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A REVIEW

Microbial flora of rum fermentation media

L. Fahrasmane and B. Ganou-Parfait

I.N.R.A. Station de Technologie des Produits Végétaux, Pointe à Pitre cedex, France (F.W.I.)

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1. INTRODUCTION

Rum is the alcoholic beverage made exclusively from sugar cane (*Saccharum officinarum* L.) juice and its by-products (molasses from the manufacture of cane sugar or syrups). The first stage of rum-making is an alcoholic fermentation of musts made of raw materials diluted with water. The fermented media are then distilled. The distillates are matured for a few days up to several years in tanks, wooden vats or oak casks, before being reduced, by water dilution, to a commercial alcoholic strength (Fahrasmane *et al.* 1996).

In rum production, the alcoholic fermentation is performed through the action of yeasts, traditionally comprising *Saccharomyces* strains and, depending on the type of rum, *Schizosaccharomyces* strains. Bacteria that are found mainly in raw materials (cane juice and molasses as well as dilution waters) have metabolic activity simultaneously with the ethanol-producing yeast flora during the alcoholic fermentation, interact with its kinetics and biochemistry and affect the organoleptic properties of rums (Table 1).

The nature and abundance of the bacterial flora depend on the sanitary status of the raw material and the must components.

The bacteriostatic or sterilizing thermal treatment of must components and the acidification of the media, as well as the use of antibiotics and fermentation yeasts, make it possible to control the bacterial flora, which produces aromatic compounds. Some of these compounds (acrylic acid, acrolein, etc.) may be detrimental to the organoleptic properties of the rum and be a source of unwanted specific toxicity.

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.

In the present study carried out on Guadeloupe, Martinique and Haiti, a list was established of the microbial flora of molasses or cane sugar-based fermentation media, while the dynamics of the bacterial population during the fermentation cycle were also investigated. Bacterial overpopulation affecting the organoleptic properties of the products was analysed and technical information is provided for the control of bacterial populations at levels that enable the production of aromatic rums.

The results and data presented are a synthesis of 20 years' work. Consequently taxonomic references are not the most recent.

2. RUM TECHNOLOGY EVOLUTION AND MICROBIOLOGY

At the end of the 15th century, Christopher Colombus, representing Genoese and Venetian interests, prospected for areas in America better adapted to sugar cane crops than the Mediterranean islands and shores. As a result, rum production started with the expansion of sugar cane cropping on the American continent from the 16th century onwards. Molasses, a by-product of cane sugar manufacture, were a source of fermentable sugars.

Correspondence to: Louis Fahrasmane, I.N.R.A. Station de Technologie des Produits Végétaux BP 515, 97165 Pointe à Pitre cedex, France.

Table 1 Features of the four main types of rum

	Rhum agricole	Rhum industriel	Heavy-flavour rum	Light-flavour rum
Raw materials	Sugar cane juice	Molasses	Molasses	Molasses
NA	>225	>225	>800 (Ester >500)	<225
Distillation type	Simple, continuous column	Simple, continuous column	Simple, continuous column	Rectification, multistage column
Fermentation type	Mixed	Mixed	Mixed	Pure
Microbial flora	Bacteria, *Saccharomyces*	Bacteria, *Saccharomyces*	Bacteria, *Schizosaccharomyces*	*Saccharomyces*

NA, non-alcohol (volatile compounds other than ethanol); values are in g hl^{-1} pure alcohol.

In those days, musts, rum fermentation media, were generally composed of 10–15% molasses by volume, 40–70% stillage, the residuary liquor from distillation otherwise named slop or spent wash, and water. Under these conditions, 'wild' fermentation is able to start spontaneously; microorganisms show good resistance to previous handling during the manufacture of sugar (heating, clarification, etc.) and to competitors brought in with the wooden vats used for molasses fermentation but not cleaned out after previous operations. They arise in composition ponds and then become active during fermentation. Nowadays, 'rhum industriel' (made from molasses) results from the evolution of this kind of production.

