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Research Article

Aromatic Composition of "Sodabi", a Traditional Liquor of Fermented Oil Palm Wine

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Abstract: The aim of this study is to determine the profile of the volatile chemical compounds of *Sodabi* which is a traditional liquor widely consumed by people in the West Africa. *Sodabi* is a distilled product of fermented oil palm wine and its production is artisanal, using rudimentary equipment and recycled materials under precarious sanitary conditions. The production of this liquor is also often associated with adulterating practices such as the use of substrates other than palm wine and additives susceptible of producing toxic compounds in the end product. Chemical analysis of some samples of *Sodabi* showed a pH of 4.25±0.72; an acidity of 660±29.39 mg/L; a density of 0.9625±0.01; an alcohol contents of 44.31±1.95%v/v and a soluble solid contents of 31.45±2.44 mg/L. Volatile components of *Sodabi* samples were analyzed by gas chromatography-mass spectrometry and the results revealed forty-eight (48) components. The most abundant molecules was ethanol (98.95%v/v) and higher alcohols including 3-methylbutan-1-ol and 2-methylbutan-1-ol. Esters (methyl salicylate, diethyl succinate), aldehydes (furfural), ketones (butyrolactone) and phenols (phenol, 4-vinyl-2-methoxyphenol) were also determined. The compounds found in *Sodabi* were for the most part similar to those of industrial spirits. Trace amounts of methanol and lead were detected but the quantities of which were well below those associated with acute toxicity and representing no threat to the consumption of *Sodabi*.

Keywords: Aromatic profile, craft distillation, local spirit, oil pam wine, sodabi

INTRODUCTION

The production and consumption of alcoholic beverages have been omnipresent activities in the life and culture of many traditional societies around the world for centuries (McGovern, 2009). In West Africa, there is a traditional liquor called *Sodabi* in Togo and Benin, *Akpeteshie* in Ghana and *Ogogoro* in Nigeria. It is produced by the distillation of fermented sap of oil palm (*Elaeis guineensis*) or raphia palm (*Raphia hookeri*). In Togo, the use of *Sodabi* is widespread and deeply rooted in the dietary and cultural habits of the population.

Formerly limited to rural areas and reserved for adults, *Sodabi* has now reached urban areas and its consumption is widespread regardless of age, gender or social class. It is used in celebrations of happy as well as unhappy events and in traditional and religious ceremonies. It is the unavoidable drink of communion serving as a bridge between the material and immaterial worlds in traditional libations and rites (Oshodin, 1995). It is also used as maceration solvent in many traditional therapeutic potions and provides substantial income to producers. It therefore plays an important socio-economic role in traditional societies. Although the ban on the production of *Sodabi* in Togo has now been lifted, clandestine distilleries often in the bush have continued to operate. The production facilities are rudimentary and very simple. The environment and production conditions are precarious.

The quality of the end product and its alcohol content remain uncontrolled. The low price of *Sodabi* compared to that of imported spirits has favored trade in this traditional spirit which is today very lucrative and flourishing with its own distribution network. The commercial success of this liquor has spawned unorthodox production and sometimes fraudulent practices such as the use of raw materials other than palm wine, the introduction into the drink of foreign ingredients or additives (roots, leaves, bark, herbs) for flavoring and coloring or to give the product artificial medicinal properties or qualities that it doesn't naturally

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possess and the addition of foreign spirits to increase the alcohol content. Some of the consequences of these fraudulent practices are harmful to consumer health and constitute a public health hazard. *Sodabi* is therefore assigned to artisanal spirits that are sometimes illicitly produced. They are reputed to contain toxic substances or impurities such as methanol and disinfectants (Rehm *et al*., 2010) that may result in adverse health and social consequences (Lachenmeier *et al*., 2009; Leitz *et al*., 2009). Unlike imported modern spirits, the complete chemical composition of *Sodabi* is little studied and remains unknown. Publications have focused on the mode, the social determinants and consequences of consumption of the local alcohol (Dumbili, 2013). Other works have studied the chemical characteristics (Ejim *et al*., 2007; Adeleke and Abiodun, 2010; Zakpaa *et al*., 2010). By contrast, few are works like those of Odeyemi (1980) and Ejim *et al*. (2007) that have pushed their investigations to the point of determining the volatile and non-volatile chemical compounds of *Ogogoro* obtained from raphia palm (*Raphia hookeri*).

