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Is rum toxic?

Le rhum est-il toxique ?

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Abstract – Introduction: During his second voyage to the Americas, Christopher Columbus brought to the West Indies, at the end of the 15th century, the sugar cane *Saccharum officinarum*, originally from Asia. It was only during the 17th century, somewhere around 1640, that an alcohol obtained from the sugar cane or more exactly from molasses, a residue of the sugar cane manufacture, appeared in different islands of the Caribbean. Rum (in French, *rhum*) is obtained by distilling fermented cane juice (agricultural rum) or molasses (industrial rum). Today, every year more than 200 000 tons of sugar cane produce 8 M litres of rum and 4000 T of sugar in Martinique. **Methods**: The authors describe the manufacturing procedure of rum in Martinique (fermentation and distilling processes), then present the various qualities of agricultural and industrial rums and explain the criteria necessary for their A.O.C. appellation. As we know, rum contains 40 to 50% alcohol and is drunk pure or as a cocktail with sugar cane syrup or fruit juices. It may be dangerous for health. So, two pathologies must be considered: those where sugar is concerned and those where alcohol is involved. Some epidemiological studies have been conducted to sum up the situation of Martinique regarding these two problems. **Results**: In Martinique, type 2 diabetes appearing in the adult is the most frequent form. The prevalence of diabetes is 8 to 10%, which is 2 to 3 times higher than in metropolitan France and the rest of the world. While it is widely recognised that alcoholism has negative health effects, moderate consumption has been found in some research to have a positive effect on longevity. However, in the case of abuse, oxidative and nonoxidative pathways of alcohol metabolism have numerous detrimental consequences that contribute to tissue damage and diseases seen in alcoholic patients. Martinique is in particular exposed to excessive alcohol consumption: 14% of the male population and 2.7% of the female population show an addiction to alcohol. Young people under 18 are two times less likely than young people in metropolitan France to declare that they consume alcohol on a regular basis and four times less likely to declare repetitive drunkenness. As concerns the death rate related to alcoholism, it is considered that 80 to 95% of deaths due to liver cirrhosis, alcoholic psychosis, alcoholism and upper digestive tract cancer are related to an excessive alcohol consumption. On this basis, 85 to 100 deaths can be attributed to alcohol every year in Martinique. In comparison with metropolitan France, Martinique shows a lower death rate for liver cirrhosis and upper digestive tract cancer, but a higher death rate for alcoholic psychosis and alcoholism. This could be due probably to a genetic predisposition of the population. **Conclusion**: Rum is a strong alcoholic beverage. Its consumption is not forbidden but requires caution, and people may be informed of its adverse health consequences. As for the question: is rum toxic? The answer is: it all depends on how you manage it.

Key words: Rum in Martinique, manufacture, risks for health

Résumé – Introduction : Au cours de son second voyage vers les Amériques, Christophe Colomb importa dans les Antilles à la fin du 15e siècle, la canne à sucre, *Saccharum officinarum*, d'origine asiatique. Ce n'est qu'au cours du 17e siècle, vers 1640, qu'un alcool obtenu à partir de la canne à sucre ou plus exactement de la mélasse, un résidu de l'industrie sucrière, fait son apparition dans les Caraïbes. Le rhum (*rum*, en anglais) est obtenu par distillation du jus de canne fermenté (rhum agricole) ou de la mélasse (rhum industriel). Aujourd'hui chaque année plus de 200 000 T de canne à sucre sont récoltées en Martinique et produisent 8 M de litres de rhum et 4000 T de sucre. **Méthode** : Dans ce travail, nous décrivons la fabrication du rhum (fermentation et distillation) puis nous présentons les différentes variétés de rhums agricoles et industriels et précisons les critères nécessaires à leur appellation contrôlée. Comme on le sait, le rhum qui renferme 40 à 50 % d'éthanol est bu pur ou sous forme de cocktails à base de sirop de canne ou de jus de fruits. En cas d'excès de consommation de ce type de boissons, deux sortes de pathologies peuvent en découler : celle où