Towards the middle of the 19th century, another system of rum production was developed in which the source of sugar was no longer molasses, but raw or boiled sugar cane juice as well as syrups. In fact, syrup was probably used as far back as the 18th century. This system originated from the slump in the sugar market and marked the beginning of 'rhum agricole' (made from sugar cane juice) production on plantations that were independent of sugar-manufacturers. The percentage of stillage in the must composition was lower (10–30%) than in molasses-based rum production. The fermentation flora was of the 'wild' type with elliptical yeast strains.

The composition and therefore the flora of rum fermentation media changed in the course of time in relation to technical and economic factors, control of water resources and increasing experience in microbiology. These changes in production processes, just as the move from still to column distillation during the 19th century, modified the composition and the organoleptic properties of rums.

Four types of rum are determined by raw materials, microbiology of the fermentation media and distillation. They are as follows (Table 1): 'rhum agricole'; 'rhum industriel'; light-flavour rum and heavy-flavour rum.

The physico-chemical conditions of the media have always largely determined the microbiology and the course of the fermentation process; acidity and non-sugar components are of primary importance in the 'wildness' of fermentation involving *Schizosaccharomyces*, while the non-sugar content has a considerable effect on the yield of the sugar–alcohol transformation; temperature (26–35 °C) has a substantial influence on the nature and importance of bacterial flora metabolites. These factors contribute to rum characteristics.

In addition to the microbial aspects, the yield of the sugar–alcohol transformation has a large variability both in rum and bioethanol production. The sugar content of the musts is generally about 100 g l^{-1}, while the fermentation cycle ranges from 18 to 40 h. In 1917, Magne showed that the considerable variations in yield for molasses were related to yeasting conditions: pure yeast 85–95% of Pasteur yield; yeast with antiseptic 70–85%; pressed yeast 50–75% and 'wild' fermentation 40–60%.

During the treatment of sugar cane stalks in distilleries, nearly half of all the losses of yield of alcohol occurs during the fermentation stage (Table 2).

Table 2 Losses at different stages of the process in the rum distillery as percent of ethanol equivalent

	Losses	
Operation	Ethanol production in Brazil*	Rum production in F.W.I.†
Extraction/crushing	6·0	9·0
Clarification	2·0	—
Fermentation	10·0	12·5
Distillation	3·0	0·9
Others	—	2·0

*According to Ebeling (1989).
†Means for 39 samples from 13 cottage distilleries in the French West Indies (F.W.I.).

Measurements of the sugar–alcohol yield in fermentation media containing molasses, syrup or cane juice in a given rum distillery indicate that the variations depend on the raw material used (Destruhaut *et al.* 1985): Gay-Lussac yield, 0·64 l of pure alcohol (lPA) kg^{-1} glucose; Pasteur yield, 0·61 lPA kg^{-1} glucose; theoretical maximal yield, 0·59 lPA kg^{-1} glucose (97% of Pasteur yield); yield on molasses, 0·52 lPA kg^{-1} glucose (85% of Pasteur yield); yield on cane juice, 0·47 lPA kg^{-1} glucose (77% of Pasteur yield); yield on syrup, 0·40 lPA kg^{-1} glucose (66% of Pasteur yield).

In Brazil, the average yield is 0·53 lPA kg^{-1} glucose in bioethanol produced from cane juice and enriched by the addition of concentrate or molasses (Ebeling 1989) (Table 2).

From sugar beet, in the same ethanol production system, Allar and de Miniac (1985) obtained yields of 0·59 and 0·60 with molasses using condensed recycling and with waste water involving slop recycling, respectively.

These figures indicate that, being higher in molasses, the non-sugar component in raw materials is a nutrient source as well as a factor affecting fermentation yield. A significant improvement in rum yields is also possible.

The spectra of short-chain fatty acids of rums show a particular pattern, both in terms of quality as well as quantity, resulting from the bacterial activity in fermentation media; these compounds contribute to the formation of esters. Propionic, butyric and valeric acid levels are particularly high in rums compared with other spirits (Suomalainen 1975). Propenoic acid indicates an intense bacterial activity (Fahrasmane *et al.* 1983). Formic acid can provide information on the conditions of rum production and also contribute to quality evaluation; an increase in formic acid content often reveals bacterial problems (Jouret *et al.* 1990).

