



## **Health and Nutritional Qualities of Drinks Produced in the Beninese Brewery Company and Those Sold on the Benin Market**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author CKCT designed the study, wrote the protocol, performed the statistical analysis and wrote the first draft of the manuscript. Authors JSBB, AF, TA, AB, PSAS and RTMB managed the analyses of the study and performed the statistical analysis. Authors AAMD, KTA, PA and IPBY managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

**Aims:** This study aims to evaluate the microbiological, physicochemical and sensory qualities of beverages sold on the market in Benin.

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**Study Design:** The biological material used consisted mainly of beverage samples (126) collected at random from three wholesalers at the points of sale on two different occasions (regular period of 15 days) at the Dantokpa international market in Cotonou (Benin) in between April and September 2019.

**Place and Duration of Study:** This study was conducted between April and December 2019 at the Food Safety Research, Laboratory of Microbiology and Food Technologies, Department of Plant Biology, Faculty of Science and Technology, University of Abomey-Calavi, Benin.

**Methodology:** Microbiological, physicochemical and sensory qualities of samples were evaluated.

**Results:** The results of the microbiological analyzes revealed that all the drinks analyzed contained neither the total mesophilic aerobic flora, nor wild yeast, *Saccharomyces* nor lactic bacteria. Therefore, the drinks are free from all pathogenic microorganisms that may harm the health of consumers. These products sold on the market complied with the criteria set by the standards and were therefore of satisfactory hygienic quality. However, the physicochemical parameters of the various drinks analyzed varied significantly from one brand to another. Results showed that the Nigerian Guinness produced contained more foam (287 s at 20 °C) and was rich in Diacetyl (0.119 mg / l) than the Benin Guinness (0.050 mg / l). As for the beer "La Béninoise", it produced more foam (220 s at 20 °C) than the Goldberg (209 s at 20 °C) but less than the Satzenbrau (250 s at 20 °C). The beer "La Béninoise" was less rich in Diacetyl (0.026 mg / l) and shown more than Goldberg (0.047 mg/l) and Satzenbrau (0.034 mg/l). As for the types of mixed drinks, it is the star Radler of Nigeria which presented a beautiful foam (235 s at 19.9 °C) with a cloudy aspect compared to the variegated one of Benin (227 s at 20.1 °C). Sensory analysis revealed that Beninese Brewery Company drinks were more appreciated by tasters.

**Conclusion:** In view of these results, all the beverages analyzed can be recommended to consumers because most of these drinks are of satisfactory quality and consistent with the standards.

*Keywords: Beer; soft drinks; motleys; consumers; quality.*

## 1. INTRODUCTION

In Africa, hunger and malnutrition remain a scourge affecting nearly eight hundred million people, the majority of whom are in developing countries where the notion of food security remains a luxury [1]. The fight against food insecurity involves increasing agricultural production and promoting local products through the use of technical knowledge. Humans have used fermentation for millennia to obtain foods of improved nutritional value [2,3]. In Africa, certain cereals such as sorghum, maize, barley and millet are often processed into drinks, the manufacture of which includes an alcoholic fermentation steps [4,5,6]. In Benin, cereals are primarily used for human food. Fermented products made from these cereals are often used as refreshing drinks commonly consumed, especially in urban areas, where they are very popular, especially during periods of intense heat [7]. The sector of their productions plays a big role in the Beninese economy. In general, there are several categories of drinks on the Beninese market that differ in terms of the manufacturing ingredients and the presentation of the packaging. These categories include local drinks of the Beninese Brewery Company such as

beers ("La Béninoise", Castel beer, Beaufort Lager, etc.), soft drinks (fruit cocktails), LB shandy, etc. and imported drinks such as Nigerian products (satzenbrau, star Radler, Goldberg, etc.). Drinks therefore play an important role in the cultures of peoples. Beer, for example, is a refreshing, energizing and euphoric drink. Its manufacture involves the alcoholic fermentation of a cereal must whose complex sugars have been made fermentable [8]. It is therefore a product which, consumed in moderation, fits into any healthy and positive lifestyle and which can be enjoyed and shared in all circumstances [8]. In a global context characterized by the fall of the Naira resulting in the significant drop in the prices of Nigerian food products including drinks, some Beninese consumers prefer these cheaper products and consume them everywhere during events such as weddings, celebrations of end of years, defenses, birthdays and funerals to the detriment of local products. This crisis of the last two years due to the importation of several categories of beer on the Beninese market has forced the Beninese Brewery Company to close one of these large factories, that of Parakou, the only one located in the part northern part of Benin. The other category also prefers local drinks.