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le sucre est en cause et celle où l'alcool est impliqué. Diverses études épidémiologiques ont permis de cerner la situation en Martinique vis-à-vis de ces deux problèmes. **Résultats** : Le diabète de type 2 chez l'adulte constitue ainsi la forme la plus fréquente de la première pathologie. La prévalence de cette maladie concerne 8 à 10 % de la population ce qui est 2 à 3 fois plus fort qu'en métropole et dans le reste du monde. Bien qu'il soit unanimement reconnu que l'alcoolisme exerce des effets néfastes sur la santé, diverses recherches ont montré que la consommation modérée d'alcool augmente significativement la durée de la vie. Cependant, en cas d'abus, le métabolisme de l'alcool éthylique est responsable de nombreux effets délétères sur l'organisme qui contribuent à endommager les tissus et à créer des pathologies bien caractéristiques chez l'alcoolique. La Martinique, comme plusieurs autres départements français, n'échappe pas à ce problème qui touche surtout la population adulte. En 2001, 14 % des hommes et 2,7 % des femmes montraient une addiction à l'alcool, mais l'usage quotidien d'alcool concernait moins de 1 % des jeunes de 18 ans. En 2004, les jeunes âgés de moins de 18 ans étaient deux fois moins nombreux que les jeunes métropolitains à déclarer consommer régulièrement de l'alcool et quatre fois moins nombreux à déclarer des ivresses répétées. En ce qui concerne la mortalité liée à l'alcoolisme, le Haut Comité de la Santé Publique considère que 80 à 95 % des décès par cirrhose, psychose alcoolique, alcoolisme et cancer des voies aerodigestives supérieures sont liés à une consommation excessive d'alcool. Sur cette base, ce sont 85 à 100 décès qui peuvent être imputés chaque année à l'alcool, en Martinique. Comparativement à la métropole, la Martinique présente une sous-mortalité pour les cirrhoses et les cancers des voies aérodigestives supérieures mais une surmortalité pour les psychoses alcooliques et l'alcoolisme. Cette différence est peut-être due à une prédisposition génétique de la population. **Conclusion** : Le rhum est une boisson alcoolisée. Sa consommation n'est pas interdite, mais nécessite de faire attention et chacun se doit d'être informé sur les conséquences qu'il encourt pour sa santé. Aussi à la question : le rhum est-il toxique, notre réponse est : tout dépend de l'usage que l'on en fait !

Mots clés : Rhum en Martinique, fabrication, risques pour la santé

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1 What is rum?

Rum is more than just a drink, it is a culture in itself. Rum-tasting is a ritual that requires a long initiation: to savour its divine flavour, to distinguish between its myriad of varieties and to delight in a particularly fine bottle you need to be taught by an expert!

2 Some history

During his second trip to the Americas, Christopher Columbus, at the end of the 15th century, brought sugar cane, originally from Asia. The first plantations were probably located in Santo Domingo, from where the first sugar shiploads were sent to Spain.

During the 17th century, an alcohol derived from sugar cane, or more exactly from molasses, a residue of manufactured sugar cane, appeared in different islands of the Caribbean. A text from the middle of the 17th century dealt with this brandy under the name of "wobbler" and "rumbullion" – "keep silent devil" describing the force released by its consumption. At the end of that century, the designation "wobbler" seemed to disappear and the word "rum" – an abbreviation of "rumbullion" – became commonly used. In 1635, the French settled in Martinique. The main produce for export was coffee and cotton. The first experiments were being conducted for growing sugar cane (1638: birthday of Louis XIV). In 1650, Martinique already exported small quantities of sugar but this was not a profitable activity, for only a small proportion of the juice was transformed into sugar. As production increased, a solution was sought for this waste, that was solved by a factory labourer who tasted the juice which had fermented by the heat and natural yeast: sugar mill molasses rum or industrial rum was born [1].

Then Father Du Tertre arrived on the scene, who fabricated a distilling apparatus for processing the scum and rough syrup. In 1694 Father Labat invented the still. A great number of sugar factories then extended the plant to include a rum distillery. In 1767, sugar syrup became the international currency exchange. There were 450 sugar factories in Martinique (1769: birthday of Napoleon I). In 1870 cane fields covered 57% of all farmland; several traditional sugar works pooled together to form centralised factories. However, confronted with the collapse of the sugar rates, other markets had to be found: hence appeared the idea of distilling the fresh, fermented cane juice. Thus emerged agricultural rum or habitant rum. To meet demand, a veritable rum industry was set up. On May 8, 1902, there was the eruption of the Mount Pelee volcano that totally destroyed the town of Saint-Pierre and reduced production capacity by half. During the First World War, revival of the town was well under way, and factories were modernised. Rum gave soldiers courage. Rum also entered into the composition of explosives: the production was doubled. In 1918 mainland France distilleries became concerned by this competitor with such low and anarchical rates: metropolitan France limited imports of colonial rum. Today in Martinique, the cane-sugar-rum sector includes approximately 4000 employees, and 4000 hectares planted in sugar cane. During 2005, 200 000 tons of cane were produced: along with 8 million litres of rum and 4000 tons of sugar, while 4.6 M T and 120 M T of cane were harvested in the Caribbean and the world, respectively. "Agricultural rum" is the result of the direct distillation of the sugar cane juice as opposed to "industrial rum" which defines the distillation of the by-products of sugar refining [2].

3 Manufacturing procedure of rum in Martinique

3.1 Agricultural rum

Sugar cane (*Saccharum officinarum*) is crushed through a press, resulting in a compact biomass referred to as "bagasse". This is later placed in a grinder composed of three cylinders in order to ensure a tough grinding to extract the maximum juice. Sugar cane must be ground within 36 hours after it has been cut. The cane juice (vesou) is gathered in a drainage system for filtering and pumped onto the fermenting vats. The remaining bagasse is used for fuel and ensures the necessary energy for the process of fabrication.