3. YEASTS IN RUM PRODUCTION

Greg (1895) in Jamaica and Pairault (1903) in the French West Indies, especially in Martinique, followed by Allan (1906) and Ashby (1909) in Jamaica and then Kayser (1917) in the French West Indies were among the few researchers in a position to observe that *Schizosaccharomyces* strains are the only alcoholic yeasts to develop in molasses- and slop-based fermentation media in which acidity is due to the addition of slops. The osmotic pressure is prejudicial to the activity of elliptic yeasts. The latter yeasts (*Saccharomyces, Torula, Zygosaccharomyces*, etc.) are active in media in which the slop content is low or replaced by water.

3.1 Evolution of the yeast flora

Bryan Higgins, an Irish naturalist, was the first to study rum production in Jamaica in a scientific way. His work (1799–1803) is considered as a classic reference. About 100 years later, in Jamaica, the Englishman Greg (1895), who studied microbiology with the Danish workers Hansen and Jorgensen, published several articles on the subject. At the beginning of the 20thcentury, in Martinique, Pairault (1903), the head chemist of the French colonial army, came to the conclusion that 'wild' yeast should imperatively be replaced by pure fermentations. Kayser, the director of the fermentation laboratory at the Institut Pasteur in Paris, carried out a detailed survey of rum yeasts in 1913. As a result, he advocated pure fermentation with selected yeasts. These researchers, who thought that the bacterial flora adversely influenced rum fermentation, were especially concerned with improving productivity. On the contrary, two chemists who studied rum production in Jamaica (Allan 1905; Ashby 1907) agreed on the leading role of bacteria in the aroma development of heavy-flavour rums.

After 1918, some distillers in the French West Indies who wanted to increase the alcoholic yield decided to put into practice the advice of Pairault and Kayser on pure fermentations. Although the result was an increase in yields, the quality of these products evidently fell because of their increased chemical neutrality. Rocques (1927) was commissioned by the French Ministry of Agriculture to carry out a study which concluded that 'rums produced from pure and rapid fermentations are characterized by low levels of acid and ester as well as relatively high contents in the higher alcohols'.

Most rum producers subsequently gave up the use of selected yeasts and decided that 'wild' fermentations gave the best results, by producing rums with richer flavour.

Arroyo (1945), working in Puerto Rico, thought that controversies about the seeding of fermentation media and the role of bacteria in rum production were due to misunderstandings and over-hasty generalizations. Indeed, production targets in organoleptic properties seemed not to have been taken into account in choosing the correct moment for modification of the fermentation stage. Therefore, this scientist considered that some bacterial species, which can be found to a certain extent according to the kind of rum produced, increased the volume and the persistence of the aroma.

Kervegant (1946) wrote an account of the history and state of the art in this field in his 500-page book entitled *Rhums et eaux-de-vie de canne*.

In the 1970s in the French West Indies, operators attempting to control fermentation risks (cessation, prolongation and acidification) decided to use dried baker's yeast—a cheap and easily available commodity—as a booster to alcoholic fermentation. Moreover, production was moving towards lighter products to meet the market demand and, as a result, slops were no longer used in must composition.

According to a classification of 'wild' yeasts drawn up by Parfait and Sabin (1975) (Table 3), *Schizosaccharomyces* yeasts can only be found in the fermentation media used in heavy-flavour rum production. *Saccharomyces* are alcoholic agents

Table 3 Occurrence of yeast strains in the raw material, must and stillage in 26 samples (10 from plant using molasses and 16 using cane juice)