The main objective of this study is to characterize the *Sodabi* produced from palm wine by determining the profile of the volatile chemical compounds for a better and updated knowledge of its chemical composition. This analytical profile will also assess the potential harmfulness of the drink.

MATERIALS AND METHODS

Sample collection: To better identify the different steps and operations of the artisanal production of this local spirit, we carefully monitored its preparation from March 12, 2014 to October 13, 2016 and took samples from 20 producers in different important producing areas in the Maritime and Plateaux regions of Togo. *Sodabi* production tests were also conducted in the laboratory. The *Sodabi* samples to be tested were put in 250 mL flasks which were hermetically sealed and stored in a refrigerator at 7°C until analysis.

Chemical analyses: Chemical analyses were conducted on twenty-five *Sodabi* samples. Total soluble solids were determined using a refractometer (Euromex HC type 0-32, Holland). The pH was measured with an electronic pH meter (WTW type pH 330i) and acidity estimated by titration with 0.1N sodium carbonate using phenolphthalein as indicator. The density and alcohol contents were measured by pycnometry (AOAC, 1990). An Atomic Mass Spectrometer (AAS) was used to determine the levels of copper and lead in the samples.

Analysis of volatile compounds by Gas Chromatography (GC) coupled with mass spectrometry: GC separation is a method of analysis which is applicable to gaseous compounds or compounds that can be vaporized by heating without decomposition (Tranchant and Arpino, 1995). Volatile molecules of *Sodabi* extracts were identified and quantified using a gas chromatograph type HP 6890 (Series GC System, Agilent J and W GC Columns) coupled with a Mass Spectrometer (MS) Agilent 7890A (GC system, 5975C inert XLEI/CI MSD with Triple Axis Detector).The latter was equipped with an ion trap analyzer that allows the ionization of molecules both in Electronic Impact mode (EI) and in Chemical Ionization (CI) mode and to analyze the mass spectra by ion current. Analysis by GC/MS coupling is generally used to access the mass spectra of the various constituents which are then compared to the spectra listed in reference libraries (Jennings and Shibamoto, 1980; König *et al*., 2001).

Identification and quantification of volatile compounds in GC/MS: Identification of each volatile compound was performed by comparing the mass spectrum obtained to those recorded by the same equipment and contained in a database. The presence of each volatile compound identified by MS, was determined by a retention index (Ir) calculated from a range of alkanes or rarely from linear methyl esters at constant temperature: Kovats index (Kovats, 1965) or temperature programming (Van Den Dool and Kratz, 1963). Polar and non-polar retention indices were compared with those of authentic samples in reference libraries developed in the laboratory, in commercial libraries (Jennings and Shibamoto, 1980; König *et al*., 2001) or listed in the literature. Confirmation of the identity of the compounds was carried out by:

- Studying the mass spectrum of the compounds in electronic impact mode
- Checking the retention index in linear alkanes with existing data in the literature (Index+/-30)
- Injecting a diluted pure or synthesized standard according to Ledauphin *et al*. (2010).

The compounds for which a standard was not injected were considered only as possibly present. In each test sample, for each of the identified compounds, an area was calculated by integration and an individual calibration for each pure and authentic compound was achieved. Analysis by GC/FID was carried out in parallel in the same operating conditions for the most abundant compounds in the different samples when pure substances were available. The chosen method of quantification was external calibration.

Sensory assessment: A panel of 62 usual consumers completed a sensory evaluation of *Sodabi*. The test method was the attribute rate/scaling and the attributes were color, acid flavor, palm taste, palm aroma, appearance and overall acceptability.