Indeed, some popular opinion claims that it is because imported products are of poor quality that they cost less. Does the consumption of these drinks really have a harmful effect on the health of populations? It is to answer this question that this research work was initiated. It aims to compare the quality of certain drinks produced at Beninese Brewery Company and those sold on the Beninese market. Specifically, this involved studying the physicochemical, microbiological and sensory quality of Beninese Brewery Company beers and motleys and that of other drinks sold on the local market.

## 2. MATERIALS AND METHODS

### 2.1 Collection of Samples

Seven types of beverages namely: "La Béninoise 33 cl" beers, "Panaché La Béninoise", "Guinness from Benin 33 cl" which are the three beverage from Benin and "Goldberg 60 cl" beers, "Satzbrau 45 cl" beers, "Guinness from Nigeria 33cl", and foreign motleys "Star Radler 45 cl" were (Fig. 1.) collected randomly from three wholesalers with three samples from each vendor at the points of sale. The samples were collected on two different occasions (regular period of 15 days) at the Dantokpa international market in Cotonou. Thus, nine sample of each type of beverages with their original packaging (Fig. 1.) in a cooler containing cold accumulators were used in one occasion for physicochemical, microbiological and sensory analyzes.

### 2.2 Physicochemical Analysis of Beers

#### 2.2.1 Determination of original extract, apparent extract, real extract, alcohol content and pH

The original extract, apparent extract, real extract and alcohol content of a product were determined by the certified AlcoLyzer Beer precision analysis system by a digital density metre of the oscillation type (Xample 510, Anton Paar, Austria). The pH was determined by a pH meter (Accumet Basics AB15).

#### 2.2.2 Analysis of foam stability and turbidity

The foam stability was determined through MEBAK method (2.141.2) using a NIBEM-T meter (Analytica, 2004). Following, the sample's turbidity was analyzed according to the method described by Brautechnische Analysemethoden [9].

### 2.2.3 Dressing and the crimping control

The dressing and the crimping were also checked by visual observation.

### 2.2.4 Color determination

The color was determined by the spectrophotometric method according to ASBC [10].

### 2.2.5 Carbon dioxide determination

The Carbon dioxide (CO<sub>2</sub>) was determined by method described by Ali-Mattila and Lehtonen [11].

### 2.2.6 Diacetyl analysis

The Diacetyl was determined by the broad spectrum method according to ASBC [12].

### 2.2.7 Bitterness

The Bitterness was determined by ASBC [13].

## 2.3 Microbiological Analysis of Samples

The microbiological analyzes of the beverages were carried out by filtration of 100 ml of beer samples through a white membrane (0.45 µm pour size) in accordance with the AFNOR (1999) and ISO 9001: 2008 standard. The isolation and enumeration of germs on all the beers to be compared required preparation of culture medium. Specific media was used with their instructions to grow the microbes with following conditions (Table 1). The microbiological parameters sought in this work and their suitable environments are given in Table 1.

## 2.4 Organoleptic Analysis of Samples

The sensory evaluation was carried out to evaluate the different organoleptic characteristics of the samples of beers and motleys according to the NF V09-002 method (AFNOR, 1995). These samples were presented blind to the tasters to be appreciated on the basis of a tasting sheet. Smell, color, bitterness, taste and overall acceptability of samples were evaluated using a 10 point hedonic scale on a scale of 1 to 10 with 1 to 4 = I don't like at all, 5 to 6 = I like moderately, 7 to 8 = I like it and 9 to 10 = I like it a lot. The panel used was composed of 8 experienced tasters trained for sensory analyzes in breweries.

## 2.5 Statistical Analysis

All data collected from analysis were processed using SPSS 16.0 software that permitted to make

analysis of variance (ANOVA) and Tukey's test for comparison of means. The significance level of 5% is selected ( $p < 0.05$ ).



