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Improved *Koutoukou* Production: Physico-Chemical And Organoleptic Characterizations

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Abstract
Generally, the quality of *koutoukou* (KTK) locally manufactured in Côte d'Ivoire, is generally poor compared to industrial drinks. The objective of this study is to produce *koutoukou* and to determine its physico-chemical and organoleptic characteristics. The traditional process has been modified by including good hygiene and manufacturing practices techniques. This brandy has a yield 27.5% at ten days of bandji fermentation. The improved *koutoukou* contains a methanol level 16.91 mg/L which is below the recommended threshold, none of the higher alcohol and heavy metal were detected during the analysis. Sensory tests reveal that the improved *koutoukou* has a "less full-bodied" taste, a "colourless" and "odourless" appearance. Thus, good hygiene and manufacturing practices (GHP/GMP) applied in the production of *koutoukou* allow to obtain a controlled alcoholic beverage, free of heavy metals and higher alcohols, with a methanol content below the authorized threshold. The improved *koutoukou* does not pose any health risks to consumers.

Keywords: improved *koutoukou*, bandji, GHP/GMP, yield, quality.

INTRODUCTION

Alcohol is the most widely consumed psychoactive substance in the world. It has been present in many cultures for many centuries. Africa is one of the most alcohol consuming continents with 8 African countries in the top 15 according to WHO report in 2014. Alcohol consumption varies by country and time period. Thus, Côte d'Ivoire ranks 10th among African alcohol consuming countries with 5.98 g of alcohol per capita per year (**Delfolie, 2017**). According to World Health Organization (WHO) data from 1970 to 1980, wines were consumed more than beer and liqueurs. But since 1986, beer has been the largest consumer of alcoholic products. With the economic crises, alcohols of artisanal production are increasingly consumed, particularly *koutoukou* (**Yao et al., 2015**).

Koutoukou production is carried out by both women and men, with men predominating (2017 survey data). *Koutoukou* production techniques are still very traditional. Production is carried out in the bush, in "workshops" (places of production and marketing), and often in homes of women producers. The way methods are learned has been through family transmission for generations. Unfortunately, this drink is produced under unsatisfactory hygienic conditions, due to presence of insects, waste and standing water around the production sites. In addition to this sometimes unhealthy environment, which can be a danger to quality of the drink produced, there is use of rudimentary equipment, the lack of fermentation control and lack of control over temperature and distillation time. The liquor obtained at an unknown alcohol level contains methanol, higher alcohols including propanol and heavy metals. The quality of drink varies greatly from one production to another depending on the raw material chosen. All these parameters lead to high toxicity of finished product, which is inevitably a public health problem for consumers.

The objective of this study is to apply good manufacturing and hygiene practices by producing an improved alcoholic beverage (*koutoukou*) based on limits of artisanal production carried out by traditional producers

1. Materials

The study material consist of palm wine (*bandji*) and *koutoukou* from the production of the improved diagram and good manufacturing pratices.

2. Methodology

2.1. Improved *koutoukou* production method

The production of improved *KTK* required 1000L of palm wine (*bangji*). This *bangji* was collected from an industrial plantation in Toumanguier (Bonoua). The method described by **Koffi et *al.* (2017)** was used modified by control techniques and an improved diagram (figure 1). Some essential steps are described through the following unit operations: reception of palm wine, 1st filtration, fermentation of sweet must, 2nd filtration, distillation of fermented must, 3rd filtration and conditioning.

2.1.1. Palm wine reception

Palm wine was harvested using small four (4) liter cans placed underneath the palm tree. To accelerate the flow of the *bandji*, the farmers introduce flaming twig into the crack of the palm tree and, with the help of the fan, fan the fire. The palm wine was received and transported to production plant in 30 and 50 L cans for filtration.

2.1.2. 1st Filtration

This step is absent among traditional producers. It has been set up to remove coarse and visible waste (wood debris, insects, stones,...) present in palm wine during harvesting. The palm wine was filtered a sieve with diameter 1000 µm. After this step, the wine was subdivided into five (5) 200 L batches and fermented on the same day of harvest.

2.1.3. Fermentation of palm wine

The fermentation of palm wine begins as soon as it is harvested. The *bandji* batches were distributed according to different fermentation times. These fermentation periods are four (4) days, seven (7) days, ten (10) days, fifteen (15) days and twenty-one (21) days. The cans are equipped with fermentation indicators which consist of tube and jar containing water to observe the fermentation. These indicators are based that as the yeasts degrade the sugar in medium, energy (ATP) and carbon dioxide (CO_2) are produced, which is perceived as an air bubble in jar used as indicator. The must is mixed daily for 1 to 2 minutes to homogenize the fermentation in the environment. After this step, the fermented must is filtered before distillation.

