery pieces are placed. In order to preserve energy while allowing the cooking of the maguery, this is covered with a layer of dry waste pulp (mats and banana leaves are also used) and later covered with soil, allowing a minimum of three days to achieve full cooking. In the case of tequila, Valenzuela ⁸ and Blomberg ³ coincide in mentioning that the cooking of maguery was carried out in big, stone-covered ground cavities with a shape of inverted cones, where blazes are lit with a large amount of firewood. The heads of maguery are placed over the burning embers while covered with hay, wet soil and refractory stones, leaving a central vent for water supply. The same authors coincide in pointing out that the changes in the old procedures began with the cooking process, as masonry ovens were introduced in the last decade of the XIX century (requiring 48 hours for cooking). Later on, firewood and other fuels were substituted by vapor. Autoclaves were introduced in 1960 (requiring 12 hours for cooking) which

work like a pressure pot where vapor is injected for the cooking. In the case of the state of San Luis Potosí, Mexico, the cooking is made in vaulted-roof ovens built of stone, with an access door in the front and a skylight in the upper part. Four to six of these ovens are built one next to the other. At certain height above the floor, rail parquet is presented on which refractory stones are deposited and, over these stones, the heads or maguery pineapples are deposited. In order to heat the ovens, vapor or maguery that have already completed their cycle are used. In the case of ovens that work with vapor, a boiler fed with maguery or fuel oil is used. When the cooking is carried out with vapor, a channel is located below the parquet with the purpose of gathering the juices. The loading, carried out by the “faineros,” is made through the access door and the capacity of the ovens is from twenty to sixty metric tons⁴.

According to Sánchez ⁶, regarding the instruments used in Oaxaca, Mexico, it is possible to characterize the mill of the mezcal-producing units in two types; manual mill and mill with animal traction. The manual mill is carried out with simple wooden mallets with the form of a bat or a hammer. Since a large amount of effort is required for this type of mill, this takes place in locations with low volume of mezcal elaboration and discontinuous production. The mill that uses stone mill with animal traction is observed in places that produce mezcal in a continuous way and with production dedicated to market consumption. The stone is coin-shaped and made of quarry or cement, jagged or flat with an approximate weight of half ton. The wheel rotates on a stone or cement floor, which is formed in such a way that allows the formation of a circle of approximately 4 metres in diameter. The axis and wheel are joined by a timber that crosses the wheel trough its center and acts as the horizontal axis used to move the stone, using a horse or a mule. In the case of tequila, Valenzuela ⁸ mentions that in the milling process, the flour mills or stone mills used during the mid XIX century were substituted by the same type of mills used to crush sugar cane in the 1950's.

The maguery can be cooked either when cut in small pieces, in head halves or in whole heads. Once the cooking process is finished, the cooked material is transported to mills where it is cut into small pieces of a few centimetres wide. In the case of tequila, the mashing of the cooked heads is made by hitting them with sticks and axes. Later on, a modified flour mill was used. The modification consisted of a round ground cavity inside of which the enormous circular stone was rolled, moved by mules or other animals. Cooked pineapples were accommodated, using tridents, in front of the mill stone which later crushed and squeezed them in order to extract the juice, while loosening or tearing the fibers. These fibers immediately absorbed again an important amount of the juice ².

The objective of this work was to develop knowledge of the techniques and the technologies used in the production of mezcal.

Materials and Methods

The work was divided in two stages; in the first one, office work and bibliographical research was performed while the second stage consisted of field work. The first stage was focused on obtaining the larger possible amount of information regarding mezcal types, production processes and technology. The second stage consisted on visiting each one of the mezcal production units working in the center of Mexico. These are: Laguna Seca,



Figure 2. Flour mill.



Figure 3. Filling of oven with pineapples through skylight.

Saldaña, Santa Teresa, Jarillas and Santa Isabel; it also consisted on deepen the knowledge of the problem surrounding the mezcal production, equipment and techniques used in its production.

Results and Discussion

From the bibliographical research and from the field work it was found that cooking is one of the most important aspects in mezcal production. It directly influences the quality of mezcal regarding flavor, the efficiency regarding hydrolysis or conversion of polysaccharides into fermentable sugars. That is the reason why different techniques (processes) for cooking have been used, from the ovens built from simple hollows to the raised ovens (some heated with firewood and others with vapor) and, in recent years, the use of autoclaves. In the case of ovens heated with vapor, the loss of honeys is reduced as there is a channel that allows for the gradual gathering of the honeys that the pineapples loose during the cooking process. It is considered that the cooking is better still in autoclaves, as it is done in many tequila-producing plants. However, it is important to keep in mind that the flavor would be sacrificed, as it is completely changed with this process. The cooking promotes the conversion of the polysaccharides (inulin) of the pineapple into fermentable sugars. The time of cooking depends on variables like the capacity of the ovens and the filling process, or second load, of pineapples to the oven. This is done through the skylight on the roof which, in fact, compresses the first load enabling the leaking of honeys. In a