Isolated yeasts	Raw material	Must	Stillage
Saccharomyces cerevisiae	10	19	15
Saccharomyces chevalieri	3	5	4
Saccharomyces rouxii	1	1	1
Saccharomyces aceti	1	5	3
Saccharomyces microellipsodes		1	
Saccharomyces delbruckii		1	
Saccharomyces carlsbergensis		2	1
Schizosaccharomyces pombe		1	1
Pichia membranaefaciens			1
Hansenula anomala	2	2	2
Hansenula minuta			1
Candida krusei	1		2
Candida pseudotropicalis	1		
Candida tropicalis	1		
Torulopsis candida	2		
Torulopsis globusa	3		1
Torulopsis glabrata	4	2	3
Torulopsis stellata	1	1	

From Parfait and Sabin (1975). Identifications according to Lodder (1970).

in 'wild' fermentation media as well as seeded media in which the slop content is low or, as in most cases, not used.

An inquiry carried out in the early 1970s into Haitian distilleries, where fermentations were obtained from cane juice diluted with stillage, showed that *Schizosaccharomyces* were found as the alcoholic fermentation yeast (Fahrasmane *et al.* 1988). Three species were identified from 60 samples. Under Lodder's nomenclature, they were classified as follows: *Schizosaccharomyces pombe* LINDNER (55 samples); *S. malidevorans* RANKINE and FORNACHON (four samples) and *S. japonicus* YAKAWA and MAKI (one sample).

After a more recent classification by Barnett *et al.* (1990), *S. pombe* and *S. malidevorans* are considered as the same species, i.e. *S. pombe*. *Schizosaccharomyces japonicus* has been renamed as *Hasegawea japonica* YAMADA and BANNO. The latter yeast species has a low fermenting capacity and relatively slow kinetics compared with the other *Schizosacharomyces* species tested in the laboratory.

As early as 1945, Arroyo pointed out that economic necessities such as production standardization would lead to fermentation control through selected yeasts.

3.2 Prospects

The selection of rum yeasts from 'wild' strains of sugar cane-based media is now under way at our laboratory. We are currently developing protocols for the use of these strains. One of our strains has the characteristic of high temperature resistance (36 °C). Among our comparative works for rum yeast selection, the best results were obtained with a local strain. The world's first selected rum yeast from our collection, a *Saccharomyces cerevisiae* var. *cerevisiae*, is marketed by Lallemand Inc. under the appellation Danstill 493 EDV. Attempts are being made to define the characteristics of a 'fermenting' cane that is better adapted to the distillery objectives than sugar cane and its by-products.

The search for new means of nutritional supplementation of fermentation media to improve yield and productivity, such as sterols from clarifying mud (Bourgeois and Fahrasmane 1988) and the selection of yeasts adapted to sugar cane-based media, is essential in order to improve the fermentation.

Yield improvement in rum production should take account of the fact that aroma gives the rums their organoleptic characteristics, which are mainly developed by the bacteria in aromatic rum production.

4. BACTERIAL FLORA

The fermentation media contain a bacterial flora whose nature depends on the raw materials used and the environment; the bacterial count is related to the healthiness of the must components. Some substances, produced by bacteria that essentially acidify the media, may sometimes disturb the alcoholic fermentation and are detrimental to the organoleptic properties of the end-product.

Along with the bacteria that are significant from a technological point of view (see Table 4), a minor flora of common forms is also present (*Enterobacteria, Streptococcus, Pseudomonas,* etc.) (Ganou-Parfait *et al.* 1989) as well as sulphate-reducing bacteria (SRB). Until now, few studies have been made on these bacteria.

Bacterial metabolites have been proposed as markers for rums and as discriminants between 'rhums industriels' and 'rhums agricoles'. Alkylpyrazines, which are components of molasses, appear to be of interest in distinguishing 'rhums blancs agricoles' from molasses-based rums (Jouret *et al.* 1994).

4.1 Origin and nature of the bacterial flora

In the French West Indies, the fermentation of molasses- and cane juice-based media traditionally occurs without further protection other than acidification of musts at pH 4·5 by the addition of sulphuric acid. This acid treatment has progressively replaced slop addition since the beginning of the century.