"Guinness (BF)"

"La Béninoise"

"Beninese motley (LB)"

### BEVERAGE SAMPLES OF BENIN



"Guinness (NG)"

"Satzenbrau"

"Goldberg"

"Star Radler motley"

### BEVERAGE SAMPLES OF NIGERIA

Fig. 1. Photos of the different beverages samples

Table 1. Growth condition of culture media for microbial growth

Culture environment	Germs desired	Culture temperature	Incubation time
WLN-Agar	Total aerobic flora (yeasts, molds and bacteria)	26°C ± 2	5 Days
MRS-Vegetative	Anaerobic bacteria (lactic)	25°C ± 2 anaerobic (in jar with gaspack bag)	7 Days
Lysine	Wild yeasts non-saccharomyces	26°C ± 2	5 Days

### 3. RESULTS AND DISCUSSION

#### 3.1 Results

##### 3.1.1 Physicochemical characteristics

The means values of pH, turbidity, apparent, real and original extracts, CO<sub>2</sub> saturation, color, bitterness, diacetyl, foam Stability, alcohol content, controlled dressing and crimping on the different varieties of drinks sold on the market are recorded in Tables 2, 3 and 4. The dressing (label, back label, collar, stanioles), the setting and the best before date (DLUO) on all Beninese Brewery Company beer and motley samples as well as Nigerian samples are well respected. Our comparative study was carried out on the results of physicochemical parameters such as turbidity, diacetyl and foam resistance.

Turbidity refers to the decrease in the transparency of a liquid caused by the presence of dissolved organic and inorganic matter (standard DIN EN 27027). The turbidity of lager beers is less than 1 EBC [14]. The foam resistance is the duration of the descent of the foam in the beer during a given time (measurement range 190 to 300 seconds at 20 °C ± 3). Diacetyl is a chemical with the formula C<sub>4</sub>H<sub>6</sub>O<sub>2</sub> which appears as a result of certain fermentation processes to produce a buttery flavor and is therefore present in some beers (0.000 to 4.000 mg / l).

The turbidity results of the two (02) Guinness BF and NG are close (respectively 7.41 and 7.18 EBC). The statistical analysis revealed that there is no significant difference at the 5% level between turbidity content of two Guinness. The turbidity of the beer "La Béninoise" (0.65 EBC) is high compared to satzenbrau and goldberg values (0.25 and 0.26 EBC respectively) however statistical analysis revealed that there is no significant difference at the 5% level between turbidity of the three types of beers. As for the LB ("La Béninoise") motley, it has a low turbidity value (0.74 EBC) compared to the Star Radler motley (99.99 EBC). Statistical analysis showed that there is a significant difference at 5% between the two motleys. Guinness BF is less rich in diacetyl (0.050 mg / l) than Nigerian Guinness (0.119 mg / l) but this different is not significant. Likewise, "La Béninoise" beer is less rich in diacetyl (0.026 mg / l) than Satzenbrau (0.034 mg / l), and Goldberg (0.047 mg / l). The different foam stability values of the beer and motley samples from Beninese Brewery Company as well as those from Nigeria vary from 209s to 287s seconds at 20 °C ± 3. Guinness NG and Satzenbrau contain more foam (287s at 20 °C; 250s at 20 °C) than Guinness BF (260s at 20 °C), "La Béninoise" (220s at 20 °C) and Goldberg (209s at 20 °C). As for Motleys, Radler's motley contains more foam (235s at 20 °C) than LB motley (227s at 20 °C). Statistical analysis showed that there is a significant difference at 5% between foam stability contents of all the beverages samples.

**Table 2. Physicochemical characteristics of Beninese GUINNESS (BF) and Nigerian GUINNESS (NG) drinks samples**

Parameters	Guinness		References
	Guinness BF	Guinness NG	Measuring range [15,16]
Dressing	Good	Good	-
Crimping	Ras	Ras	-
Apparent extract (°P)	3.70 <sup>a</sup>	4.51 <sup>a</sup>	0.0 - 30 °P
Original extract (°P)	17.13 <sup>a</sup>	17.04 <sup>a</sup>	0.0 - 30 °P
Real extract (°P)	6.28 <sup>a</sup>	6.92 <sup>a</sup>	0.0 - 30 °P
Alcohol (%v/v)	7.39 <sup>a</sup>	6.91 <sup>a</sup>	0.0 - 12 %v/v
Diacetyl (mg/l)	0.050 <sup>a</sup>	0.119 <sup>a</sup>	0.0 - 4.0 mg/l
Color (EBC)	170.3 <sup>a</sup>	183.6 <sup>b</sup>	0.0 - 100.0 EBC
Bitterness (BU)	47.56 <sup>a</sup>	51.27 <sup>a</sup>	1.0 - 80.0 BU
Foam Stability (s)	260 <sup>a</sup> at 19.9 °C	287 <sup>b</sup> at 20 °C	249 - 267 s
CO2 saturation (g/l)	5.32 <sup>a</sup>	5.36 <sup>a</sup>	5.3g/l – 5.7g/l
pH	3.80 <sup>a</sup>	3.82 <sup>a</sup>	3.8 – 5.8
Turbidity (EBC)	7.41 <sup>a</sup>	7.18 <sup>a</sup>	0.0 - 100.0 EBC