The second step is the rum fermentation process which takes approximately 30 hours in big fermenting vats. During fermentation, the sugar present in the sugar cane produces alcohol and carbon dioxide. Rum fermentation media containing yeast and bacterial flora of the "wild" type are natural ecosystems giving rise to flavours in the rum so that it possesses distinctive features linked to the local natural environment.

$$C_6H_{12}O_6 \quad \text{—(zymase)}\rightarrow \quad 2\,C_2H_5OH + 2\,CO_2$$

(Pasteur, 1857)

The third step is the distilling process: the vesou enters the top of the analysing column and steam is injected at the bottom of the column. Vapour is produced from the boiling wash, then travels up the analysing column through a number of perforated plates and goes through the vapour pipe to the base of the rectifying column, where the vapour then condenses. A ton of sugar cane is enough to produce approximately 100 litres of 55° agricultural rum [3].

There are various qualities of agricultural rum:

- White rum (*rhum blanc*), the basis of "Ti-punch", reveals all the flavour of freshly cut sugar cane. Its alcohol content is reduced to 50 and 55 degrees by the addition of distilled or spring water.
- Aged rum (*rhum vieux*) is white rum conserved in oak barrels for three years or more, depending on the quality. "Three-year-old" rums are 45 degrees approximately. "Five- to forty-year-old" rums are a rival to any premium spirit and are to be consumed accordingly.
- Straw rum (*rhum paille*) is a type of rum which has remained in an oak cask for 12 to 18 months and has thus been slightly discoloured. It is generally around 50 degrees.
- Amber rum (*rhum ambré*) is obtained by mixing aged rum and straw rum, resulting in a taste with the force of the latter and the perfume of the former. This rum is extremely strong and is often used for pastries, cocktails and crepes.

3.2 Industrial rum

Industrial rum is manufactured by distilleries directly attached to cane-sugar factories. Molasses is fermented with the help of yeast, which gives an alcoholic liquid of around 5 to 6 degrees. Distillery is then continued in similar column stills to agricultural rum, until the alcohol content reaches 65 to 75 degrees, though legislation does not allow the sale of alcohol of more than 65 degrees. This is compensated for by the addition of water.

There are also various qualities of industrial rum:

- Traditional rum is the most typical of rums for consumption, containing 40% of alcohol and a rather strong flavour, most typically used for confectionery, pastry and cooking.
- Grand aroma rum has a unique flavour, due to its long fermentation period of 8 to 10 days. It is a mixture of molasses and wine blended in wooden casks, used essentially for cocktails, cooking and pastries. This rum is almost solely for export, so it is not well-known by Antilleans, even though it is manufactured in Jamaica and Martinique.

3.3 Martinique and the French A.O.C. label

As we have seen in the description above, industrial rum is of an inferior quality to agricultural rum, and is often referred to as traditional rum in commerce. The term "agricultural rum", however, is a serious marketing blunder, which does little to actually reflect the exceptional quality of the beverage concerned. Martiniquean producers have thus lately turned towards the communication of the controlled origin of their product. The first demand for AOC recognition was formulated in 1970 by Gustave Garnier Laroche, president of the Professional Association for Producers and Bottlers of Agricultural Rum in Martinique. It took him over thirty years to obtain this "appellation". Today eleven rums have been certified. As a general rule, appellations are granted to products bearing distinct characteristics of a certain territory, regional tradition and particular quality. Specificity is the key, making sure that the product has a unique taste, which differentiates it from other similar products. Technically speaking, each step of the process must follow a strict code, from the selection of sugar cane to the process of ageing. White rums, for example, must be aged a minimum of three months. Straw rums and aged rums must have spent at least three months in the production area in oak barrels of a capacity less than 650 litres [4].

For scientific purposes, we analysed four old rums of the same origin (Rhumerie Clément) and from different years (1953, 1975, 1985 and 1995) by HS-GC-MS. There is no difference between their chromatographic profiles. Major volatile constituents are ethanol, 1-propanol and 3-methyl,1-butanol. These results confirm the constancy of the manufacturing (Fig. 1).

4 Legendary uses of rum

In the beginning, rum was the drink of slaves and sailors. In the 1650s, the Royal Navy instituted the daily distribution of rum to the sailors, but later it was replaced by a mixture made of two volumes of water for one volume of rum, which was baptised "grog". In the Caribbean, the English had also taken up the practice of mixing rum with several other ingredients: tea, sugar, lemon, etc. They gave this cocktail the name "punch". Today it is without doubt the island's national drink: heaven itself for users and hell for abusers! Sometimes it may be used as an antiseptic, but that is very rare [5].

