RHUM – RON – RUM: TECHNOLOGY AND TRADITION

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ABSTRACT

Rum is a distilled alcoholic beverage obtained from sugary raw material such as sugar cane, with an alcohol content of 35%V V^{-1} to 54%V V^{-1}. The manufacturing process involves several stages, including harvesting of the sugary raw material, appropriate fermentation, distillation and aging in oak barrels, the end result being a liquid ranging from amber to mahogany in colour, with a particular bouquet of wide historical acceptance. The rum producing areas are almost all in America, southern Europe and the Canary Islands, with a small remnant in the Philippines. This chapter provides extensive reference to the characteristics of rum, processing techniques and production areas.

Introduction

Rum is the alcoholic beverage resulting from the distillation of fermented raw materials with high sugar contents. Its alcohol content varies from 35%V V^{-1} to 54%V V^{-1} measured at 20°C. The various legislations of the countries where this beverage is produced determine the minimum alcohol content rum must have. For example, in Brazil the legal contents range from 38%V V^{-1} to 54%V V^{-1}, in Venezuela the amount is 40%V V^{-1}, in Colombia it is 50%V V^{-1}, in Cuba no less than 35%V $V^{-1}$and in Spain the minimum is 37.5%V V^{-1}. For some special types of rum, such as those produced in the Canary Islands (Spain) the minimum content permitted is 30%V V^{-1}.

Rum producing areas are mainly found in both the Spanish and Portuguese-speaking regions of the Caribbean, as well as in areas of English and French influence, although there is a rum-producing tradition in the Spanish provinces of Granada, Malaga and the Canary Islands. Generally speaking, areas where sugar cane has traditionally been grown are also rum-producing.

Although rum is one of the so-called congeneric beverages, i.e. it has a distinctive aroma achieved during fermentation and distillation, another intrinsic characteristic is the requirement for it to be aged in oak barrels (depending on the country of origin, other types of wood such as cherry can also be used) for a period ranging from a few months to several years, or even decades. After the aging process the rum finally acquires its own organoleptic characteristics.

The techniques involved in the production of rum can be summarized in the following stages: 1) Harvesting and preparation of the raw material; 2) Fermentation of the raw material; 3) Distillation; 4) Aging; 5) Standardizing and preparation for bottling.

Characteristics of the raw material

Rum must be made using sugary raw materials also containing a number of compounds necessary for the initial fermentation.

The juice of sugar cane is used as the sugary raw material, as well as molasses and/or other by-products of the production of sugar from sugar cane, although molasses is the most commonly used. As a by-product of sugar production, molasses was only found to be of practical use in the making of rum. It was introduced into the alcohol industry over 300 years ago, and the British Crown even passed a "Molasses Law" which it attempted to impose in all its possessions in the New World.

In the process of sugar production, molasses is formed as the inorganic and organic substances considered impurities, most of the water (in several stages) and finally the sucrose are extracted from the juice ("guarapo" in Cuba), leaving a high density, viscose liquid characterized by its sugars, total solids and ash. The physical, chemical and physico-chemical characteristics of sugar cane molasses have an important effect on the resulting rum.

Generally speaking, sugar cane syrup mainly consists of water and sugars such as sucrose, glucose, with smaller amounts of fructose and inverted sugar. In an alkaline medium fructose can produce furfural and hydroxymethylfurfural, which inhibit fermentation and are therefore undesirable.

In addition to the sugars, non-sugary compounds are also present, such as metallic cations (potassium, calcium, sodium, magnesium, iron, zinc, and manganese as macrominerals, and copper, iodine, cadmium, chrome, molybdenum, nickel, and vanadium as microminerals), anions (chloride, sulphate, nitrate, nitrite, phosphate), nitrogenised organic compounds (glutamic acid, aspartic acid, valine, arginine, leucine, peptids, colorants, pyrazines, and pyrroles), non-nitrogenised organic compounds (citric acid, malic acid, lactic acid, aconitic acid, propionic acid, butyric acid, and phenolic compounds such as p-cumaric acid, ferulic acid and syringic acid), fatty acids and vitamins (biotin, pantothenic acid, inositol, thiamine, nicotinic acid and pyridoxin). It should be pointed out that organic nitrogen is responsible for the formation of higher alcohols (such as isoamyl and isobutyl) during fermentation, which is not entirely desirable.

Many of the foregoing compounds, such as the vitamins and minerals, are considered contributing factors in the transformation of the sugars during alcoholic fermentation. Although they are found both qualitatively and quantitatively in the molasses, other contributing compounds not found in the composition must be added. This is the case of inorganic nitrogen, which is rapidly assimilated and is added to obtain a cleaner alcohol. Likewise, the addition of sulphur as a sulphate is recommended for the synthesis of the amino acids required as nutrition for the yeast, and phosphorus to assist in yeast growth.

Water and microorganisms such as yeast and bacteria are also considered contributing factors in fermentation and are present in the composition of the molasses. Water is the medium in which the other components are dissolved and it is indispensable for fermentative reactions to take place. Yeast and bacteria are naturally present in molasses and play a fundamental role, not only by causing the fermentation of the raw material, but also in the production of light or heavy rum, depending on the type and species of microorganism. In any case, the yeasts responsible for the fermentation of rum molasses must be able to achieve a high degree of ethanol and a correct, balanced content of aromatic compounds. Table 1 summarizes some of the most common genera and species of yeast and bacteria found in molasses <Table 1 near here>

Apart from the bacteria naturally present in molasses, selected cultures of other bacteria are added at the start of fermentation, mainly types of *Clostridium*, which can improve the development of alcoholic fermentation by acting in synergy with the yeast (*Clostridium saccharobutyricum*), as well as producing volatile acids (e.g., butyric acid) characteristic of heavy rums (*Clostridium butyricum*, *Clostridium pasteurianum*).

Alcoholic fermentation in rum production

Fermentation is a process in which chemical changes take place in an organic substrate under the action of the enzymes produced by a specific type of living microorganism. It is characterized by incomplete oxidation, the transformation of large quantities of substances and by being a highly exothermal anaerobic reaction.

In the case of alcoholic fermentation, the initial substrates are fermentable sugars such as glucose and fructose, and the end product consists mainly of ethyl alcohol, lesser amounts of other congeneric products, and the large-scale release of CO_2 (Figure 1) <Figure 1 near here>.

In order for alcoholic fermentation of the raw material to commence, a number of requisites must be met for both the raw material and the conditions in which fermentation is to take place. One of these factors is the presence of sugars and both the intrinsic and extrinsic contributing compounds of the molasses. Other factors within the control of the knowledgeable rum producer are temperature, fermentation time, the pH value, the predominant type of yeast during fermentation, and the density of the medium (Table 2) <Table 2 near here>.