Statistical analysis: Experiments were conducted on *Sodabi* samples and the results of three measures of chemical characteristic values were expressed as mean and standard deviation. The statistical analyses were carried out using the Microsoft Excel 2003 software. The data collected were also statistically analyzed using a One Way ANOVA (Analysis of Variance). Statistical significance was set at $p<0.05$.

RESULTS AND DISCUSSION

The *Sodabi* production process: The monitoring of *Sodabi* production among 20 producers in different regions made it possible to identify the different methods and stages of artisanal production of *Sodabi*. The techniques of distillation remain the same and similar to those of industrial production but using rudimentary materials. Spontaneous fermentation of palm tree sap is the widely used method, but this gradually gives way to other practices because of palm wine shortage. The collection of sap begins with felling by uprooting the oil palm tree. A notch is made on the upper part of the spathe below the branches. The sweet white sap is collected during one month depending on the size or variety of oil palm tree. Fermentation is spontaneous and occurs in barrels or pots for 6-8 days to transform the sugar in the sap into alcohol. The palm wine obtained from spontaneous fermentation undergoes distillation. The still consists of recovery drums as boiler and copper tubing serving as a coil as practiced in Togo, Benin (Antheaume, 1970) Ghana, (Zakpaa *et al*., 2010) and Nigeria (Ohimain *et al*., 2012). The energy source is sawdust and wood chips. Distillation comprises two stages: In the first distillation stage, the barrel is usually 2/3 full to prevent explosion and the heating is regularly checked. In the second distillation stage, the remaining 1/3 palm wine and the distillate are mixed and distilled again. The vapor from distillation is cooled to recover *Sodabi*. The water for cooling may be stored in a canvass or several drums. The end of distillation is determined by the skill of the distiller, who uses either the fire test on the liquid coming directly from the tip of the coil or the taste of the distillate. The alcohol level varies from one producer to another and is higher at the beginning of the distillation. The *Sodabi* recovered is stored in drums or sold directly to buyers who resell to individuals at the point of sale generally called "white curtains". Illegal practices observed at the places of production are: the addition of industrial ethanol (alcohol at 95 %vol) at the time of the first distillation. The adulterated *Sodabi* would be obtained by mixing in empirical proportions, real *Sodabi* with sugar cane alcohol or soaking the soft inner parts of the oil palm tree in industrial ethanol for a time to extract the aroma. These types of *Sodabi* are devoid of specific organoleptic characteristics found in real *Sodabi*. The artificial *Sodabi* would also be made by the fermentation of sugar in the presence of chemical leavens and a small amount of palm wine.