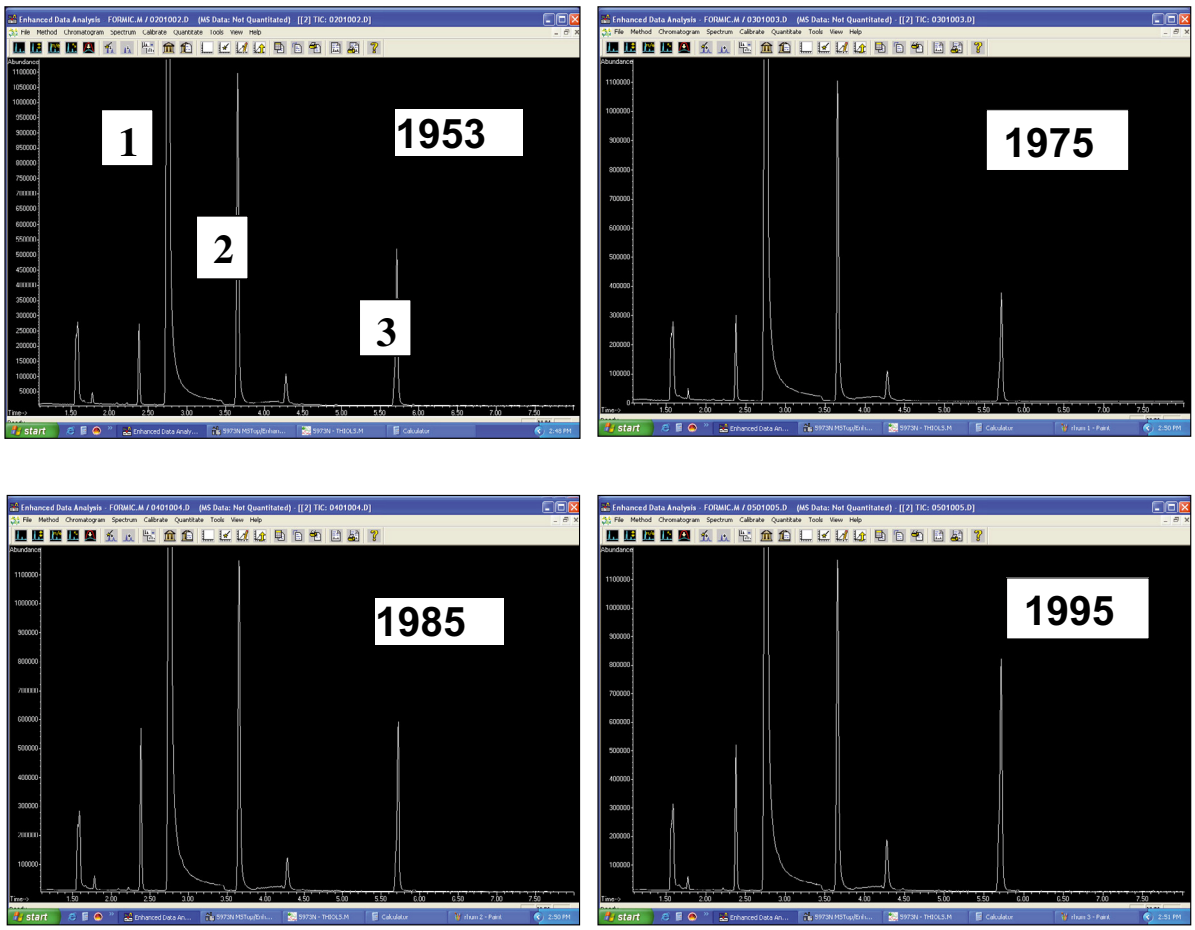

Fig. 1. HS-GC-MS of the 4 old rums from the same origin (Rhumerie Clément). 1: ethanol; 2: 1-propanol; 3: 3-methyl, 1-butanol.

5 Some toxicology

Rum contains alcohol: it may be dangerous for your health. As we know, it is drunk pure or as a cocktail with sugar cane syrup and fruit juices: "Ti-punch", "Planteur", "Blue Lady", "Daïquiri", etc. So two types of pathology must be considered: those where sugar is concerned and those where alcohol is involved.

5.1 Diabetes in Martinique

Diabetes is characterised by a growing increase in glucose in the blood (glycaemia higher than 1.26 g per litre, without eating anything). In Martinique the prevalence of diabetes is 8 to 10%, which is 2 to 3 times higher than in continental France and in the rest of the world. Type 2 diabetes appearing in adults is the most frequent form. With more than one out of five admitted patients, this represents the second reason for long-term cases. This diabetes is characterised by a partial deficit and/or inefficiency of insulin: it is supported by adiposity and sedentariness [6].

5.2 How and where does alcohol go in the body?

Ethyl alcohol (ethanol, CH_3CH_2OH) is a low-molecular-weight aliphatic compound, which is slightly soluble in lipids and completely miscible with water. Thus, it is readily distributed throughout the body and may cross important biological membranes such as the blood brain barrier, to affect a large number of organs and biological processes in the body. Absorption of ethyl alcohol into the blood can occur through the skin and via the lungs but the major route of alcohol entering into the body is by drinking alcoholic beverages. So ethyl alcohol is a typically human toxicant as it is the normal constituent of most alcoholic drinks, especially here where it is consumed as pure rum or as cocktails. Ethyl alcohol distributes in the body in proportion to the water content in the particular tissue. Ethanol crosses with water into the bloodstream; therefore the process of distribution is rapid. The blood alcohol concentration (B.A.C.) following a known dose absorbed may be estimated on the basis of the subject's sex, body weight and degree of adiposity. The volume of distribution is about 0.7 in men and 0.6 in women. During its absorption, B.A.C. is not homogenous in all the circulatory system: arterial blood contains more ethanol than venous blood. Equilibrium is reached in about 45 to 60 minutes in a normal subject. The ratio of ethanol between plasma or serum and whole blood is comprised between 1.10 and 1.25. Among the factors that can influence absorption from the gastrointestinal tract, the most important determinant seems to be gastric emptying. In general, the faster the gastric emptying, the more rapid absorption is. Therefore, factors which influence gastric emptying influence absorption. One of