Table 4 Significant bacteria in rum technology

Type	Genus	Species	Origin	Presence	Optimum temp.	Optimum pH	Technological features	Effect −	Effect +
Aerobic bacteria	*Micrococcus*	*luteus*	Worm-eaten cane	Start F	37 °C	6·5	Acrylate, propenol propanol	Acrylate	
		varians	Worm-eaten cane	cycle	37 °C	6·5	production. Ethanol-resistant	Propenal	
	Bacillus	*cereus*	Rodent-eaten cane	Start and	37 °C	6·3			
		subtilis	Rodent-eaten cane	end	37 °C	6·3	Ferment lactate in volatile	Acrylate	Aldehyde
		megaterium	Rodent-eaten cane	F	37 °C	6·3	fatty acids	Propenal	Butanediol
		sphaericus	Rodent-eaten cane	cycle	37 °C	6·3			
	Brevibacterium	*incertae sedis*	Sugar cane stalk		30 °C	6·5			
	Corynebacterium	*incertae sedis*	Sugar cane stalk	Musts	37 °C	6·5	Metabolize glycerol and	Propenol	
	Erysipelothrix		Sugar cane stalk	and	30 °C	6·5	higher alcohols.	Acrolein	
	Kurthia	*zopfli*	Worm-eaten cane	fermented	30 °C	6·5	Ethanol-resistant	Acidity	
	Listeria		Rodent-eaten cane	media	37 °C	6·0			
	Microbacterium	*lacticum*	Sugar cane stalk		37 °C	6·5			
Microaerophilic bacteria	*Propionibacterium*	*acidipropionici*	Sugar cane stalk	During F					Rum
		jensenii	Molasses	cycle	37 °C	6·5	Produce priopionic acid		characteristics
		freudenreichii							
	Lactobacillus	*fermentum*	Sugar cane stalk		30–40 °C	6·0		Acidity	
		fructivorans	Molasses	During	30–40 °C	6·0	Significant growth at pH 3·2	Propenol	Aldehyde
		hilgardii	Water	F	30–40 °C	6·0	Acidifying	Yield	Ester and
		viridescens		cycle	30–40 °C	6·0		Propenal	precursors
	Leuconostoc	*mesenteroides*	Sugar cane stalk		30 °C	6·5	Sugar changed into dextrane	Propenol	
		paramesenteroides	Molasses		30 °C	6·5	Acidifying	Yield	
Anaerobic bacteria	*Clostridium*	*butyricum*							
		beijerinckii					Higher alcohols production		
		acetobutylicum					from sugars		
		felsineum	Soils	At the			Sugar consumption		
		puniceum	Waters	end of F	37 °C	6·5	Production of propionic acid	Acrylate	Ester
		thermosulfurigenes		cycle			from glycerol and lactate		precursors
		thermohydrosulfuricum					Formic acid production		
		sporogenes					Butyric acid production		
		bifermentans							

F, Fermentation; Effect +, positive effect on rum organoleptic properties; Effect −, negative effect on rum organoleptic properties and yield.
Taxonomic references according to *Bergey's Manual*, 8th edn.

4.1.1 Cane juice. During a fermentation cycle, an aerobic microflora first appears in musts, coming partly from the waters used for dilution and from the equipment. It is composed of corynebacteria, *Micrococcus* species, enterobacteria and *Bacillus* species. Secondly, during the active phase of alcoholic fermentation, yeasts and microaerophilic bacteria appear, including *Lactobacillus*, *Propionibacterium* and *Leuconostoc* species (Ganou-Parfait *et al*. 1989; Ganou-Parfait and Saint-Marc 1994) (Table 4).

The qualitative and quantitative composition of the bacterial flora is related to the phytosanitary condition of the sugar cane. Juices extracted from sound and fresh sugar cane contain a flora with a predominance of lactic bacteria.

The crushing of unsound cane stalks significantly increases the bacterial count in the must up to 10^9 cfu ml^{-1}.