Mean values with the same letter on the same line are not significantly different at the 5% level. Data represents in table is mean of three replications

**Table 3. Physicochemical characteristics of "La Béninoise" beers from Benin and those from Satzenbrau and Goldberg from Nigeria**

Parameters	Beers			References Measuring range (NIBEM-T_Klopper, 1977; Renaud, 1963; EBC; MEBAK; ASBC)
	"La Béninoise" – Beninese	Satzenbrau- Nigerian	Goldberg- Nigerian	
Dressing	Good	Good	Good	-
Crimping	Ras	Ras	Ras	-
Apparent extract (°P)	1.70 <sup>a</sup>	1.28 <sup>a</sup>	1.23 <sup>a</sup>	0.0 - 30 °P
Original extract (°P)	10.13 <sup>a</sup>	11.24 <sup>a</sup>	10.69 <sup>a</sup>	0.0 - 30 °P
Real extract (°P)	3.32 <sup>a</sup>	3.19 <sup>a</sup>	3.05 <sup>a</sup>	0.0 - 30 °P
Alcohol (%v/v)	4.43 <sup>a</sup>	5.25 <sup>a</sup>	4.97 <sup>a</sup>	0.0 - 12 %v/v
Diacetyl (mg/l)	0.026 <sup>a</sup>	0.034 <sup>a</sup>	0.047 <sup>a</sup>	0.0 - 4.0 mg/l
Color (EBC)	6.62 <sup>a</sup>	7.81 <sup>a</sup>	8.77 <sup>b</sup>	0.0 - 100.0 EBC
Bitterness (BU)	16.61 <sup>a</sup>	18.61 <sup>b</sup>	18.15 <sup>b</sup>	1.0 - 80.0 BU
Foam Stability (s)	220 <sup>a</sup> at 20°C	250 <sup>b</sup> at 20°C	209 <sup>c</sup> at 20°C	249 - 267 s
CO2 saturation (g / l)	5.78 <sup>a</sup>	5.92 <sup>a</sup>	5.18 <sup>a</sup>	5.3g/l – 5.7g/l
pH	4.11 <sup>a</sup>	4.01 <sup>a</sup>	3.99 <sup>a</sup>	3.9 – 5.8
Turbidity (EBC)	0.65 <sup>a</sup>	0.25 <sup>a</sup>	0.26 <sup>a</sup>	0.0 - 100.0 EBC

Mean values with the same letter on the same line are not significantly different at the 5% level. Data represents in table is mean of three replications.

**Table 4. Physicochemical characteristics of the samples of the Motleys**

Parameters	Motleys		References
	Motley LB Beninese	Star Radler Nigerian	Measuring range (NIBEM-T_ Klopper, 1977; Renaud, 1963; EBC; MEBAK; ASBC)
Dressing	Good	Good	-
Crimping	Ras	Ras	-
Apparent extrait (°P)	6.18 <sup>a</sup>	8.08 <sup>b</sup>	0.0 - 30 °P
Original extrait (°P)	9.92 <sup>a</sup>	11.76 <sup>a</sup>	0.0 - 30 °P
Real extrait (°P)	6.91 <sup>a</sup>	8.80 <sup>b</sup>	0.0 - 30 °P
Alcohol (%v/v)	1.99 <sup>a</sup>	1.99 <sup>a</sup>	0.0 - 12 %v/v
Color (EBC)	2.68 <sup>a</sup>	14.00 <sup>b</sup>	0.0 - 100.0 EBC
Bitterness (mg/l)	17.063 <sup>a</sup>	6.203 <sup>b</sup>	1.0 - 80.0 BU
Foam Stability (s)	227 <sup>a</sup> at 20.1°C	235 <sup>b</sup> at 19.9°C	249 - 267 s
CO <sub>2</sub> saturation (g/l)	5.72 <sup>a</sup>	4.38 <sup>a</sup>	5.3g/l – 5.7g/l
pH	2.95 <sup>a</sup>	3.02 <sup>a</sup>	3.9 – 5.8
Turbidity (EBC)	0.74 <sup>a</sup>	99.99 <sup>b</sup>	0.0 - 100.0 EBC