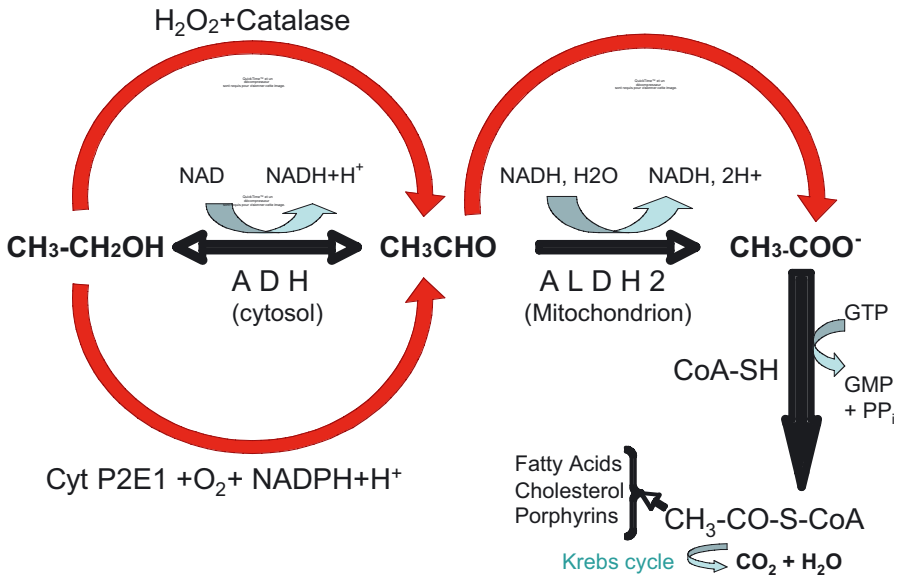

Fig. 2. Oxidative pathways of ethanol metabolism.

the predominant factors is the presence of food. Food delays gastric emptying and therefore delays absorption of ethyl alcohol. Interestingly, the type of food, whether fat, carbohydrate or protein, does not seem to be a factor in the absorption of ethyl alcohol. Physiological factors such as strenuous physical exercise also delay gastric emptying, thus decreasing ethyl alcohol absorption. Additional factors such as drugs (*e.g.* nicotine, marijuana and ginseng) that modify physiological factors regulating gastric emptying also modify ethyl alcohol absorption in a predictable manner. Women absorb and metabolise alcohol differently from men. The difference in B.A.C.s has been attributed to women's smaller amount of body water and may also be related to a lower stomach enzyme ADH activity [7].

After alcohol is swallowed, it is absorbed primarily from the small intestine into the veins that collect blood from the stomach and bowels and from the portal vein, which leads to the liver. From there it is carried to the liver, where it is exposed to enzymes and metabolised. Although the liver is the main organ responsible for metabolising ingested alcohol, other organs such as the brain, pancreas and gastrointestinal tract may perform some transformations. In general, alcohol metabolism is achieved by both oxidative pathways, which either add oxygen or remove hydrogen through pathways involving alcohol dehydrogenase (ADH), cytochrome P 450 2E1, catalase enzymes and nonoxidative pathways. Most of the alcohol consumed is metabolised in the liver, but that which remains unmetabolised permits alcohol concentration to be measured in the breath and urine [8].

5.3 Metabolism of ethanol and biological consequences

5.3.1 Oxidative pathways

As shown in Figure 2, during the first step of its metabolism, ADH, cytochromes P 450 and catalase all contribute to oxidative ethanol in acetaldehyde [9].

Alcohol Dehydrogenase. The major pathway of oxidative metabolism of ethanol in the liver involves ADH (present in the cytosol), an enzyme with many different variants (isoenzymes). Metabolism of ethanol with ADH produces acetaldehyde, a highly reactive and toxic by-product that may contribute to tissue damage and, possibly, the addictive process by forming salsolinol, responsible for dependence. ADH constitutes a complex family and, in humans, five classes have been categorised based on their kinetic and structural properties. This oxidation process involves an intermediate carrier of electrons, nicotinamine adenine dinucleotide (NAD^+), which is reduced by two electrons to form NADH. As a result, alcohol oxidation generates a highly reduced cytosolic environment in hepatocytes. In other words, these reactions leave the liver cells in a state that is particularly vulnerable to damage from the by-products of ethanol metabolism, such as free radicals and acetaldehyde.