With the exceptions of temperature and fermentation time, all these factors must be fulfilled in the molasses prior to the start of fermentation. The molasses is therefore diluted to the appropriate density to avoid blockages in the distillation apparatus, particles in suspension are precipitated with alumina, inorganic nitrogen is added in the form of urea, ammonium salts and phosphorus, and the pH is adjusted with phosphoric acid and even sulphuric acid. At times, if selected yeasts or bacteria are to be added, pasteurization is required to ensure the elimination of autochthonous microbial flora that might compete with the added flora and reduce their output. The characteristics of this type of industrial yeast must be such as to allow the appropriate development of fermentation, such as high fermentation velocity, resistance to ethanol, temperature, acidity and osmotic pressure, as well as alcoholic output and the production of appropriate aromatic compounds. It is now also thought very desirable for these yeasts to have a “killer” capacity, by controlling the development of other undesirable yeasts during fermentation.

In order to accelerate the start of fermentation, a mixture known as “bottom of the vat” is prepared at 4-10%V V^{-1} with yeasts selected from the molasses. This pre-ferment is added to the vat and, when fermentation begins, diluted molasses is gradually added to avoid excessive temperature. Although the ideal temperature for fermentation is 21ºC (Table 2) <Table 2 near here>, the temperature range is quite wide, depending on the type of rum produced. For example, for light rums temperature can vary from 28ºC to 33ºC, while for heavy, Jamaican-type rums the range is from 30ºC to 33ºC, and cases have been recorded of 37ºC fermentation. The production of dark or heavy rums always involves the use of higher temperatures and fermentation times (Table 2) <Table 2 near here> and even the possible addition of the "dunders", which are the nitrogen-rich residues or lees of previous distillations.

Just as there are factors that encourage the development of alcoholic fermentation, other compounds also found in molasses have the opposite effect above certain concentrations. Compounds such as hydroxymethylfurfural (≥ 0.05%V V^{-1}), butyric acid (≥ 0.1%V V^{-1}), valerianic acid (≥ 0.1%V V^{-1}) and minerals such as silver, arsenic, barium, mercury, lithium, nickel, osmium, lead, selenium and tellurium (≥ 100 μM) can delay or even inhibit alcoholic fermentation. Acetic acid is a special case, as it can affect yeast activity, modifying their tolerance to both alcohol concentration and temperature. The higher the concentration of this compound in the medium, the lower the alcohol tolerance of the yeast, up to a maximum of 1%V V^{-1}, where tolerance is zero. Similarly, at a concentration of 1%V V^{-1} the critical temperature of yeast falls to 26ºC in comparison to the 42ºC maximum that some types of yeast can tolerate in the absence of acetic acid.

Once alcoholic fermentation has begun, when the alcohol concentration is 3.5-4.5%V V^{-1}, the amount of sugar in the medium is below 6g $100mL^{-1}$ and fermenting temperature is below 30ºC, the Clostridium culture is added. The most efficient cultures of Clostridium saccharobutyricum have a bacteria to yeast ratio of 1:5, as they accelerate the formation of alcohol during fermentation and encourage the formation of a balanced aromatic profile. The function of other bacteria is not clear.

The majority end products of alcoholic fermentation are ethyl alcohol and CO_2. A number of other compounds, known as congeneric compounds, are also formed, which have an important effect on the bouquet of the rum, although others are present in the raw material. The congeneric compounds are mainly glycerol, propylic alcohol, organic acids (acetic and lactic acids), higher alcohols (isoamylic and isobutylic), aldehydes (acetaldehyde), esters (ethyl acetate) and fatty acids. The production of congenerics is closely related to the type of yeast and the predominant pH during alcoholic fermentation. Tables 3 and 4 provide some examples of the foregoing <Table 3 near here> <Table 4 near here>.

A rest period of 24 to 40 hours after the conclusion of fermentation is recommended to increase the rum's bouquet. Low fermentation temperatures and low pH values towards the end of the process likewise encourage the concentration of esters. It is also thought that significant concentrations of a higher alcohol such as n-propanol are the result of high concentrations of glutamic acid in the molasses.

Different fermenting systems are used in the production of rum. Discontinuous systems are commonly used in the closed batch and Melle-Boinot variants (Figure 2) <Figure 2 near here>. These are closed processes in which the pre-ferment and nutrients are added at the start of fermentation, allowing incubation to take place in optimum fermentation conditions. When the desired level of reaction has been reached, the fermentation vessel is emptied, cleaned and the process repeated. Multiple stage continuous fermentation systems are also used, where the nutrients and pre-ferments are continuously added and withdrawn from the vat or bioreactor. Conditions are thus kept uniform throughout the fermentation vessel, with a balance between nutrients, microorganisms and end products (Figure 3) <Figure 3 near here>.

After fermentation and before distillation the fermented mass or wash ("batición" in Cuba) is left to stand in order that the yeast can settle on the bottom. The insoluble matter in suspension is separated by centrifuge.

Distillation in rum production

After fermenting, the next stage is distillation, which has developed over time according to the different geographical areas of production. However, the Industrial Revolution brought about the most important change in distilling processes, allowing highly homogeneous beverages to be produced regardless of year, raw material, etc. Better understanding of chemistry, closed circuits and, especially, the principles of evaporation and condensation altered rum production forever.

Generally speaking, the term "distillation" is applied to processes of vaporization in which the steam produced is recovered by condensation. More specifically, the constituents of a liquid mixture are separated by partial vaporization and separate recovery of the steam and the residue. A higher concentration of the most volatile components of the initial mixture passes into the steam, while the less volatile concentrate in the remaining liquid. In this way, the alcoholic products of the yeast fermentation are separated, selected and concentrated. Rum is made using either simple, discontinuous, batch distillation, or by continuous distillation in a column or a system of 3 to 5 columns.

Simple, discontinuous, or batch distillation (Figure 4) <Figure 4 near here> is used in the French and English areas of the West Indies and in Brazil for heavy rums. It is typically a relatively simple, low-cost, flexible system producing high quality rum, although production costs are high. A typical installation is similar to a simple pot-still with three stages. The mixture to be distilled is pumped into a copper distillation vessel, from which the distillate obtained, known as low wine, is collected in a second vessel where another distillation takes place, producing high wine. The heads and tails of the second distillation are discarded and only the heart or middle cut of the high wine is distilled to produce rum. The head fraction of the high wine is obtained at temperatures below 78ºC and is rich in very volatile, dangerous substances such a methanol, acetone, acetaldehyde and ethyl acetate. The tail fraction is the last to be obtained at temperatures above 82ºC and consists of the components with highest boiling point, higher alcohols, furfurals and aromatic compounds with a high boiling point that could impair the aromatic characteristics of the distillate if their recovery is prolonged, leading to high contents in the final product. The central fraction is collected between 78ºC and 82ºC and consists mainly of ethyl alcohol and congeneric compounds, reaching an alcohol content of 90-95%V V^{-1}. The master distiller's skill consists of knowing how to collect only the central of the three fractions, determining when they begin and end, and ensuring the absence of undesirable alcohols and the presence of a high percentage of aromas, although correction can be carried out to obtain pure ethanol. The correction processes enrich the alcoholic vapours by passing them counter current through the liquids descending from the upper parts of a column. Inside the column the vapours exchange heat and mass with the liquid and eventually condense on leaving the column with partial reflux, which "washes" the components with highest boiling point out of the rising vapour flow. At the same time, some the compounds with low boiling point are also lost.