Chemical characteristics: The results of the chemical characteristics are presented in Table 1. The alcohol content was 44.31±1.95%vol. This degree was in the range of values (30-60%vol.) recorded by Oladeinde *et al*. (2002) and Ohimain *et al*. (2012) on *Ogogoro*, however it was greater than the values obtained by Zakpaa *et al*. (2010) on *Akpeteshie* (20.5 to 20.8%vol.), Obot (2000) (40%vol.), Adeleke and Abiodun (2010) and Ejim *et al*. (2007) (32.2-42.6%vol.) on *Ogogoro* obtained from palm wine or raphia palm. The variability in alcohol contents is related to the type of distillate (first, second or third distillate) or dilution with water. The *Sodabi* had a density of 0.9625±0.01 comparable to that recorded (0.9897) by Adeleke and Abiodun (2010) on *Ogogoro*. It had a pH = 4.25±0.72 and appeared more acidic than *Ogogoro* (pH = 6.3) (Adeleke and Abiodun, 2010) and *Akpeteshie* (pH = 5) (Zakpaa *et al*., 2010). The latter authors showed that during storage, the pH of *Akpeteshie* could decrease to 2.0 with a gradual appearance of acetic acid in the beverage. The soluble solid content of 31.45±2.74 mg/L would be due to mineral salts from contamination of the *Sodabi* by the distillation apparatus and/or the water sometimes used to dilute it (Ejim *et al*., 2007). Methanol is the substance most often associated with the toxicity of distilled spirits. The *Sodabi* had a methanol content of 28.65±7.34 mg/L greater than (10 mg/L) registered by Zakpaa *et al*. (2010) on *Akpeteshie* but lower (between 40 and 310 mg/L) than registered by Adeleke and Abiodun (2010) on *Ogogoro*. Although a certain amount of methanol was detected in all samples of *Sodabi* analyzed, the quantities did not exceed the maximum acceptable levels in spirits which is 10000 mg/L for the European Union countries (European Council, 1989) or 50 000 mg/L according to Paine and Davan (2001). This methanol would come from pectic substances of the wines or musts distilled and products of fermentative metabolism and non-enzymatic reactions initiated by heating (Scriban, 1985). The copper content of the *Sodabi* was 7.47±1.25 mg/L and this content exceeded the standard of 2 mg/L specified by WHO (2006) for drinking water. On the contrary, *Akpeteshie* had a higher copper content (12.615 mg/L) (Zakpaa *et al*., 2010) and that of *Ogogoro* ranged between 0.11 and 3.7 mg/L (Ejim *et al*., 2007). The copper concentrations may eventually be attributed to the dilution water and/or the copper coil used in distillation which is often oxidized into copper oxide by vapors and carbon dioxide. The work done by Tompsett (1992) reported a daily copper requirement per person of about 0.6 mg/L. The amount of copper contained in the *Sodabi* was above the threshold and may be detrimental to the health of the consumer. The *Sodabi* had a lead content of 0.03±0.01 mg/L which was three times higher than the standard (0.01 mg/L) specified for drinking water (European Council, 1988; WHO, 2006). Ejim *et al*. (2007) found 5 mg/L in one of the five samples of *Ogogoro* analyzed in Nigeria. Given that ions are in general non-volatile, most minerals found in the liquor could be derived from the water

Table 1: Chemical characteristics of *Sodabi*

pH	Density	Alcohol content (% vol.)	Acidity (mg/L)	Methanol (mg/L)
4.25±0.72	0.9625±0.01	44.31±1.95	660±29.39	28.65±7.34
	Soluble solids (mg/L)	Copper (mg/L)	Lead (mg/L)	
	31.47±2.74	7.47±1.25	0.03±0.01	