Cytochromes P450. The cytochrome P450 isoenzymes, including CYP2E1, 1A2 and 3A4, which are present predominantly in the microsomes, or vesicles, of a network of membranes within the cell known as the endoplasmic reticulum, also contribute to alcohol oxidation in the liver. CYP2E1 is induced by chronic alcohol consumption and assumes an important role in metabolising ethanol into acetaldehyde at elevated ethanol concentrations (K_m = 8 to 10 mM, compared with 0.2 to 2.0 mM for hepatic ADH). In addition, CYP2E1-dependent ethanol oxidation may occur in other tissues, such as the brain, where ADH activity is low. It also produces reactive oxygen species (ROS), including hydroxyethyl, superoxide anions and hydroxyl radicals, which increase the risk of tissue damage.

Catalase. Another enzyme, catalase, located in cell bodies called peroxisomes, is capable of oxidising ethanol in vitro in the presence of a hydrogen peroxide (H_2O_2)-generating system, such as the enzyme complex NADPH oxidase or the enzyme xanthine oxidase. Quantitatively, however, this is

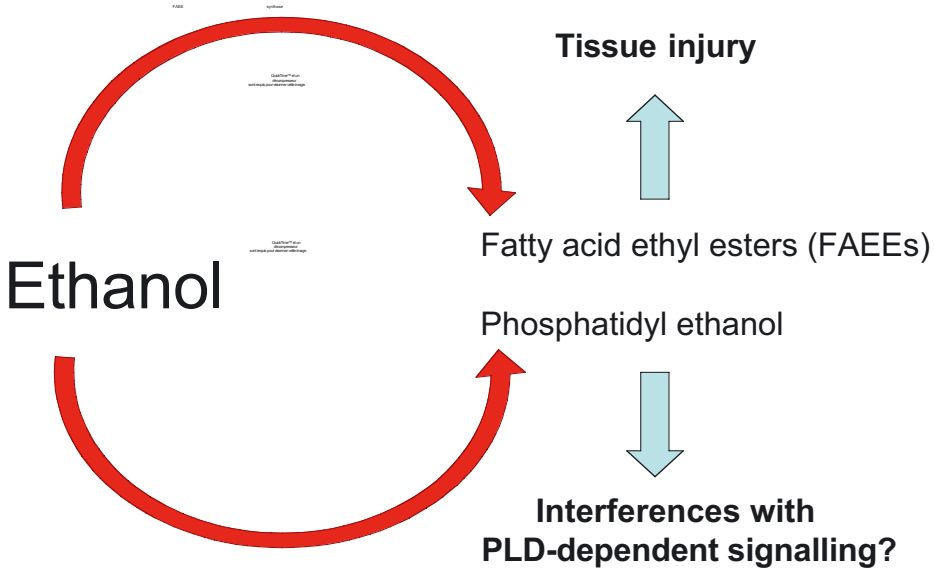

Fig. 3. Nonoxidative pathways of ethanol metabolism.

considered as a minor pathway of alcohol oxidation, except in the fasted state.

Acetaldehyde and acetate are produced during the second step of metabolism and contribute to cell and tissue damage in various ways.

Acetaldehyde. Acetaldehyde, produced by alcohol oxidation through any of the mechanisms outlined above, is rapidly metabolised into acetate, mainly by ALDH2 (in the mitochondria), to form acetate and NADH. NADH is then oxidised by a series of chemical reactions in the mitochondria (in the electron transport chain). Acetaldehyde has the capacity to bind to proteins such as enzymes, microsomal proteins and microtubules. It also forms adducts with dopamine to form salsolinol, which may contribute to alcohol dependence, and with DNA to form carcinogenic DNA adducts such as 1,N^2-propanodeoxyguanosine. Formation of protein adducts in hepatocytes impairs protein secretion, which has been proposed to play a role in hepatomegaly.

Acetate. Acetate, produced from the oxidation of acetaldehyde, is oxidised into carbon dioxide (CO_2). Most of the acetate resulting from alcohol metabolism escapes from the liver into the blood and is eventually metabolised into CO_2 in the heart, skeletal muscle and brain cells. Acetate is not an inert product; it increases blood flow into the liver and depresses the central nervous system, as well as affecting various metabolic processes. Acetate is also metabolised into acetyl CoA (CH_3-CO-S-CoA), which is involved in lipid and cholesterol biosynthesis in the mitochondria of peripheral and brain tissues. It is hypothesised that upon chronic alcohol intake the brain starts using acetate rather than glucose as a source of energy.

5.3.2 Nonoxidative pathways

The nonoxidative metabolism of alcohol is minimal, but its products may have pathological and diagnostic relevance. Alcohol is nonoxidatively metabolised by at least two pathways. One leads to the formation of fatty acid ethyl esters (FAEEs) from the reaction of alcohol with fatty acids that play functional roles in human cells. The other nonoxidative pathway results in the formation of phosphatidyl ethanol (see Fig. 3). FAEEs are detectable in serum and other tissues (hair) after alcohol ingestion and persist long after alcohol is eliminated. The role of FAEEs in alcohol-induced tissue damage remains to be further evaluated.