*Mean values with the same letter on the same line are not significantly different at the 5% level. Data represents in table is mean of three replications.*

### 3.1.2 Microbiological characteristics of inoculated beers and motleys

The results of the microbiological analyzes of the beers and motleys obtained show the absence (0 UFC/ml) of total mesophilic aerobic flora, non-Saccharomyces wild yeasts and lactic acid bacteria in beverages. The absence of parameters sought in the beverages sold comply with the normative microbiological criteria of the BGI Castel group (Absent / ml) to which Beninese Brewery Company belongs. The absence of total mesophilic aerobic flora, non-Saccharomyces wild yeasts and lactic acid bacteria in beverages sold on the market gives the product good hygienic and marketable quality.

### 3.1.3 Sensory characteristics of beer and motley samples

Fig. 2. Illustrates the overall acceptability of beers and motleys.

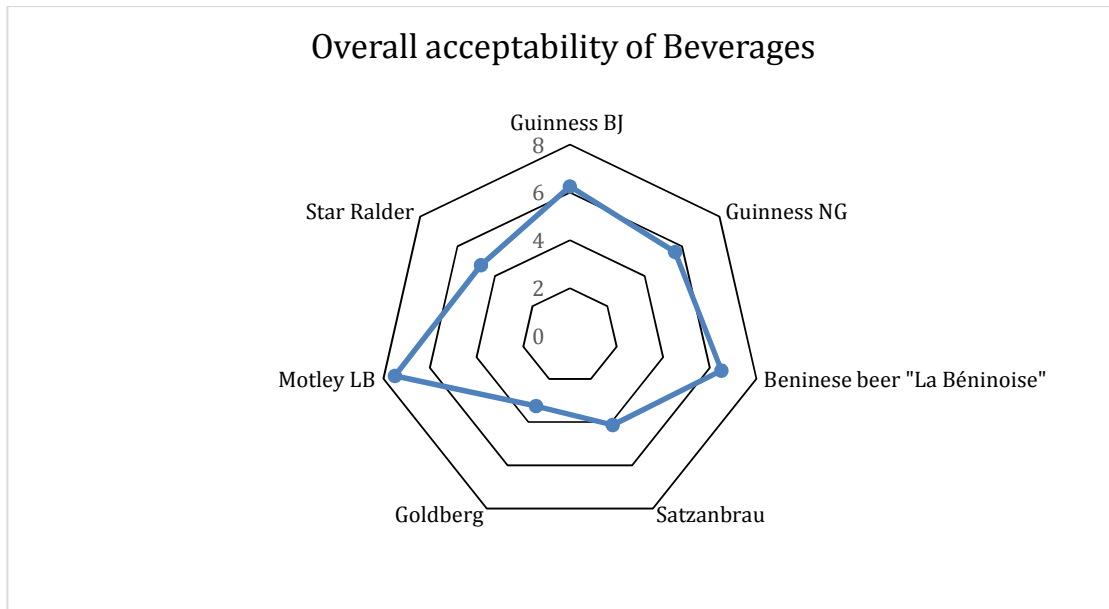
The analysis in Fig. 2. generally shows that Beninese Brewery Company beers and motleys are more popular with tasters to the detriment of Nigerian beers and motleys.

## 3.2 Discussion

The results indicate that the physicochemical parameters of the different types of drink used during the study vary significantly from one type to another as well as the dressing. The results of the apparent, original and real extracts (EA, EP and ER), bitterness, CO<sub>2</sub> saturation, color and alcohol level are for information only and are specific to each manufacturer according to the types of beers to produce. The Beninese (BF) and Nigerian (NG) Guinness's have similar turbidity values (7.41EBC and 7.18EBC). The statistical analysis revealed that there is no significant difference at the 5% level between turbidity content of two Guinness. They may be due to the use of same type of raw materials (barley, barley malt, roasted barley). The turbidity values of other beers such as "La Béninoise", Satzenbrau and Goldberg vary from 0.25 to 0.65 EBC. These recorded values are in accordance with the speculation of DIN EN 27027 which defines turbidity as the decrease in transparency of a liquid caused by the presence of dissolved organic and inorganic matter (Macherey-nagel). The turbidity of filtered lagers is generally less than 1 EBC (turbidity / color in brewing). This attests that these beers are clear and are of