2.1.4. 2nd Filtration

The second filtration of fermented wine was filtered with a 500 µm diameter sieve placed inside the funnel used to introduce the fermented must into the cucurbite. This step removes the whitish deposits contained in fermented wine and some invisible waste during the first filtration

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2.1.5. Distillation

Distillation is carried out using a modern still composed of valves arranged on the column to evacuate the methanol; a thermometer to check the boiling temperature 78.5°C of ethanol. The entire device is made of stainless steel, which makes it possible to have a drink free of heavy metals from the still. During this operation, the alcohol level was measured using an alcoholometer. The distillates obtained averaged 50% vol. The distillation time was recorded and the production yield calculated according to the method described by **Boulal et al. (2013).**

2.1.6. 3rd Filtration

A third filtration is carried out at distillate level. It consists in removing all physical impurities from the finished product using a filter composed of fine linen placed in a funnel mounted on a graduated canister.

2.1.7. Conditioning

The *koutoukou* was packaged in clean bottles that were sent to laboratory for analysis.

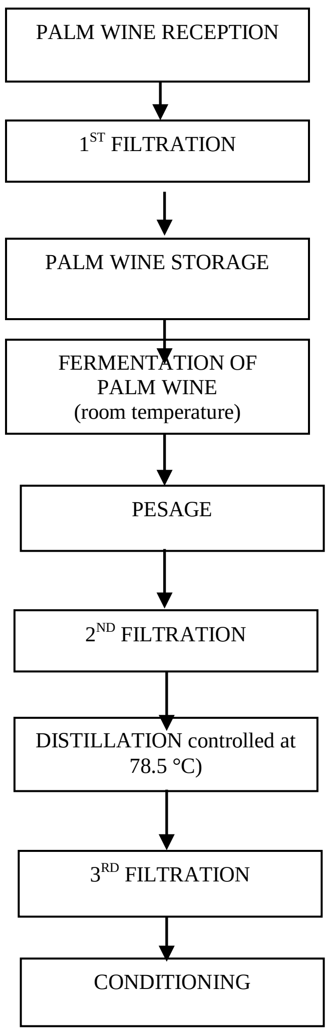

Figure 1 : production diagram of improved "*koutoukou*" from palm wine

2.2. Physico-chemical characterization

At each fermentation, one liter (1 L) of *koutoukou* produced was collected. These samples were put in glass bottles away from the light. Five (5) liters of beverages were collected throughout this production phase. All these samples were kept cold (4°C) under aseptic conditions limiting any external contamination for the various modified analyses (**AFNOR, 1994**).

2.2.1. Determination of pH

The pH of various beverages was determined using a pH meter according to the method (**OIV, 2009**). Two hundred and fifty (250) ml of each type of drink is poured into beakers and placed under magnetic stirrer. The electrode of pH meter (previously calibrated) is immersed in liquid. The pH reading of drink is determined on pH meter screen. This operation is repeated three times.

2.2.2. Determination of alcoholic strength by volume (ASV)

The alcoholic strength by volume was determined using a GAY-Lussac alcoholometer by the **OIV** (**2012**) method. Thus, 0.5 L of each KTK is poured into a measuring cylinder. The alcoholometer is immersed in liquid to determine the alcohol degree. The ASV reading is made directly on graduated rod of device. This operation is repeated three times to calculate the average of the values obtained

2.2.3. Determination of Brix degree

The Brix degree was determined at refractometer using the method used by **Téhoua et *al.* (2013**). A few drops of the sample are spread over the prism of the refractometer, then the soluble dry residue rate is read on the scale of this device at the intersection of the light and dark areas. After each analysis, the prism tray should be cleaned with distilled water and wiped with a soft cloth. The operation is repeated three times for each sample.

2.2.4. Heavy metal contents

The multi-element content was determined according to method described by International Organisation of Vine and Wine (**OIV, 2012**). It is a digesting method the samples that was carried out as follows: five (5) millilitres of standard solutions were used to plot the calibration curve for each element sought. Then, ten (10) millilitres of each type of sample are transferred to a vial to be placed on a spectrophotometer to determine the mineral composition. The content of lead (Pb), cadmium (Cd), iron (Fe) and copper (Cu) was obtained by assay with an air-acetylene flame atomic adsorption spectrophotometer (Varian AA 20, Syndney, Australia).