Any of the variations of continuous distillation are only suitable for large-scale production (approximately 10,000 litres in 24 hours), with consequent savings in fuel and time. However, the great disadvantage is the inability to obtain a suitable degree of splitting. An installation of this type consists of a distilling column, a rectifying column, one or more purifying columns and three or more condensers (Figure 5) <Figure 5 near here>. The end product is complex, with alcoholic strength 40-70%V V^{-1} and important amounts of aldehydes, acids, esters, higher alcohols, etc., and is known as liquor.

Distillation contributes decisively to the volatile composition of the rum distillate. For example, the heating causes oxidation, esterification and partial dehydration giving rise to new compounds, with an increase in aldehydes, ethyl acetate and other esters as well as furfural. Sugar cane fermentates (worts) contain very little furfural, but it can appear due to dehydration of pentoses and pentosans during distillation. A wort with higher sugar contents and more acid will give rise to a higher furfural content in the distillate. Similarly, the increase in acetaldehyde is due to the incomplete oxidation of ethyl alcohol. This acetaldehyde can also react with ethanol to produce acetal.

Another important consideration in the production of rum, and of any distilled beverage, is the presence of methanol. This alcohol, whose chemical structure is very similar to that of water, is toxic and poisonous, meaning that it must never occur in the distillate. It is metabolized in the liver by the alcohol dehydrogenase enzyme, which also metabolizes ethanol, to formaldehyde and, by action of aldehyde dehydrogenase, to formic acid, which can be excreted via urine or oxidated by folate dependent reactions to CO_2 and eliminated via the lungs. Approximately 3% to 5% is eliminated in unmetabolized form via kidneys and lungs. The lethal dosage varies according to the individual, ranging from 20 to 100 mL, although there have been cases of up to 240 mL. Symptoms commence with drunkenness, headache, nausea, vomiting, tachycardia, blindness (caused by the formaldehyde and formic acid), and conclude with respiratory failure leading to death.

In order to ensure the absence of methanol in the distillate, systems can be used consisting of columns that leach methanol by trichloroethylene in the liquid-vapour phase, although the different regulations in rum-producing countries set maximum limits. In Cuba, for example, the maximum is set at 10 mg $100mL^{-1}$ and in the European Union and other Caribbean nations it is 30 mg $100ml^{-1}$.

Another manner of purifying rum is by using active carbon. This is a porous adsorbent consisting mainly of carbon, with a high adsorption capacity for gaseous substances as vapour or in solution. This is the result of a particular thermal treatment known as activation, which increases the specific surface of carbon and its high porosity. The use of this product on rum decreases the acidity, and the phenol, ester and fatty acid contents, as well as providing a slight decrease in higher alcohol contents and the elimination of lactones. If necessary, it can also have a bleaching effect.

Aging of rum

Aging of rum involves storage in white oak barrels (cherry is used in some regions) for a certain time, depending on the quality and type of product desired, with the aim of improving its taste. This improvement is the result of a number of transformations that take place between the components of the distillate and those of the oak wood. Reactions occur between the different compounds of the distillate; complex substances are extracted from the wood; the compounds of the distillate and those of the wood oxidate, just as new reactions occur between the original compounds, extracted compounds and those formed previously. The most influential reactions taking place in the distillate during aging are esterification, oxidation and the decomposition of lignin.

Esterification depends on alcoholic strength, acid contents, temperature and time, while oxidation is more intense at the start of the aging process because of the presence of a large amount of oxygen dissolved during the preceding stages. Oxidation begins by affecting the components of the rum, with an increase in aldehydes and acetic acid, and over time it also affects the components of the wood.

The most commonly used wood for aging of rum is oak (Gen. Quercus). The most widely used species is white oak (*Q. alba*, *Q. minor*, *Q. platanoides*, *Q. iberica*, *Q. longipes*, *Q. robur*, *Q. canariensis*) because of its excellent porosity and the important contribution it makes to the aromatic composition of the rum, providing both volatile and non-volatile compounds. The main role of most of the non-volatile compounds is to act as precursors for the formation of flavour during contact of the oak with the alcoholic beverage, whereas the volatile compounds can make direct contributions to the taste and bouquet of the rum.

Oak wood contains cellulose (40%-45%), hemicellulose (20%-25%), lignin (20%-33%) and a heterogeneous group of compounds that can be extracted using solvents (2%-10%). The latter are important, as they can provide the characteristic colour and smell of wood. This large group includes resins, volatile oils, terpenes, fatty acids, carbohydrates, polyhydric alcohols, nitrogenous compounds (proteins and alkaloids), phenolic compounds and inorganic components.

The decomposition of lignin (Figure 6) <Figure 6 near here> causes the appearance in the distillate of compounds such as coniferaldehyde and synapaldehyde and their derived acids and aldehydes, which have an important role in the organoleptic characteristics of the rum. The longer the aging process, the higher the presence of these compounds in the distillate, although the contents depend to a large extent on the age and usage of the barrel, and the same is true of other compounds from the wood, such as tannins and oak lactones. Similarly, the intensity of the internal scorching of the barrel as part of its construction also has an effect on all the compounds of the beverage that originate in the wood.

Although all the compounds appearing in rum during aging have some active participation in its sensorial characteristics, the oak lactones are possibly the most important. The two oak lactones that can be recognized in rum are oak trans-lactone and oak cis-lactone. The former gives off aromatic notes of grass, straw, spices, a slight smell of firewood and a moderate smell of coconut, while the second smells of cinnamon and strongly of coconut. The lactone contents in rum depend on the species of oak and the intensity of charring the inside of the barrel during construction. The oak species with highest lactone contents are Rumanian and French, while American oak, which is the species used for rum aging, has medium contents. The lowest concentration of lactones is found in Japanese oak, which is hardly ever sued. The heavier the charring of the barrel, the higher the oak lactone contents, although it should be mentioned that the maximum charring time is 15 minutes (heavy charring), and some barrels used for light rums that are only lightly scorched, or not at all. Charring has several effects on the wood composition: thermal decomposition of polyoxides, creating furanic aldehydes; thermal decomposition of lignin, creating volatile phenols, aldehydes and phenolic acids; thermal decomposition of tannins, creating gallic and ellagic acids; thermal decomposition of lipid components, creating lactones.