The second nonoxidative pathway requires the enzyme phospholipase D (PLD), which breaks down phospholipids (primarily phosphatidylcholine) to generate phosphatidic acid (PA). This pathway is a critical component in cellular communication. PLD has a high K_m for ethanol, and the enzymatic reaction does occur predominantly at high circulating alcohol concentrations. The product of this reaction, phosphatidyl ethanol, is poorly metabolised and may accumulate to detectable levels following chronic consumption of large amounts of alcohol, but its effects on the cell remain to be established. However, the formation of phosphatidyl ethanol occurs at the expense of the normal function of PLD, namely to produce PA, resulting in inhibited PA formation and disruption of cell signalling.

Oxidative and nonoxidative pathways of alcohol metabolism are interrelated. Inhibition of ethanol oxidation by compounds that inhibit ADH, CYP2E1 and catalase results in an increase in the nonoxidative metabolism of alcohol and increased production of FAEEs in the liver and pancreas.

5.3.3 Biological consequences of ethanol metabolism

The different pathways of ethanol metabolism described above have numerous detrimental consequences that contribute to the tissue damage and diseases seen in alcoholic

patients. These consequences include oxygen deficits (*i.e.*, hypoxia) in the liver; interaction between alcohol metabolism by-products and other cell components, resulting in the formation of harmful compounds (*i.e.*, adducts); formation of highly reactive oxygen-containing molecules (*i.e.*, reactive oxygen species [ROS]) that can damage other cell components; and changes in the ratio of NADH to NAD^+ (*i.e.*, the cell's redox state) [10].

Tissue damage

The direct actions of alcohol (*e.g.*, disordering of membrane components and effects on signalling proteins) and the indirect effects resulting from ethanol metabolism act in concert to induce tissue damage. In fact, ethanol metabolism is often considered to be the predominant factor causing alcohol-associated tissue damage, particularly through the generation of ROS and oxidative stress in the tissues. ROS are generated during ethanol and acetaldehyde oxidation both by ADH/ALDH and by CYP2E1. The rate of ethanol and acetaldehyde oxidation by ADH and ALDH is determined by the rate at which the NADH generated can pass through the mitochondrial electron transport system owing to the malate-aspartate shuttle. Because the mitochondrial electron transport system requires oxygen and generates ATP, the rate of NADH oxidation depends both on the cell's oxygen supply and on its demand for ATP. If either of these two factors is limited, electron transport activity is reduced. This has two effects: first, ethanol and acetaldehyde are inefficiently metabolised and, second, electrons passing through the mitochondrial electron transport chain are "diverted" into forming harmful ROS, mainly superoxide. Because ethanol metabolism by ADH and ALDH occurs primarily in the liver, any adverse effects associated with ethanol metabolism by these enzymes and associated ROS production primarily would affect that organ.

In contrast, CYP2E1, which also oxidises ethanol, particularly following chronic alcohol intake, is found in many tissues in addition to the liver, including the brain, heart, lungs and certain white blood cells (neutrophils and macrophages). Accordingly, metabolic consequences of CYP2E1-mediated ethanol oxidation would affect numerous tissues. Harmful effects associated with CYP2E1-mediated ethanol metabolism primarily are related to the production of ROS, mainly superoxide and hydroxyl radicals. This ROS production contributes to alcohol-induced damage to a variety of tissues not only by causing oxidative stress but also by enhancing apoptosis triggered by various stimuli. In the liver, CYP2E1-mediated ethanol metabolism generates oxidative stress that leads to DNA damage and may thereby play an important role in alcohol-related development of liver cancer.

Effects on foetal development

Oxidative stress plays an important role in ethanol-induced damage to the developing foetus. Low levels of CYP2E1 are found in the prenatal brain, suggesting that CYP2E1-derived ROS could play a role in the development of alcohol-related birth defects, including foetal alcohol syndrome (FAS). Moreover, ROS produced during CYP2E1-mediated ethanol metabolism would probably be particularly harmful because the foetal brain shows only low levels of antioxidant enzyme activity compared with the adult brain.

Impairment of other metabolic processes

Chronic ethanol consumption and alcohol metabolism may also influence various other metabolic pathways, thereby contributing to metabolic disorders frequently found in alcoholics, such as fatty liver and excessive levels of lipids in the blood, accumulation of lactic acid in the body fluids, excessive production of ketones in the body, and elevated levels of uric acid in the blood.

The liver is most commonly affected by alcohol-induced damage. The first stage of liver damage following chronic alcohol consumption is the appearance of fatty liver, which is followed by inflammation, apoptosis, fibrosis and, finally, cirrhosis. The development of fatty liver is induced by the shift in the redox state of the hepatocytes that results from ethanol metabolism by ADH. This shift in the redox state favours the accumulation of fatty acids, rather than their oxidation. In addition to these metabolic effects, chronic ethanol consumption contributes to the development of fatty liver by influencing the activities of several proteins that help regulate fatty acid synthesis and oxidation.