2.2.5. Determination of methanol and higher alcohols

The determination of methanol and higher alcohols is carried out according to method OIV-MA-AS312-03A amended (**OIV, 2012**). A calibration curve was drawn from the volume of standard solutions which are pure methanol, ethanol, propanol-1 and 2 and butanol. Then, the samples are placed in coupled gas chromatography of mass spectrometer (GC-MS) from SHIMADZU (Japan). Using a syringe, 1µl each *KTK* samples (traditional or improved) are injected successively into the GC-MS injection chamber. The initial temperature of furnace is 50 °C and its final temperature is 150 °C. The temperatures of the injector and detector system are 225°C and 245°C respectively. The flow rate of the carrier gas (helium) is 25°C/min. The analysis samples was carried out in 20 minutes and gave calibration curves of different standard solutions and curves showing the different peaks of analyzed samples. The elements found are expressed in milligrams per litre (mg/l).

2.3. Organoleptic characteristics

The traditional and improved *koutoukou*, after their analyses, were sudmitted to a jury for descriptive tests.

2.3.1. Jury formation

The training was addressed to forty (40) people distributed as follows: twenty (20) I2T civil servants, ten (10) students from Nangui Abrogoua University and ten (10) people working in informal sector (carpenters, painter masons and others...). All these people have experience in terms of sensory analysis, especially of *koutoukou*. The training initially consisted a theoretical explanation of *koutoukou* quality criteria that will be analysed. These include appearance, odour, flavour and taste. After the theoretical phase, practical exercises were carried out. After these training sessions, fifteen (15) tasters with the best performance were selected for the tests.

2.3.2. Descriptive test

The analyses were conducted at I2T Quality Control and Food Biochemistry and Tropical Technologies (LBATPT) laboratories in UNA. Based on *koutoukou* quality criteria defined by the producers, a descriptive analysis was carried out on traditional and improved *koutoukou* samples. Indeed, the appearance (clear-colour), odour (odourless alcoholic-other odour), flavour and taste (acidic/acidic-alcoholic-bitter-bitter-sweet) were measured by a jury trained (N=15) in descriptive analyses. The method described by Meilgaard et al. (1999) was adopted. The previously coded *koutoukou* samples were served (≈ 10 ml) to the tasters in disposable plastic glasses. A description sheet with the intensity of each quality criterion was used for the test. Each panelist was asked to circle the intensity that best described the criterion.

2.4. Analyses in main component

The main component analysis made it possible to group the different types of samples analysed according to the origine and time taken for fermentation before their production. It was used to assess the similary between traditional and improved *koutoukou* samples produced before and after 10 days fermentation in order to identify homogeneous groups of traditional and improved *koutoukou* using the relationships between their appearence, odour and taste parameters. The main component analysis was peformed on the sensory analysis data using the Tastel Sensory software.

2.5. Statistical analyses

The results obtained were analysed by one-factor analysis of variance (ANOVA 1) with the "IBM SPSS" software version 20.0 to compare the means of physico-chemical parameters. In case of significant differences between the parameters studied, the averages were ranked according to Turkey test. The materiality level is $\alpha = 0.05$. Statistical differences with a probability value less than 0.05 ($P < 0.05$) are considered significant. When the probability is greater than 0.05 ($P > 0.05$), the statistical differences are not significant.

3. Results

3.1. pH of palm wine and improved *koutoukou* according to fermentation time

The pH of palm wine (A) decreases as the fermentation time is extended. It ranges from 3.32 to 6.54. The pH of improved *koutoukou* (B) is 4.23 to 5.11 (Figure 2).

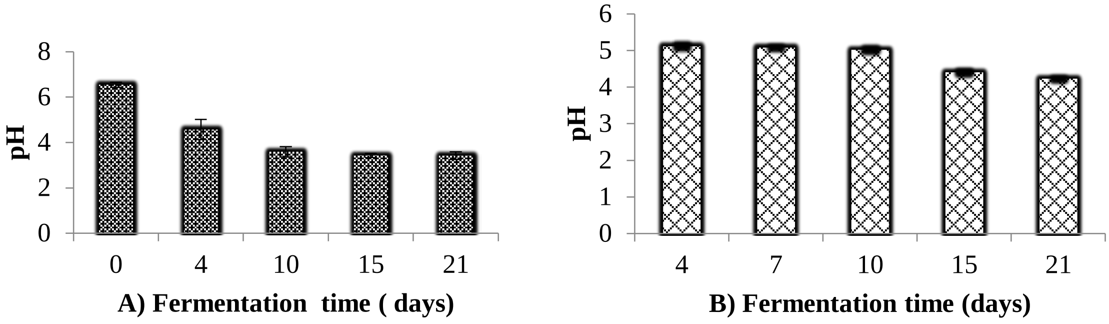

Figure 2 : pH of palm wine and improved *koutoukou* according to fermentation time
A) : palm wine B) : improved *koutoukou*