An important question to consider regarding the aging of rum is evaporation loss, which depends on several factors, such as the density of the barrel wood, the evaporation area per unit volume, the humidity of the air in the storage spaces (70% is considered optimum for balance), ambient temperature, airtightness of the barrels, and the intensity of inner barrel charring. Loss can be up to 12% per year, with a decrease in compounds such as ethanol, acetaldehyde, n-propanol, ethyl acetate, isobutanol, isoamyl acetate, isoamyl acid, ethyl caproate, and acetic acid.

The oak barrels used for aging of rum can have different morphological characteristics that have an effect on the end product. The capacity of the barrels is usually 200L or 450L, which determines the contact surface of the distillate with the wood. In a 200L barrel, the area of wood per litre of distillate is 90 cm^2, while for a 450L barrel the area is only 60 cm^2. This means that one or other type of barrel will be chosen, depending on the desired type of rum and aging time. The higher the contact surface, the more intense the organoleptic characteristics of the rum, and therefore aging time in the barrel will tend towards the legal minima, whereas in a barrel with lower contact surface aging times will increase for similar organoleptic results.

The barrels are stacked in different ways depending on the characteristics of the storage area. The most usual arrangements are known as “solera” and “racks” (Figure 7) <Figure 7 near here>, each of which has its advantages and disadvantages. For example, the “solera” arrangement, also known as “solera gallega" in Cuba, has the advantage of the economy of its set-up, but it is more awkward to work in; the rack arrangement has the advantage of the support for the barrels, but it is expensive and complex to set up, sometimes requiring the use of fork-lift trucks to move the barrels.

The traditional arrangements for barrel storage are the most common, but they have their disadvantages: large installations required to keep the barrels; increasingly scarce and costly barrels; evaporation loss during aging; deterioration of installations and barrels; periodic reactivation of the barrels; treatment of new barrels before use for aging.

In an attempt to reduce the effects of the foregoing, non-traditional aging systems have come into being. These are non-conventional aging techniques that aim to reduce evaporation loss and accelerate the aging process. To this end, these new aging techniques must achieve rapid extraction of the compounds in the oak wood by the hydroalcoholic mixture, improve the conservation and increase of the original volatile substances, and provide adequate oxidation of the components extracted from the wood and those present in the rum. Some of these non-traditional aging techniques include the use of oak extracts, oak wood chips, treatment with oxygen or ozone, the application of electrical currents to the distillate and the application of non-ionizing radiation. The most effective of all these techniques are those using extracts and chips of oak wood, whereas the others are of dubious utility.

Final treatments of rum

On conclusion of the desired aging process, and taking into account the change in alcoholic strength that may have occurred, the rum has to be diluted to the final strength permitted by the legislation for this beverage in the various producing countries. Adjustment of the alcoholic strength must be carried out with suitable water that does not contaminate the taste or smell of the rum. The same goal can also be achieved using rums of different alcoholic strengths to make a blend of the desired strength.

Other factors, such as the variety of raw material, the growth conditions of the sugar cane, the strain of yeast or the techniques of distillation and aging can lead to the same rum not always presenting homogenous characteristics. Standardizing the final rum obtained is an important part of the producer's job. It can be achieved by blending different distillates with different characteristics from different barrels, ages, amounts of distillate and aging processes, or by using small amounts of additives that do not interfere with the product's character but provide it with an easily identifiable personality. The use of colouring syrup and caramel (E-150) is very common to standardize the colour of rum, which can range naturally depending on aging from amber to mahogany colour. The use of polysaccharides as colouring is not without risk, considering that if they have an unsuitable isoelectric point or they are not alcohol-resistant, they may precipitate. This can be avoided by alcoholising them prior to use in order to ensure their suitability and stability. White or almost colourless rums can be made by bleaching with active carbon.

The use of "solera" aging methods, similar to those used in the production of Sherry wines or Sherry brandy can also help to standardize rum. This is the method used for rum made in Motril (Spain).

Having adjusted the alcoholic strength and standardized the rum, a number of operations are necessary before bottling to make the rum a clear, bright liquid attractive to the end consumer. One of these operations is to allow it to rest for a variable number of hours in order to achieve sedimentation of some components by change of solubility, the formation and sedimentation of some less soluble compounds, and the homogenization of the blend and balance of its aromatic components. Cold or coagulating agents are commonly used at this stage to achieve faster sedimentation.

Finally, the beverage is clarified in a filter system using diatomaceous earth or cellulose plates.

At present, the bottling process is no different to any other beverage. Modern machines fill and close the glass bottles, some of which can inject an inert gas (nitrogen) into the neck of the bottle to guarantee conservation of the beverage.

General types of rum

Heavy or strong rum

Maturation: charred oak or cherry. Aging time: 10 or 12 years up to 15 years. Final alcoholic strength: 40-60%V V^{-1}. Colour: variable (colourless/amber/mahogany colour). Additional colouring: caramel. Bleaching where necessary: active carbon.

Light or smooth rum

Maturation: oak or cherry, even uncharred. Aging time: short periods. Final alcoholic strength: 40-60%V V^{-1}. Colour: variable (colourless/amber/mahogany colour). Additional colouring: caramel. Bleaching where necessary: active carbon.

Commercial types of rum

White

These are clear, dry, light rums, although their alcoholic content is the same as in others. The liquor produced by the distilleries is colourless, so it could be said that white rums are the basis of the industry. Contact with the oak wood during aging gives the rum a slight amber colour, which is eliminated by active carbon filtering before marketing, although some producers bottle without filtering, retaining the name of white rum. Due to its short aging (sometimes only 1 year), this is the cheapest rum with most neutral flavour and is therefore preferred for mixing and cocktails.

Dorado, Gold or Ambré

Similar to white rum, but with a more or less intense amber colour. Because of its longer aging than white rum and lack of filtering, it has a more intense flavour due to the higher congeneric contents. Caramel is sometimes added to accentuate the colour.

Black or Dark

Heavy rums with strong body. Most are produced in pot stills and therefore retain a strong taste of molasses. The dark, almost black colour is obtained by the addition of colouring to intensify the amber colour acquired in the barrel. The main producing countries are Jamaica and Barbados. The Demerara variety is a dark rum produced in the Demerara River basin in Guyana.

Spiced or Flavoured

In this category the rum is blended with various extracts to give extra flavour. Both fruit flavours (orange, lemon, banana, pineapple, coconut, etc.) and spices (vanilla, nutmeg, cinnamon, etc.) are used. White rum is normally used for the fruit flavours, while gold or aged rums are used for spiced flavours.