Other metabolic derangements associated with ethanol metabolism result from the fact that ADH and ALDH metabolise not only ethanol but also other compounds. For example, ADH and ALDH oxidise retinol (*i.e.*, vitamin A_1) into retinal and, subsequently, retinoic acid, which plays an important role in growth and differentiation. In the presence of ethanol, ADH and ALDH may be occupied with ethanol metabolism and retinol metabolism may be inhibited. These interactions may have serious implications for foetal development, stem cell differentiation, maintenance of differentiated tissue function, and the normal structure and function of stellate cells in the liver.

Chronic alcohol consumption is also associated with disturbances in the metabolism of sulphur-containing amino acids, leading to increased levels of the amino acids glutamate, aspartate and homocysteine in alcoholic patients. These increases may have serious adverse effects. For example, homocysteine increases and modulates certain nerve signalling processes, particularly during alcohol withdrawal, and increases in homocysteine levels may possibly contribute to the alcoholism-associated tissue shrinkage (*i.e.*, atrophy) observed in brain tissue.

Cancer risk

Chronic alcohol consumption greatly enhances the risk of developing cancer of the oesophagus and oral cavity and plays a major role in the development of liver cancer. Several mechanisms have been identified that contribute to ethanol-associated tumour development, some of which are related to alcohol metabolism. For example, the acetaldehyde generated during alcohol metabolism promotes cancer development, as does induction of CYP2E1, leading to ROS formation.

6 Some genetic aspects of alcohol metabolism

Variations in the rate of alcohol absorption, distribution and elimination have been mostly attributed to both genetic

and environmental factors. Class I ADH and ALDH2 play a central role in alcohol metabolism. Variations in the genes encoding ADH and ALDH produce alcohol- and acetaldehyde-metabolising enzymes that vary in activity. This genetic variability may help explain why some ethnic groups have higher or lower rates of alcohol-related problems. For example, many East Asians (about half of the Japanese population) have impaired ALDH: this causes acetaldehyde levels to peak higher, producing more severe hangovers and other effects such as flushing and tachycardia. These polymorphisms thus give a negative experience to alcohol and will reduce drinking.

7 Psychotropic and physiological effects of alcohol

7.1 Beneficial effects

While it is widely recognised that alcoholism has negative health effects, moderate consumption (1–4 alcoholic drinks a day depending on age and gender) has been found in some research to have a positive effect on longevity. Medical research demonstrates that, consumed in moderation, alcohol increases HDL ("good cholesterol"), fibrinolysis, coronary blood flow and insulin sensitivity, and decreases thrombosis, fibrinogen and artery spasm from stress, all good for a healthy heart. Moderate alcohol consumption has been found to be associated with a lower risk of Alzheimer's disease and other dementia. In conclusion, moderate drinkers tend to have better health and live longer than those who abstain from alcohol or are heavy drinkers [11, 12].

7.2 Adverse effects

Ethanol is primarily a social and psychoactive drug which disturbs the functioning of the brain. It generally decreases the activity of the nervous system. Alcohol disinhibits cells and circuits in the brain which are normally inhibited. This may be responsible for reflex alteration, sleepiness (road accidents), industrial disputes and destruction of family life, etc. Ethanol is also a cellular poison in specific organs (liver, brain, central and peripheral nervous system) and contributes to the risk of developing different cancers. Rum is a strong alcoholic beverage; its consumption is not controlled but requires caution and people must be informed of its adverse health consequences.

As for the question: is rum toxic? The answer is: it all depends on how you manage it!

8 Alcoholism in Martinique

Alcoholism in Martinique is an important health factor, as in continental France. While 57% of the male population and 86% of the female population have a "no risk" alcohol profile, 14% of the male population and 2.7% of the female population show an addiction to alcohol. These results set Martinique on the 3rd rank among the most affected French regions [6].

Concerning the death rate related to alcoholism, the High Committee of Public Heath considers that 80 to 95% of deaths due to liver cirrhosis, alcoholic psychosis, alcoholism and upper digestive tract cancer are related to an excessive alcohol consumption. On this basis, 85 to 100 deaths can be attributed to alcohol every year in Martinique (without taking into account other causes such as road accidents or industrial injuries). These deaths occur in majority in men, as the gender ratio is 4 males to 1 female. When compared with metropolitan France, Martinique shows a lower death rate for liver cirrhosis and upper digestive tract cancer, but a higher death rate for alcoholic psychosis and alcoholism. This could be due probably to a genetic predisposition of the population, as was observed in China where cirrhosis was reduced by more than 70% in populations carrying the ALDH2*2 allele [13]. The importance of the effect of alcohol on the premature death rate is specially clear in the male population, as alcohol is attributable to 10% of male deaths occuring under the age of 65.

9 Conclusion

Rum may be dangerous, because of the presence of alcohol: so use it but don't abuse it. If moderate consumption has positive effects, chronic abuse is responsible for many physiological and psychological disorders. Remember that alcohol metabolism is controlled by genetic factors. It is surprising to know that Brazil, which is the first producer of sugar cane in the world, has chosen to favour the manufacturing of bioethanol. It is certainly extremely profitable; perhaps less fun, but more realistic today!

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