3.2. Brix degree of palm wine and improved *koutoukou* according to fermentation time

. The values of palm wine (A) change from 3.5 to 14°B while those of improved *koutoukou* samples vary from 20.12 to 20.62°B (Figure 3)

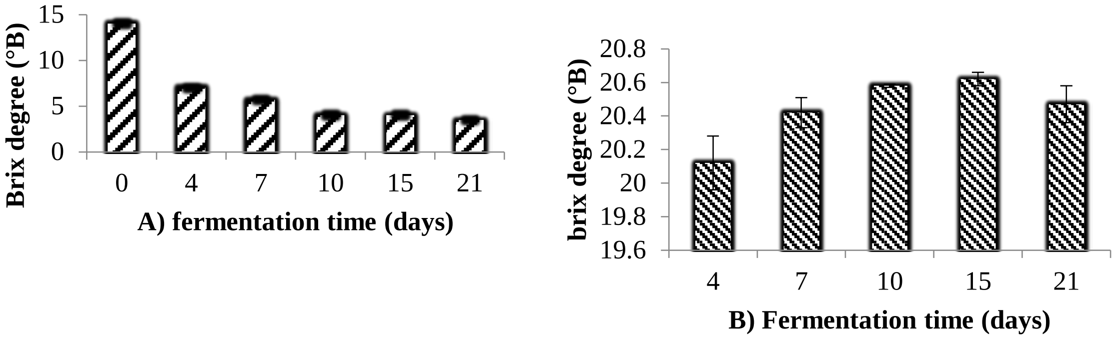

Figure 3 : Brix degree of palm wine and improved *koutoukou* according to fermentation time
A) : palm wine B) : improved *koutoukou*

3.3. Production time (distillation) of *koutoukou*

The distillation time of the koutoukou varies from 140 to 195 min from the first drops collected according to the fermentation time of the palm wine (Figure 4).

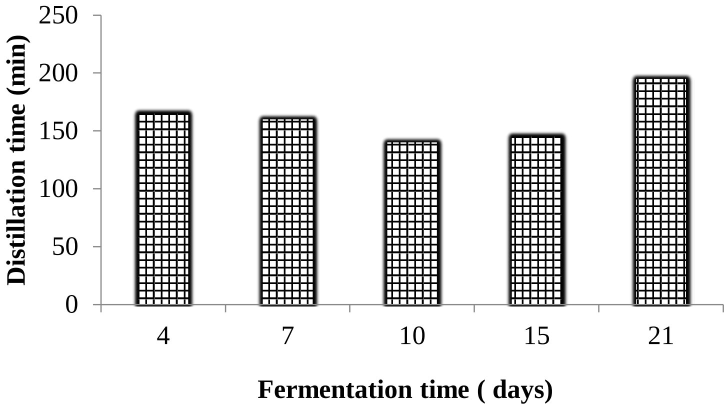

Figure 4 : Distillation time of *koutoukou*

3.4. Yield of improved *koutoukou* production as a function of fermentation time

The yield of improved *koutoukou* production has varied between 18.75 and 27.5% depending on fermentation time (Figure 5). The diagram shows the production with 10 and 15 day fermentation gives better yields than production with fermented must in a period too short (≤ 7 days) or too long (≥ 21 days).