Over-proof

These are generally white rums bottled at an extremely high alcoholic strength (100 or more degrees British proof). There are no differences between British and Canadian over-proof rums.

Premium

Premium rums are those in which aging and blending have been taken to the maximum degree of quality without economic loss. The term “Premium” is frequently used only for publicity purposes. Rums produced in small quantities for one reason or another are special cases and may be meant for private consumption or special occasions.

Production areas

Rum-producing areas coincide with the regions where sugar cane is grown. This mainly includes practically all of America, where Christopher Columbus introduced sugar cane from Andalusia. Apart from America, sugar cane is still grown in some parts of Europe, specifically southern Spain and the Canary Islands. There is also a small production of rum in the Philippines, doubtless the result of its colonization by Spain. Table 5 <Table 5 near here> summarizes the different areas and countries where rum is produced.

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Figure 1

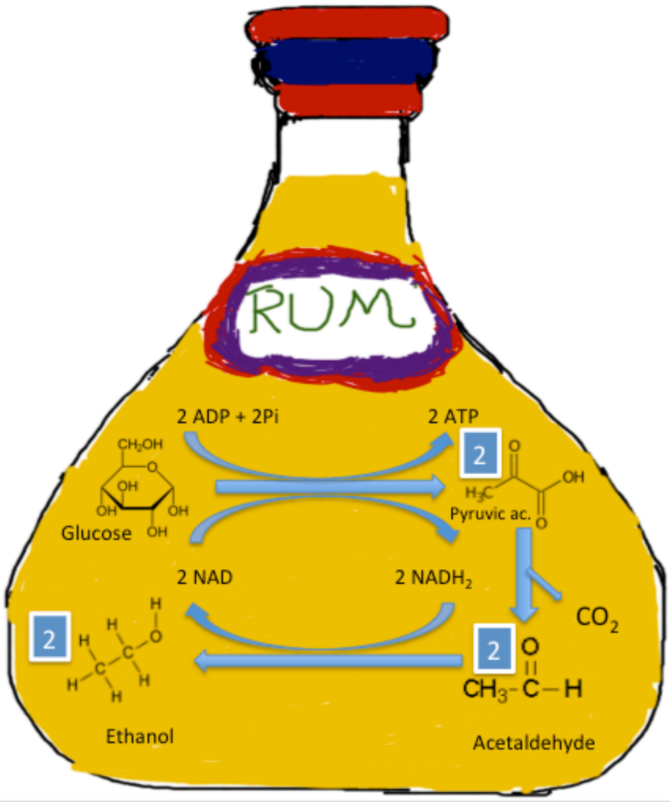
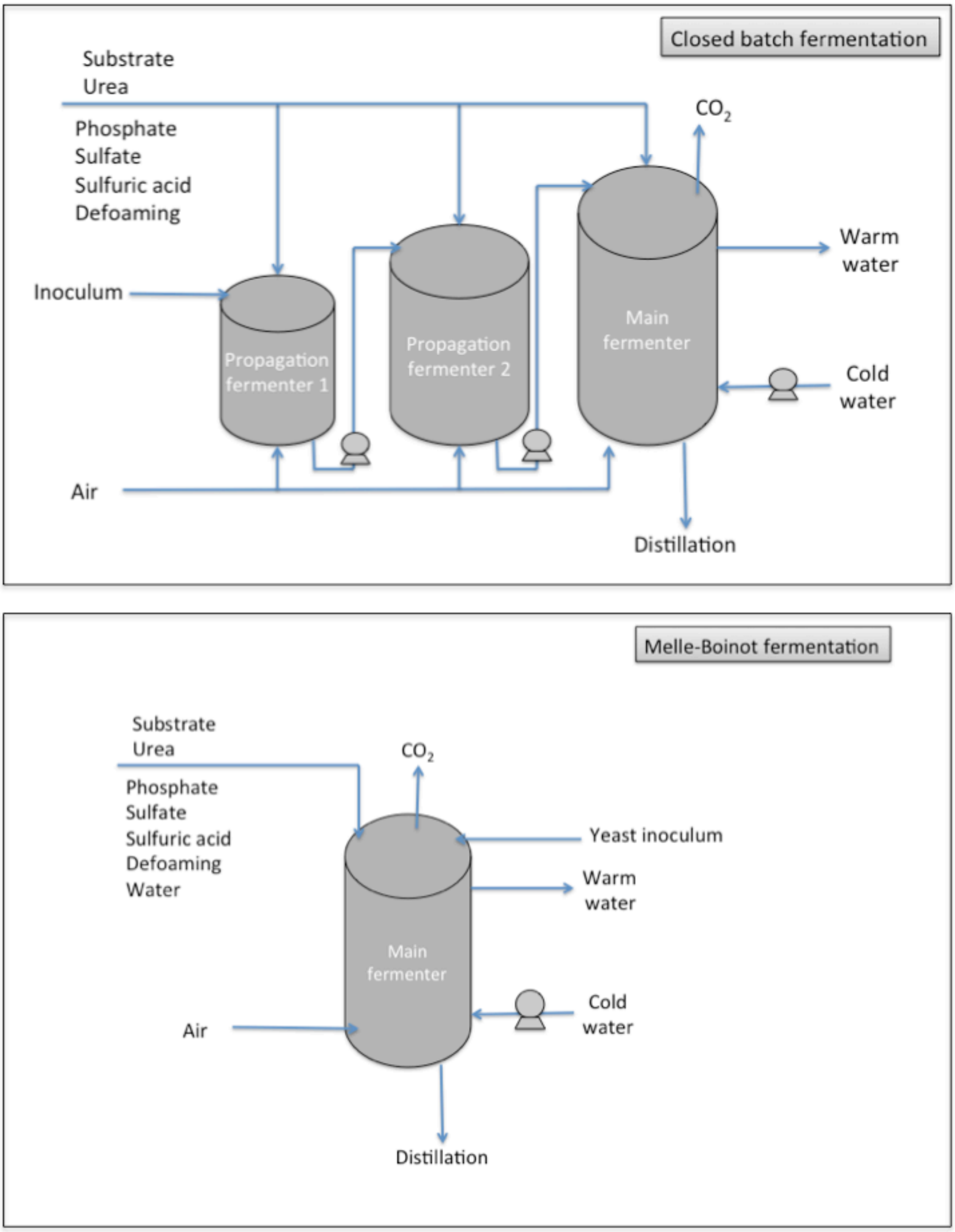
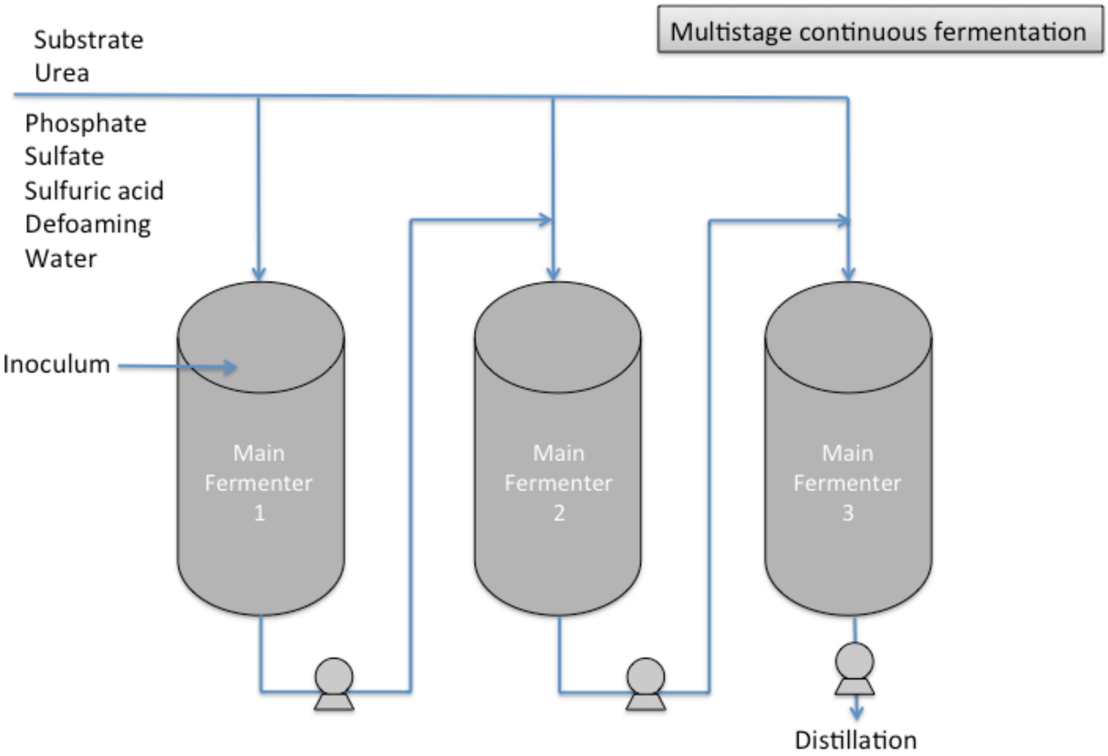