4.1.2 Molasses. In the course of sugar production, the greater part of the non-sporulated bacterial flora is destroyed. As a result, molasses are generally less contaminated than cane juice (10^2–10^3 bacteria g^{-1}). However, some aerobic and anaerobic sporulated bacteria remain. *Lactobacillus* and *Propionibacterium* species develop especially in molasses-based musts (Ganou-Parfait and Saint-Marc 1994).

4.1.3 Dilution waters. The bacteria from dilution waters are added to those coming from cane juice and molasses. A specific feature of these waters is the existence of anaerotolerant pathogens such as coliforms, faecal *Streptococcus* and *Clostridium* species and SRB, which are for the most part inhibited by the ethanol produced during alcoholic fermentation.

The mineral content depends on the water used (well or surface water). We observed that the water's mineral level appeared to be related to the bacterial populations. Waters containing high concentrations of mineral matter are the most contaminated by bacteria (Ganou-Parfait *et al.* 1991).

4.1.4 Slops. Slops are used to dilute molasses for the production of heavy-flavour rums. Since they are stored between their production and their use, they are exposed to bacterial acidification, and thereby acidify the fermentation media and seed it with an abundant anaerobic bacterial flora.

4.2 Dynamics and control of the bacterial flora

During the fermentation cycle, different respiratory types appear. They are determined by the media conditions, but in a more significant way with cane juices than with molasses. Aerobic bacteria are particularly active at the beginning during the filling of the vats, a procedure that can take between 3 and 6 h in small plants; microaerophiles and anaerobic bacteria then appear owing to the increasing activity of alcoholic fermentation yeasts.

In cane juice-based media, the aerobic flora at the beginning of fermentation is composed of *Micrococcus* species (10^1 cfu ml^{-1}), *Bacillus* species (10^2 cfu ml^{-1}) and coryneforms (10^5 cfu ml^{-1}), some of these forms being related to reduction in the healthiness of the raw materials (*Listeria* from worm-eaten canes and *Kurthia* from rodent-eaten canes). In addition, there are some common bacteria such as enterobacteria and *Streptococcus* species, etc. Almost all of these bacteria produce undesirable substances such as acrylic acid, acrolein and allylic (Ganou-Parfait *et al.* 1987; Lencrerot *et al.* 1984; Ganou-Parfait *et al.* 1988). In the active fermentation phase, lactic bacteria are developed (10^5–10^6 cfu ml^{-1}), as well as *Propionibacterium* species (10^4 cfu ml^{-1}), *Clostridium* species (10^3 cfu ml^{-1}) and *Leuconostoc* species (10^2 cfu ml^{-1}).

The *Leuconostoc* count increases when using canes from fields that are burnt before harvest to make cutting easier (Picard and Torribio 1972).

The flora of the molasses-based media is chiefly composed of lactic bacteria (10^5–10^6 cfu ml^{-1}) and propionibacteria (10^5 cfu ml^{-1}); in some cases *Leuconostoc* species can also be found (10^4 cfu ml^{-1}) depending on the quality of the molasses. The aerobic flora is rather inactive because of the low contamination of molasses by aerobic micro-organisms and the vats' filling-time which is generally shorter than with cane juice (1–3 h).

The lowering of pH by addition of sulphuric acid is not the only way to regulate the aerobic bacterial flora. The control can be improved firstly by shortening the filling phase and, secondly, by seeding the media with yeasts, so that the fermentation phase can be started rapidly. It is also possible to use mother vats, which enable seeding with yeasts in good physiological condition. Thus, the production of detrimental substances can be limited. The initial sugar contents of musts in rum production are under 100 g l^{-1}, while the fermentation is rapid and lasts from 18 to 36 h. In terms of time and sugar consumption, the aerobic phase represents 10–20% of the fermentation cycle. The conditions under which the fermentation starts may partly explain the considerable yield losses at the fermentation stage.