satisfactory quality. As for the motleys, the turbidity of the LB motley is 0.71 EBC while that of the Radler star is above the EBC reading limit. This value recorded on the LB motley justifies its brilliance, its clarity and proves that it is of satisfactory visual quality. On the other hand, the value recorded on the Radler star proves that she is cloudy and hazy. Which calls into question the visual quality of this drink. The duration of the foam retention of beers in general is between 190-300 seconds at 20 °C ± 3 depending on the criteria set. In fact, Bigoin et al. [17], who worked on the beer industry, indicate that the foam protects beer from too rapid oxidation on contact with air and flavor and keeps all of its aromas. Durable and dense foams are often a guarantee of quality. The different foam stability values of the beer and motley samples from Beninese Brewery Company as well as those from Nigeria vary from 209-287 seconds at 20 °C ± 3 with significant difference at 5% level. Guinness NG and Satzenbrau contain more foam stability (287s at 20 °C; 250 s at 20 °C) than Guinness BF (260 s at 20 °C), "La Béninoise" (220s at 20 °C) and Goldberg (209s at 20 °C). As for the motleys, the Radler star motley contains more foam (235 s at 20 °C) than the LB motley (227 s at 20 °C). Statistical analysis showed that there is a significant difference at 5% between foam stability contents of all the beverages samples. The latter are also rich in CO<sub>2</sub> in Nigerian drinks than Beninese drinks. This amount of foam depends on the amount of dissolved CO<sub>2</sub> and its behavior may depend on other compounds (barley malt proteins, hops). The values obtained meet the criteria set (190-300 seconds at 20 °C ± 3) and are therefore of satisfactory quality for consumers. The amount of diacetyl obtained varies from one category of beer to another. In Guinness, it varies from 0.050 mg / l (BF) to 0.119 mg / l (NG). On the other hand, diacetyl in "La Béninoise" (0.026 mg / l), Satzenbrau (0.034 mg / l) and Goldberg (0.047 mg / l) do not show any significant difference at 5% level. Diacetyl is a C<sub>4</sub>H<sub>6</sub>O<sub>2</sub> structural chemical, called butanedione or 2,3-butanedione that occurs naturally as a result of certain fermentation processes to produce a buttery flavor and is therefore present in some beers [18]. When a certain threshold is exceeded, the beer acquires an unpleasant flavor. The measurement range for diacetyl in beer is 0.000 to 4.000 mg/l [12]. The high values of diacetyl in Guinness (dark beers) suggest that diacetyl manifests itself in this variety of beer by impregnating it with a buttery or caramel taste. In other beers, low levels of diacetyl may make it easy to absorb in the mouth [19]. The pH of





**Fig. 2. Histogram for the evaluation of the sensory characteristics of beers and motleys**

beers and motleys is between 1.99 and 4.11. Most microorganisms, especially pathogens, are unable to develop in such an environment [20], thus guaranteeing the health quality of the product. The beers and motleys used in the present study are of satisfactory microbiological qualities with an absence of pathogenic germs, of total mesophilic aerobic flora, of non-Saccharomyces wild yeast and of lactic acid bacteria. Sensory evaluation of the different varieties of beverages used for this study revealed taste, color, odor and overall acceptability ratings by taster's values. The Beninese Brewery Company drinks were the most appreciated by the tasters. Nigerian drinks, on the other hand, were not well appreciated due to the oxidized, cooked, paper, light and mercaptan flavors that were felt in these drinks by the tasters during sensory evaluation.

#### 4. CONCLUSION

The study showed that the different drinks produced and sold on the market in Benin have varying physicochemical properties from one brand to another and comply with standards. These drinks do not contain total mesophilic aerobic flora, non-saccharomyces wild yeast and lactic acid bacteria. Therefore, the drinks are free from all pathogenic microorganisms that may harm the health of consumers. These beverages are comply with standards microbiological generally accepted for similar drinks. The

physicochemical and microbiological analyzes carried out during this study confirm the satisfactory quality of the drinks analyzed. They can therefore be recommended to consumers. All drinks are accepted by the tasters but they prefer more drinks produced in Benin than those imported.

#### DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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#### COMPETING INTERESTS

Authors have declared that no competing interests exist.

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