RUM
2 ADP + 2Pi
2 ATP
Glucose
Pyruvic ac.
2 NAD
2 NADH2
CO2
Ethanol
Acetaldehyde

Figure 2



Closed batch fermentation
Substrate
Urea
Phosphate
Sulfate
Sulfuric acid
Defoaming
CO_2
Warm water
Inoculum
Propagation fermenter 1
Propagation fermenter 2
Main fermenter
Cold water
Air
Distillation
Melle-Boinot fermentation
Substrate
Urea
Phosphate
Sulfate
Sulfuric acid
Defoaming
Water
CO_2
Yeast inoculum
Warm water
Main fermenter
Cold water
Air
Distillation

Figure 3



Multistage continuous fermentation
Substrate
Urea
Phosphate
Sulfate
Sulfuric acid
Defoaming
Water
Inoculum
Main Fermenter 1
Main Fermenter 2
Main Fermenter 3
Distillation

Figure 4

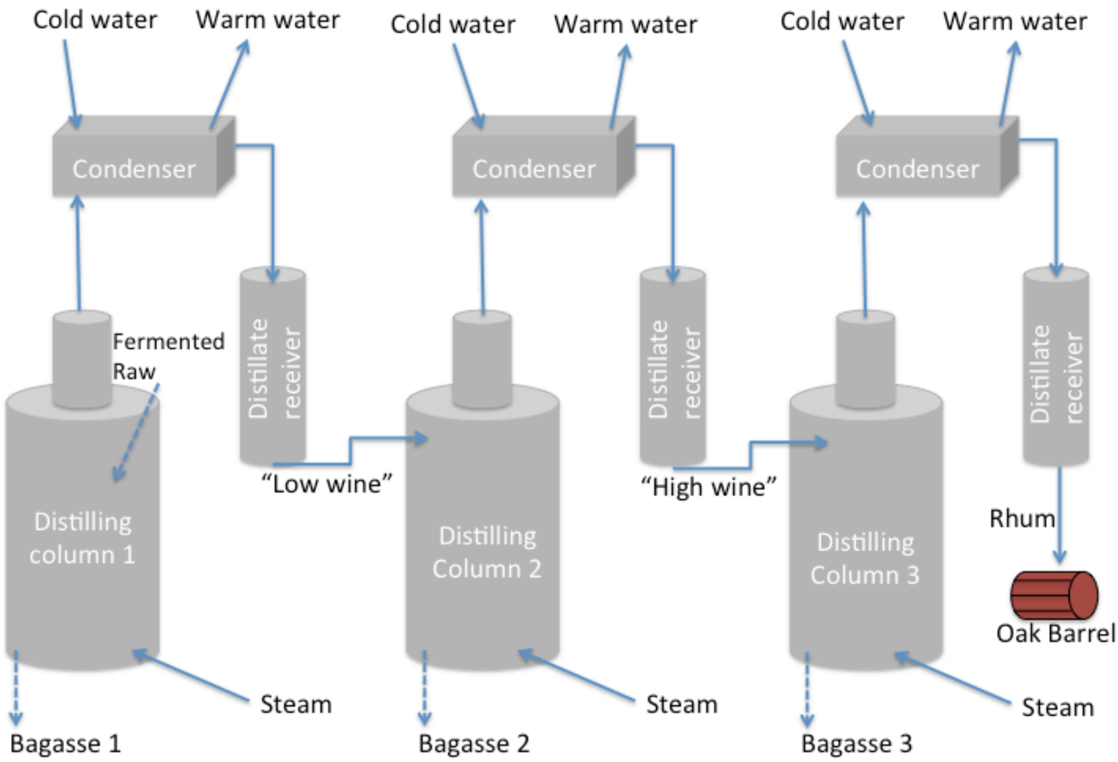

Cold water
Warm water
Condenser
Distillate receiver
Fermented Raw
Distilling column 1
"Low wine"
Steam
Bagasse 1
Cold water
Warm water
Condenser
Distillate receiver
Distilling Column 2
"High wine"
Steam
Bagasse 2
Cold water
Warm water
Condenser
Distillate receiver
Distilling Column 3
Rhum
Oak Barrel
Steam
Bagasse 3