Table 2: Volatile compounds identified in the *Sodabi* samples by CPG/SM

Compounds	RI[a]	RI[b]	Rt (min)	EI	% Compounds	Standard
Esters						
Ethyl formate	665	547	2.043	31-(100)-45-(40)-59-(24)	59	
Ethyl lactate	814	613	4.04	50-(100)-29-(20)-27-(12)	80	x
Isoamylacetate	878	877	5.214	70-(100)-55-(83)-61-(28)	83	x
Ethyl-2-hydroxyisovalerate	967	849	7.066	73-(100)-76-(30)-55-(20)	64	
Pentanoicacid 2-hydroxy-4-methyl, ethyl ester	1058	/	9.044	69-(100)-87-(88)-43-(70)	90	
2-hydroxyethylhexanoate	1059	997	9.064	69-(100)-41-(66)-87-(54)	72	
Isopentylmethylether	1069	/	9.281	45-(100)-70-(40)-55-(18)	55	
Diethylsuccinate	1181	1167	11.675	101-(100)-129-(42)-55-(30)	83	
Methyl salicylate	1194	1190	11.97	120-(100)-92-(54)-152-(48)	94	
Ethyloctanoate	1196	1199	12.007	88-(100)-101-(36)-57-(28)	98	x
Phenylethyl acetate	1256	1256	13.222	104-(100)-43-(85)-91-(22)	78	x
Ethyl beta phenylpropionate	1350	1390	15.051	104-(100)-91-(60)-107-(40)	89	
Ethyldecanoate	1395	1397	15.898	88-(100)-101-(44)41-(22)	98	x
1.2-benzenedicarboxylic acid bis 2 (methylpropyl) ester	1871	/	23.684	149-(100)-57-(30)-41-(20)	90	
Ethyl-9-hexadecenoate	1974	1977	25.15	54-(100)-69-(80)-41-(68)	96	x
Ethyl palmitate	1994	1991	25.425	88-(100)-101-((60)-42-(24)	99	x
Ethyloleate	2173	2171	27.747	55-(100)-69-(72)-41-(70)	99	
Ethylstearate	2195	2193	28.076	88-(100)-101-(62)-43-(32)	96	
1.2 benzenedicarboxylicacid 2-ethylhexyl ester	2548	/	32.276	149-(100)-167-(44)-57-(26)	74	
Ethyl-2-hydroxy isovalerate	966	849	7.04	73-(100)-76-(50)-28-(22)	72	
Alcohols						
Ethanol	630	688	1.58	31-(100)-56-(74)-47-(20)	90	x
3-methyl butan-1-ol	741	737	3.01	55-(100)-42-(88)-41-(84)	78	x
2-methyl butan-1-ol	743	739	3.046	57-(100)-56-(84)-41-(68)	72	x
2-methyl propan-1-ol	688	/	2.33	43-(100)-41-(84)-42-(54)	50	
2.3 butanediol	806	769	3.887	45-(100)-43-(15)-29-(10)	90	
2.3 dimethyl-4-heptanol	1066	/	9.206	87-(100)-45-(59)-43-(30)	47	
2-phenyl-2-propan-1-ol	1085	/	9.638	41-(100)-121-(54)-45-(18)	90	
2-phenylethanol	1116	1116	10.31	91-(100)-92-(80)-122-(24)	94	x
2-benzothiazole	1224	1221	12.565	135-(100)-108-(34)-69-(20)	94	
1-benzazole	1293	1067	13.962	117-(100)-90-(42)-89-(24)	87	
Methyleugenol	1405	1410	16.083	178-(100)-91-(52)-103-(39)	95	
Estragole	1198	1195	12.051	148-(100)-147-(52)-117-(30)	93	
Methionol or 3-methylthiopropanol	981	978	7.368	61-(100)-106-(92)-30-(86)	97	
Ethenylbenzene or styrol	903	890	5.693	104-(100)-103-(44)-76-(32)	94	
Methanol	/	/	3.484			x
Acids						
Aceticacid	710	600	2.615	43-(100)-45-(100)-60-(76)	86	x
Isobutyricacid	788	793	3.626	43-(100)-41-(42)-73-(22)	72	x
Propanoicacid	802	668	3.814	74-(100)-45-(84)-73-(56)	58	x
2-methyl butyricacid	865	/	4.974	74-(100)-57-(62)-41-(52)	64	x
Valericacid	879	911	5.245	60-(100)-43-(36)-41-(28)	80	x
2-methyl butanoicacid	886	873	5.363	74-(100)-57-(70)-41-(56)	64	
Carbonyls						
Butyrolactone	921	915	6.084	42-(100)-41(52)-56-(40)	72	
(3.5 di-butyl)-4-hydroxybenzaldehyde	1769	/	22.174	219-(100)-234-(24)-191-(20)	97	
Furfural	837	830	4.453	96-(100)-95-(92)-39-(62)	91	x
2-phenylacetaldehyde	1046	1047	8.768	91-(100)-65-(32)-39-(28)	87	x
Phenols						
Phenol	993	1050	7.608	94-(100)-66-(34)-65-(28)	87	x
4 - vinyl 2 methoxy phenol	1315	1313	14.377	104-(100)-68-(85)-45-(42)	89	
Terpene						
1.8 cineole	1033	1030	8.482	81-(100)-71-(95)-43-(75)	94	

RI[a] Calculated Retention Index using a mixture of linear aliphatic alkanes (C5-C30) according to Van Den Dool and Kratz (1963); RI[b]: Retention Index according to Ledauphin *et al*. (2010); Rt; Retention time; EI: Main fragments found in the mass spectrum produced in Electronic Impact mode with their respective intensities in parentheses; % Compound: Percentage of compounds detected by GC-FID; Standard: Compound for which a pure or diluted synthesized standard could be injected in the same analytical conditions of analysis.

used for dilution. Contamination by minerals may also be due to the equipment used. For example, during the production of moonshine in the United States, leaching that occurs during mixing in containers containing lead caused lead contamination of moonshine (Lachenmeier *et al*., 2007).