It appears that the microaerophilic, *Lactobacillus* species and *Propionibacterium* species flora is the most significant in rum production media when the bacteriological quality of the raw materials and of the water is good and when the aerobic phase is shortened. The *Lactobacillus* species flora consumes sugar and has an acidifying effect since it produces acids (lactic, acetic and formic) that can be esterified. This flora also produces 2-3 butanediol and diacetyl (Jay 1982). To a certain extent, these compounds and their by-products positively contribute to the development of the organoleptic properties of rum (Peynaud and Lafon 1951). The *Propionibacterium* species flora, owing to its special property of

producing propionic acid, distinguishes rum from other spirits by leading to relatively high concentrations of this acid (Suomalainen 1975; Jounela-Eriksson 1979). The type of raw material and the microaerophilic bacteria mentioned above are more important than the fermentation yeast in making aromatic rums a local product. Nevertheless, selected yeast should not be neglected since its use under optimum conditions enables good fermentation yields and increased productivity.

Other kinds of bacteria are only significant under certain conditions that are detrimental to the development of fermentation and the quality of the product. For instance, when there is a sanitary degradation of must components leading to an increase in the bacterial count up to 10^9 cfu ml^{-1} (Ganou-Parfait and Saint-Marc 1994), the result is a considerable and excessive acidification of the distillery products as well as an off-flavour increase (Fahrasmane *et al.* 1983; Lencrerot *et al.* 1984); at the same time, the yeast is inhibited by lactic and acetic acid and by bacteriocins (Essia Ngang *et al.* 1989, 1990). If the musts are insufficiently acidified, thus promoting bacterial development, their optimum growth varies from 6·0 to 6·5 (Table 4); the consequences are the same as those mentioned above. If the vats are overheated above 37 °C, which is the optimum temperature for the growth of many of the bacteria, the yeast is inhibited and fermentation consequently comes to an arrest (Arroyo 1945; Merrit 1966; Lonvaud-Funel 1988).

5. CONCLUSION

The key factors for bacterial control include acidification of the musts, temperature control and the use of selected yeasts. The latter provides an active fermentation with a reduced latency time, giving rise to a positive bacterial effect on the quality and authenticity of the products.

Heavy-flavour rum is an aromatic quintessence produced from media containing a 'wild' local flora; the expression of its bacterial component is quite extraordinary. On the other hand, light-flavour rums—in which the bacterial count and activity are minimized—are related to rums mainly because of the raw materials used. The 'rhums traditionnels' of the French West Indies arise from a combination of raw materials, native and/or selected yeasts and native bacteria; the products' aromas are intermediate between the extremes of light-flavour rum and heavy-flavour rum. Thus, nowadays 'rhums traditionnels' are modern counterparts of the local archetypal products made before the 20th century that have benefited from the progress in microbiology.

Sugar cane and its by-products have always been used in rum production; European regulations have given recognition to this fact (O.J. of the European Communities 1989). The diversity of production processes has led to several types of rums in which local bacterial flora is a key factor. *Lactobacillus* and *Propionibacterium* species are the most important genera in the context of a controlled technology.

Alcoholic fermentation yeasts added according to defined technical stages have optimized efficiency. Above all, yeast is a technological efficiency factor. However, the yeast also plays a role in the synthesis of the components and the precursors of aroma. For example, the synthesis of volatile fatty acids is modulated, according to the strain, by the citric acid concentration in the raw material (Fahrasmane *et al.* 1985).

The production of aromatic rums in which ethanol is a carrier-solvent for flavour-giving molecules enables this spirit to be used rather like an aromatic resource.

There are several ways of consuming and using colourless (white) or matured rums. The volume of rum sold in France in 1992 (75 000 hectolitres pure alcohol) is higher than that of Cognac, Armagnac brandy and Cider brandy together. Aromatic rum from the French West Indies is a choice ingredient for cooking with respect to its flavouring properties.

The current state of technological and chemical knowledge on rums points to the important role of the bacterial flora as far as the aromatic product composition is concerned (acids and esters, etc.).

In the future, the use of sensorial analysis, in addition to physico-chemical methods and leading on from microbiological research, will make it possible to estimate the correct limits of the bacterial expression needed to make high-quality aromatic products.

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