Figure 5

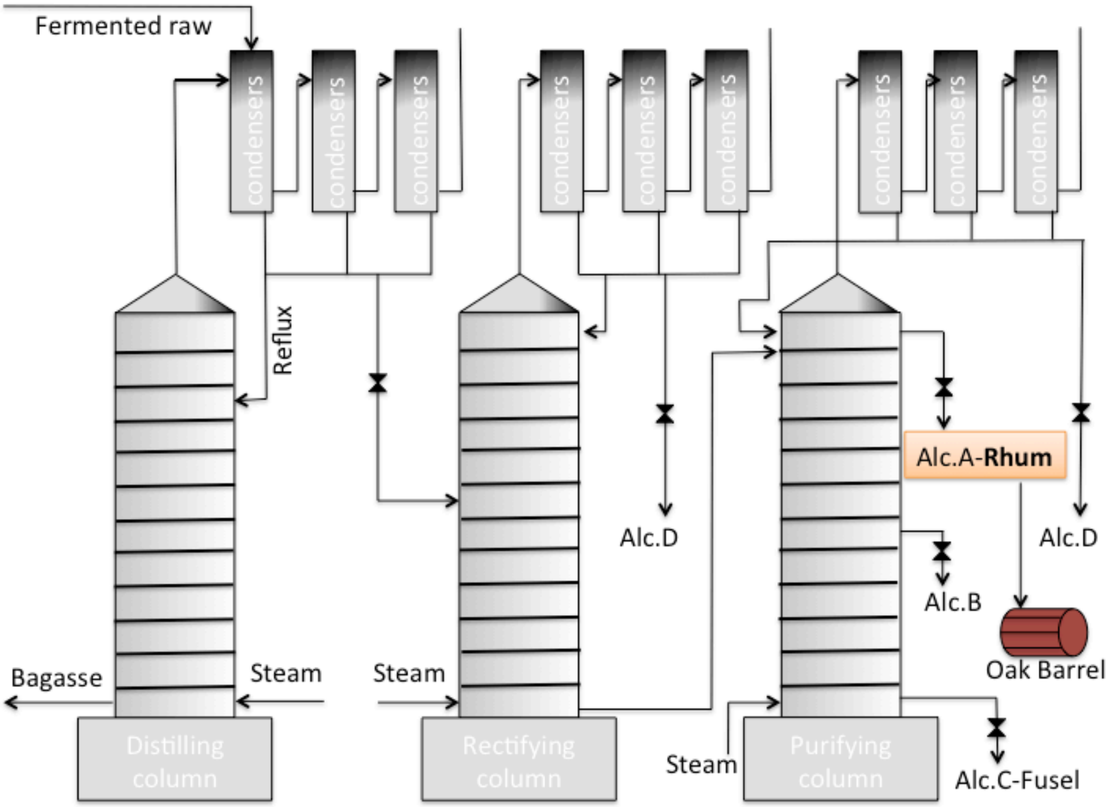

Fermented raw
condensers
condensers
condensers
condensers
condensers
condensers
condensers
condensers
condensers
Reflux
Alc.D
Alc.A-Rhum
Alc.D
Alc.B
Oak Barrel
Bagasse
Steam
Steam
Steam
Distilling column
Rectifying column
Purifying column
Alc.C-Fusel

Figure 6

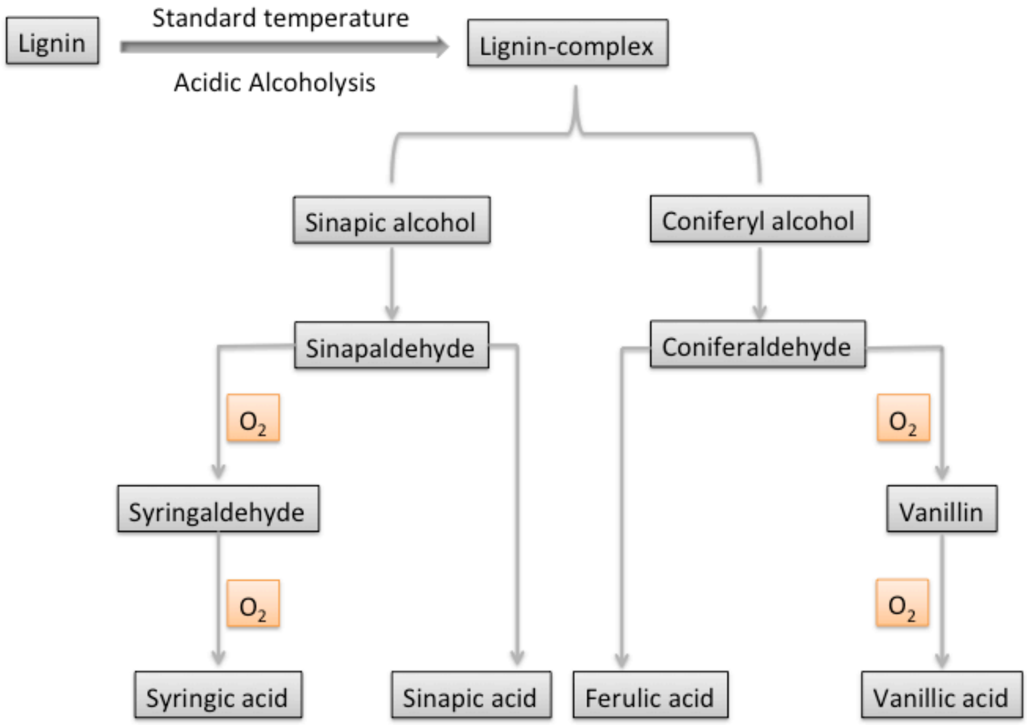

Lignin
Standard temperature
Acidic Alcoholysis
Lignin-complex
Sinapic alcohol
Coniferyl alcohol
Sinapaldehyde
Coniferaldehyde
O_2
O_2
Syringaldehyde
Vanillin
O_2
O_2
Syringic acid
Sinapic acid
Ferulic acid
Vanillic acid