The volatile compounds of *Sodabi*: The aromatic characteristics of *Sodabi* are presented in Table 2. A total of 48 volatile compounds were identified in the *Sodabi* samples analyzed against four determined by Odeyemi (1980) and a dozen by Ejim *et al*. (2007) in *Ogogoro*. Apart from ethanol (98.95%), the most abundant molecules were esters (20 compounds), alcohols (14 compounds), acids (6 compounds), carbonyl (4 compounds) and volatile phenols (2 compounds). However a terpene compound was also detected. The volatile compounds found in *Sodabi* (Fig. 1) belong mainly to four chemical classes:

Ester compounds: Esters were found in large amounts in all *Sodabi* samples analyzed. Among them, ethyl lactate, ethyl-9-hexadecenoate, isoamylacetate, phenylethylacetate, ethyl acetate, methyl salicylate and diethyl succinate represented the majority of these esters. Prior work (Ejim *et al*., 2007) detected ethyl lactate and acetate in artisanal spirits in Nigeria. These compounds are supposed to be derived from the acetylation (esterification with acetic acid) of the corresponding alcohol molecules by acetyltransferases as Lilly *et al*. (2000) reported. Esters are the main volatile compounds in wines and spirits after ethanol (Valappil *et al*., 2009). They are characterized by a very strong presence of ethyl acetate which alone may represent between 55 and 90% of total ester (Lilly *et al*., 2000; Xu *et al*., 2006). Depending on the nature of the lactic acid bacteria involved in malolactic fermentation, the volatile composition can be very different (Pozo-Bayon *et al*., 2005). Ethyl lactate ester is primarily formed by lactic acid bacteria due to the accumulation of lactic acid during fermentation (Nedovic *et al*., 2000; Sumby *et al*., 2010). Diethyl succinate (dimethylbutanedioate) is directly related to succinic acid formation that can appear during alcoholic fermentation or by the action of lactic acid bacteria on substrates such as citric or malic acid. The quantities of products are low and thus make a small contribution to the aromatic mix of the product (Lilly *et al*., 2000).

Higher alcohols: 3-methylbutan-1-ol, 2-methylbutan-1-ol, 2-phenylethanol, methyleugenol, 2-phenyl-2-propan-1-ol and estragole were the most important higher alcohols in *Sodabi*. Our results were in agreement with those of Ejim *et al*. (2007) for the first three abovementioned compounds were also detected in *Ogogoro*. The concentrations of these alcohols