masonry oven, heated with vapor and with a capacity of 30 tons, the time of cooking is between 26 to 33 hours. The passages located in the floor of the ovens take the released honeys, during the cooking, to a tub covered with wood through a copper serpentine warmed with vapor. This tub is known as "guixi" tub ("guishe") and in general the honeys remain there for a period of approximate 6 hours that allows for a concentration of sugars. The graduation of sugars that these honeys reach is from 9 to 10°Brix and it reaches a temperature of 17-20°C. Once the time of cooking is finished, the oven is opened up, using the front doors, while discharged by people known as "out-throwers" who drive the load to the following operation. The caramelization of hydrolyzed sugars, due to the excess of heat, reduces the amount of fermentable sugars (and consequently the yield of alcohol); the lack of cooking reduces the hydrolysis or conversion of polysaccharides into fermentable sugars. Now, from what was previously outlined, one can observe that raised ovens represent a great technological advance, compared to the well ovens, as the latter represent a very laborious cooking process.

In the case of the mezcal-production units of the state of San Luis Potosí, Mexico, the mill is carried out with the flour mill (see Figs 2 and 3), which is driven with a tractor, an electric motor or, in some cases, with a draught animal. The pineapples are extracted from the oven and deposited in the flour mill where and they are cut with an axe, facilitating the rotation of the stone and milling process. Later on, the by-product is deposited in a tub with water, known as laundry tub, where the waste pulp of the mill is mixed with hot water and effluvia coming from the vapor ovens and heated to a temperature between 35 and 45°C. In this way, the waste pulp is re-moisturized with the purpose of extracting any sugars left. The re-moisturized and laundered waste pulp is placed in a screw press with the purpose of extracting sugars that are still caught among the fibers. Finally, the waste pulp is exposed to the sun so it can be dried and used as raw material during the cooking process. Regarding the mill, it is very inefficient in terms of effort required for the extraction of juices, although very efficient in terms of the proportion of extraction of the available sugars. In the case of tequila, the mill begins with the ripping of fibers, followed by a mill in a sugar mill, requiring in some cases up to six on-line sugar mills, that is, once the product is ripped, it is taken to the first sugar mill then it is re-moisturized before arriving to the second sugar mill, and so on.

Experience suggests that the selection of the principle for maguey-milling is not of great importance from the perspective of the energy effectiveness of the process, but it is of great importance in the technological integration oriented towards the reduction of losses associated to processes like juice extraction and gathering, the cleaning of honeys, appropriate spaces and handling. In the fermentation tubs, the honeys obtained from the milling and laundry processes are mixed, but before this mixing takes place, the best honeys are used for preparing the base of ferment. This ferment is conditioned with diammonium phosphate at a rate of 1 kg/4000 litres of honeys, which serves as a nutrient for the yeast existing in the honeys; thereafter follows addition of compressed air as oxygen source, and vapor in order to maintain the temperature at 30°C. All this is carried out in 400-litres tubs. The prepared base of ferment is added to bigger tubs with a capacity of 4000 to 5000 litres that contain the remaining honeys; in this point the concentration of sugars is from 6 to 7°Brix. Oxygen

is added to these tubs. Vapor is also added in order to maintain the honeys at 35°C (which favors fermentation), and diammonium phosphate. Fermentation concludes after 48 hours. Once this stage is finished, the mezcal wine is left resting with the purpose of propitiating the generation of important aromatic compounds; at this point the concentration was reduced to 1°Brix.

In the case of the distilling process, the fermented honeys are channeled to a copper still, consisting of a 1000-litre pot and an internal serpentine heated by vapor. The head or turban is located in the upper part of the pot. This part picks up the vapors and drives them to the refining plates which are washed on the outside with circulating cold water, allowing the starting of the condensation of the vapor. This continues later to the coolant consisting of a serpentine submerged in water at ambient temperature, where the condensation of the evaporated alcohols concludes. The distilled product is stored in containers made of plastic or stainless steel and also in large wooden barrels known as “pipones”. These are used to temporarily store the mezcal. The mezcal that is going to be matured is filtered and it is subjected to a maturation process that last at least six months, in oak casks. The rested mezcal is matured during three months. According to the Mexican Standard⁵ the old mezcal is the product susceptible of being sampled, subject to a maturation process of at least one year, in wooden recipients made of white or holm oak, whose maximum capacity is 200 litres. The rested mezcal is the product susceptible of being sampled, which is left at least 2 months in wooden recipients made of white or holm oak, for its stabilization. Finally, the creation of a flexible model of a mezcal-producing unit is proposed. Such a model will enable modern mezcal factories, as a function of the installed features and the economical prospect of each one of them; this implies creating, redesigning and testing new machines.

Conclusions

- 1) The process of mechanization of mezcal has been reproducing schemes used, with great success, by the tequila industry.
- 2) The modernization of the process of production of mezcal has been increasing as the product wins price and market.

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