Figure 7

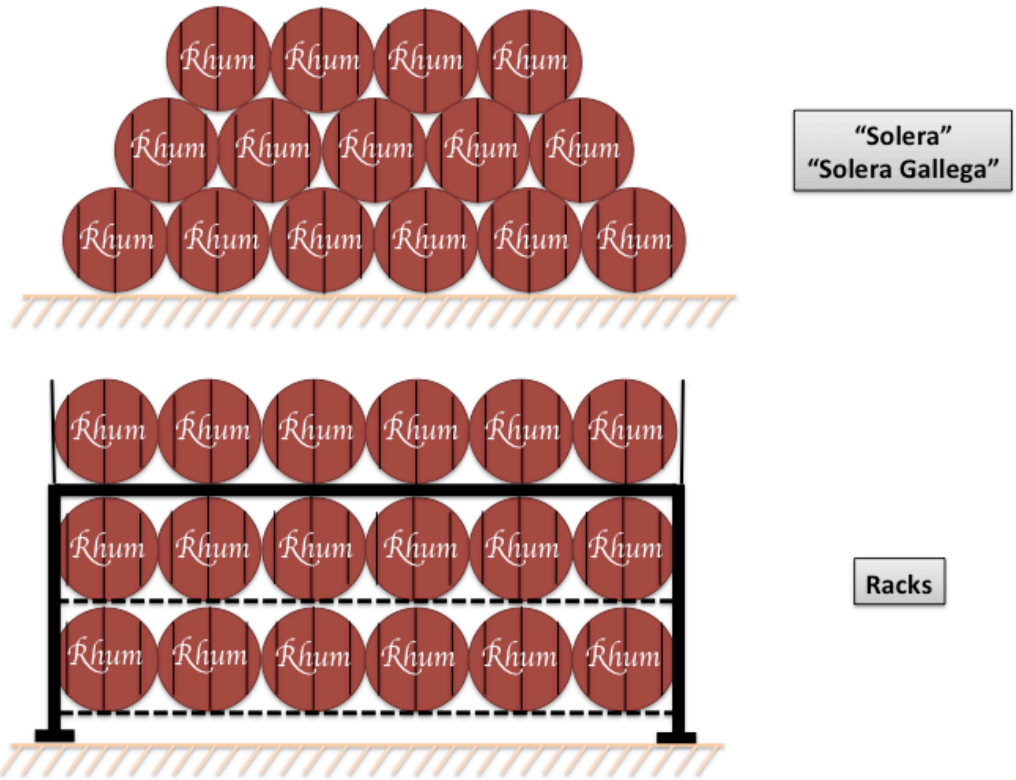


Table 1. Most frequently bacteria and yeasts in molasses.

BACTERIA	YEASTS
Bacillussubtilis	Schizosaccharomycespombe (heavy rums)
Bacilluslichemiformis	Schizosaccharomycesoctosporus (heavy rums)
Bacillusbrevis	Saccharomycescerevisiae
Bacilluscereus	Saccharomycesrouxii (light rums)
Bacillusmegaterium	Saccharomycesmellis (light rums)
Bacilluspumilus	Rhodotorula mucilaginosa
Brevibacteriumimperiale	Kluyveromycesfragilis
Bacillusbrevis	Gen. Candida
Bacilluscereus	Gen. Hansenula
	Gen. Kloeckera
	Gen. Pichia
	Gen. Sacharomycodes
	Gen. Turolopsis

Table 2. Composition and factors molasses should gather for the start and good development of alcoholic fermentation.

Nutrients			**Conditions molasses**
Sugars	**Contributing factors**		
	Intrinsic	Extrinsic	
Sucrose	Water	Inorganic nitrogen (ammonium salts in g $100 mL^{-1}$): 2.0-2.5	Ideal fermentation temperature: 21ºC (33-42ºC max, as yeast)
Glucose	Vitamins	Sulfur (sulphate)	Fermentation time: Light rum 1.5 to 2 days Heavy rum : up to 12 days
Fructose	Minerals: Macros: 0.1 to 1mM Micros: 0.1 to 100μM	Phosphorus (phosphoric acid in mg $100 mL^{-1}$): 600-750	Density (ºBrix): 16-20
Inverted sugar	Yeasts	Selected yeasts	pH: 2.5-5.5 (generally pH=4)
Non fermentable sugars Total sugars ($g\ 100 mL^{-1}$): 10-12	Bacteria	Selected bacteria (Gen. Clostridium)	

Table 3. Congener production under different yeast strains.

Strain	Acetaldehyde ($g\ 100L^{-1}a.a$)	Ethyl acetate ($g\ 100L^{-1}a.a$)	Propyl alcohol ($g\ 100L^{-1}a.a$)	Isoamyl alcohol ($g\ 100L^{-1}a.a$)	Isobutyl Alcohol ($g\ 100L^{-1}a.a$)	Total acids ($g\ 100L^{-1}a.a$)
S.pombe L/28-4-1	4.01	3.07	3.33	ND	2.31	577
K.fragilis KR 16	2.84	2.41	3.75	10.00	3.26	475
K.fragilis KR 1	1.20	2.11	2.01	5.36	2.79	517
S.cerevisiae 373	1.85	2.22	2.73	7.08	3.12	440

a.a : absolute alcohol

Table 4. Influence of pH on alcoholic fermentation.

Product	pH 3	pH 4	pH 5	pH 6	pH 7
Ethanol (g 100L^{-1}a.a)	171.0	177.0	173.0	161.0	150.0
CO_2 (g 100L^{-1}a.a)	181.0	190.0	188.0	177.0	161.0
Glycerol (g 100L^{-1}a.a)	6.2	6.6	7.7	16.2	22.2
Acetic ac. (g 100L^{-1}a.a)	0.5	0.7	0.8	4.0	8.7
Lactic ac. (g 100L^{-1}a.a)	0.8	0.4	0.5	1.6	1.9

a.a: absolute alcohol

Table 5. Rum producing countries.

Country	Rum kinds	Commercial brands
Brazil	Sugar cane rum	Cachaça
Colombia	Old rum (light)	Caldas, Antioquía
Cuba	Carte blanche (light) Golden carte (light, coloured)	Arecha, Bucanero, Caribbean, Havana Club, Isla del Tesoro
Dominican Republic	Light rum	Barceló, Brugal, Siglo
Guatemala	Light rum	Zacapa
Guyana	Demerana Courante	El Dorado, Dos Maderas, XM, Wood`s, Lam`s
Haiti	Simple distillation rum Double distillation rum	Clairin, Barbancourt
Jamaica	Light rum Blended rum Heavy rum (wedderburn, pummer)	Apletton, Capitán Morgan, Myer`s, Lemon Hart
La Martinica	Heavy rums	Bardinet, Grappe Blanche, Clement, Gran Arome, Saint James, Negrita, Bacardí, Bailly, Duquesne
La Barbada	Light rum	Mout Gay, West Indian Rum, Barbados Dt.
Philippines	Light rum	Pandy, Tanduay
Puerto Rico	White label Golden label	Bacardí, Boca chicacarioca, Don Q, Mérito, Ronrico, Matusalem, Bellows
Spain	Pale rum (light) Honey rum (sweet)	Montero, Bacardí, Bermúdez, Larios, Guanche, Aldea, Tropicana, Negus, Negrita, Bunti, Pujol
Trinidad	Light rum	Bacardí
Venezuela	Light rum	Aniversario, Cacique, Pampero, Santa Teresa, Estelar, Real Caruano