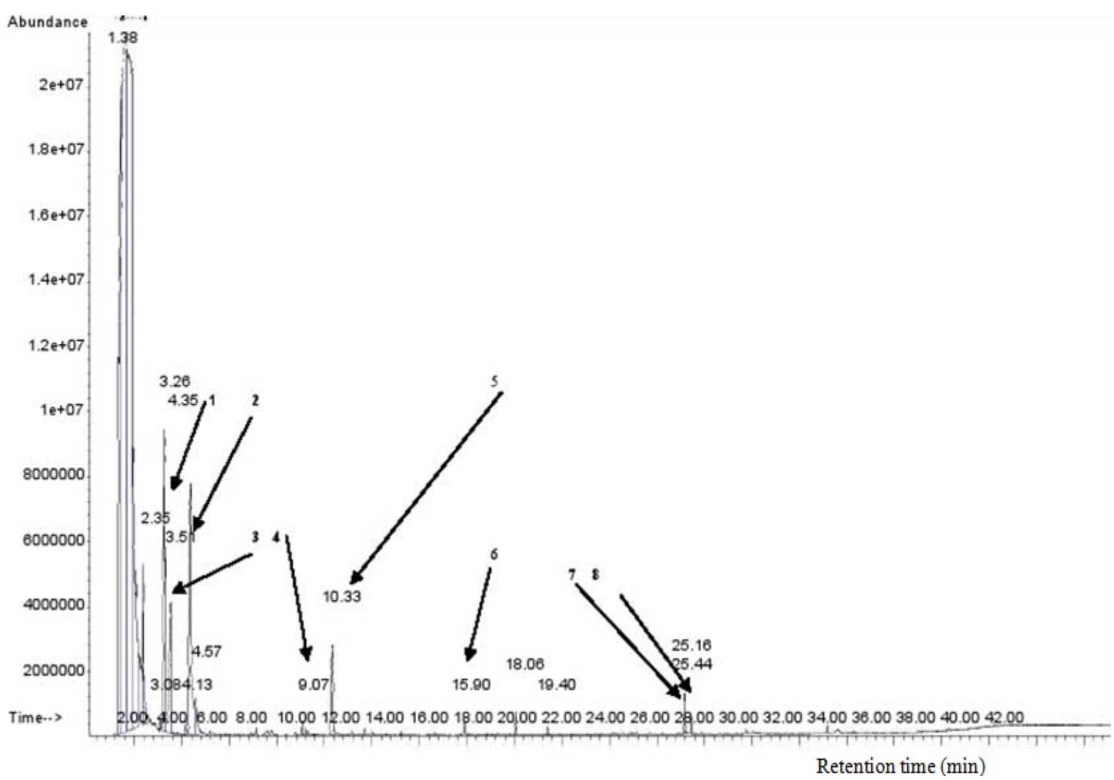

Fig. 1: Chromatogram of volatile compounds detected in one *Sodabi*sample1) 3-methyl butanol; 2) Furfural; 3) 2-methyl butanol; 4) 2-hydroxy ethylhexanoate; 5) 2-phenylethanol; 6) Ethyl decanoate; 7) Ethyl-9-hexadecenoate; 8) Ethyl palmitate

increases steadily during alcoholic fermentation in cider and other distilled wines. These compounds are known to be derived from yeast activity by the metabolism of sugars as well as amino acids such as threonine, valine, leucine and isoleucine (Lambrechts and Pretorius, 2000). They are also known to be important precursors of esters (Pinho *et al*., 2006). Since the production of higher alcohols is obviously an individual characteristic of yeast strains (Giudici *et al*., 1990), differences in volatile composition and more particularly in higher alcohols were noted by the authors according to the strains seeded in the wine. The degradation of sugars by yeast leads in the majority of cases to the production of ethanol and other higher alcohols. Herrero *et al*. (1999) showed that its concentration increased sharply midway in alcoholic fermentation effected exclusively by *Saccharomyces cerevisiae*. 3-methylbutanol which represents approximately 80% of isopentanols (2- and 3-methylbutanol) in wines and spirits (Schumacher *et al*., 1998) is likely to come largely from leucine through the formation of 3-methylbutanal. Similarly, 2-methylbutanol may result from the conversion of isoleucine, isobutanol from valine and propan-1-ol from threonine (Lambrechts and Pretorius, 2000). 2-phenylethanol which is strictly speaking not a higher alcohol but an aromatic alcohol is present from the initial fermentation phase (Vidrih and Hribar, 1999). It is generally considered, in fermented beverages, as obtained from the processing of phenylalanine via phenylethanal formation (Lambrechts and Pretorius, 2000). 2-phenylethanol and methionol are classified with higher alcohols because of their possibly identical origin. Indeed, they can also come from the degradation of two amino acids: phenylalanine and methionine (Lambrechts and Pretorius, 2000). 3- (methylthio) propan-1-ol and its acetate are derived from the amino acid methionine through the Ehrlich pathway (Etschmann *et al*., 2008). Finally it should be noted that the presence of higher alcohols and their concentration greatly influence the organoleptic properties of the product, causing a rather unpleasant solvent-like taste (Williams, 1974). The diacetyl and 2,3-pentanedione are secondary products of the synthesis of amino acids (valine and isoleucine) in yeast. At the end of fermentation, yeast are capable of reducing both compounds to acetoin and 2,3-butanediol (Herrero *et al*., 2003).

Carboxylic acids: The best markers of malolactic fermentation of distilled wine seem to be mostly carboxylic acids and derivatives of organic acids. Acetic acid, propanoic acid, 2-methylpropanoic acid (isobutyric acid), 2-methyl butanoic, hexanoic and octanoic were also found in the *Sodabi*. In general, the carbonyl compounds are derived from the decarboxylation of α-keto acids (or oxo-acids) and the oxidation of alcohols. Their olfactory perception threshold is generally low and most are regarded as providing rather unpleasant flavors (Williams, 1974).

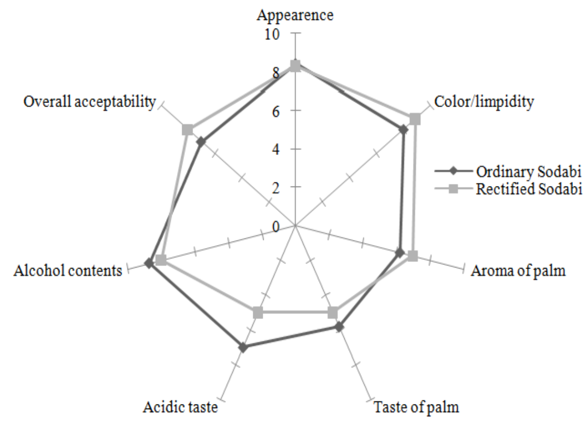

Fig. 2: Diagram of average ranking scores (on a 9-point basis) for organoleptic attributes of sodabi

Phenolic compounds: 2-methoxy-4-vinylphenol and phenol were both volatile phenols detected in *Sodabi*. In spirits, several types of microorganisms appear to be at the origin of the appearance of volatile phenols. *Collenoid Lactobacillus* (bacteria) and *Brettanomyces anomala* (yeast) are likely to produce them in large quantities (Buron *et al*., 2011). The presence of eugenol and 2- (4-hydroxyphenyl) ethanol is similar to that of 4-ethylphenol and 4-éthylguaïacol (Buron *et al*., 2011). Fermentation has a very strong impact on the production of volatile compounds. Vanbeneden *et al*. (2008a) reported that the concentration of 2-methox-4-vinylphenol increased in the medium at high temperatures. Phenolic compounds are undesirable when present in excessive concentrations as in the case of beer lager (Vanbeneden *et al*., 2008b).

Sensory characteristic of *Sodabi*: Figure 2 shows the scores given by the panelists to the main sensory characteristics of the ordinary *Sodabi* compared to the same rectified in the laboratory. This sensory evaluation showed that the ordinary *Sodabi* organoleptic characteristics were fairly well rated and therefore acceptable for consumption, however, a rectification in the laboratory produced a *Sodabi* with improved aroma, color, appearance and general acceptability with a reduction in the palm taste, alcohol content and acid flavor. The results of *Sodabi* tasting therefore showed that the rectified *Sodabi* was more preferred than the ordinary, however the difference in general acceptability was not significant ($p > 0.05$).

CONCLUSION

This analytical study allowed to expand the knowledge base of the chemical properties of *Sodabi* and to develop a better profile of the components of this local spirit produced from palm wine. This traditional alcohol was characterized by the presence of high amounts of esters, alcohols and fatty acids. Ethanol was the most representative compound with the highest content. Most of the molecules identified were similar to those found in conventional commercial spirits. Some of the compounds are known to have a negative effect on the organoleptic properties of the beverage. No major toxic compound was found except for insignificant traces of methanol at doses that pose no serious risk of toxicity on consumption of *Sodabi*. The presence of certain mineral contaminants (lead and copper) at high levels may present a risk of toxicity but these pollutants can also be avoided by diluting with drinking water unpolluted by heavy metals.

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