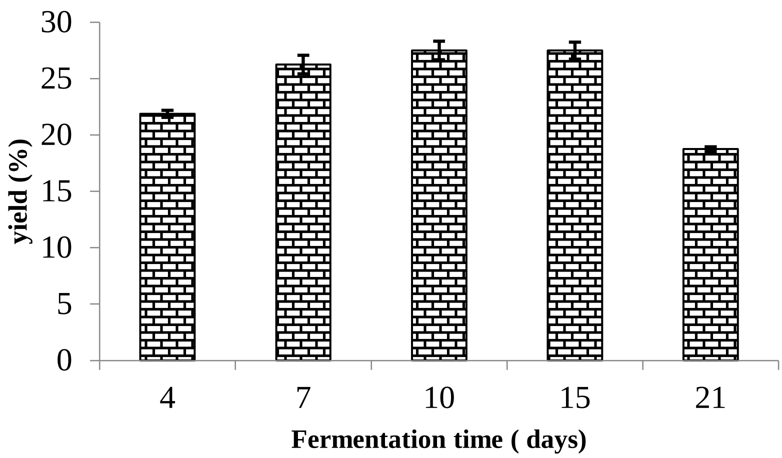

Figure 5 : yield of Improved *koutoukou* production

3.5. Methanol and higher alcohols present in *koutoukou*

Figure 7 shows the levels of methanol, acetaldehyde, higher alcohols and methylethylketone in traditional and improved *koutoukou* drinks. The methanol content of samples ranges from 16.91 to 1037.30 mg/L in improved and traditional *KTK* respectively. For acetaldehyde, the values range from 9.20 mg/L for traditional *KTK* and 17.69 mg/L for improved *KTK*. Only traditional KTK samples contained levels of propan-1-ol (39.53 mg / L); propan-2-ol (1003.23 mg / L) and butanol (12.50 mg /L) and methyl ethyl ketone with a content of 219.26 mg/L.

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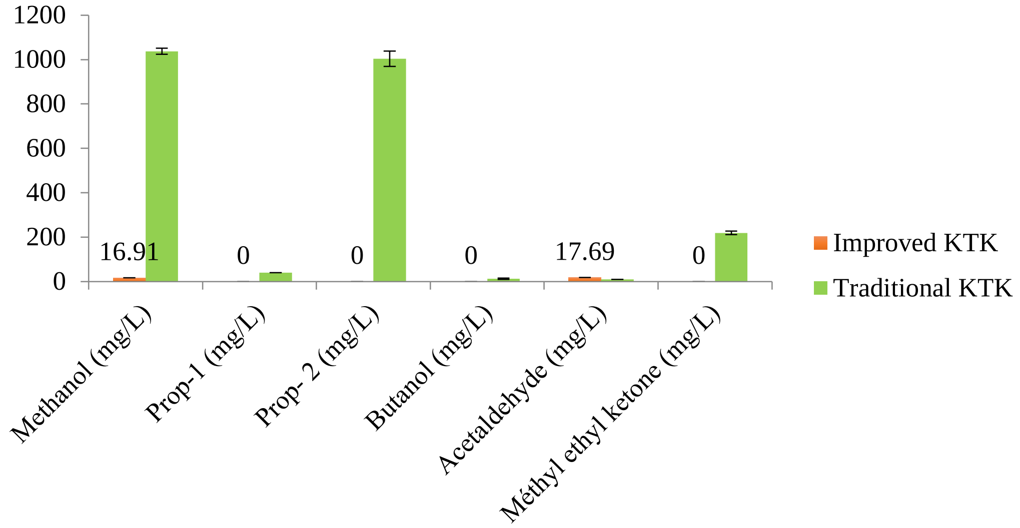

Figure 7 : content of methanol, higher alcohol, acetaldehyde and methylethylketone in traditional and improved *KTK* samples

3.6. Mineral composition of *koutoukou* and palm wine samples

The mineral composition of *koutoukou* samples is shown in figure 8. It is composed of eleven (11) minerals such as magnesium (Mg), potassium (K), calcium (Ca), manganese (Mn), iron (Fe), nickel (Ni), copper (Cu), zinc (Zn), lead (Pb), cadmium (Cd) and chlorine (Cl). Among these minerals, five (05) were detected in the three samples analyzed (bandji, traditional and improved *KTK*). These are magnesium with values between 0.83 to 1.98 mg/L, potassium (2.7 to 8,36 mg/L), calcium (0.23 to 2.50 mg /L), iron (0.03 to 33.71 mg /L) and zinc (0.06 to 23.22 mg/L). Four (4) minerals were identified in the traditional *KTK* and bandji samples : manganese (0.11 to 5.78 mg/L), copper (0.17 to 23.8 mg/L), lead (0.93 to 9.1 mg/L) and clrorine (0.08 to 14.46 mg/L). Finally, two (2) minerals were recorded only in the traditional KTK samples, nickel (25.26 mg/L) and cadmium (5.31 mg/L).

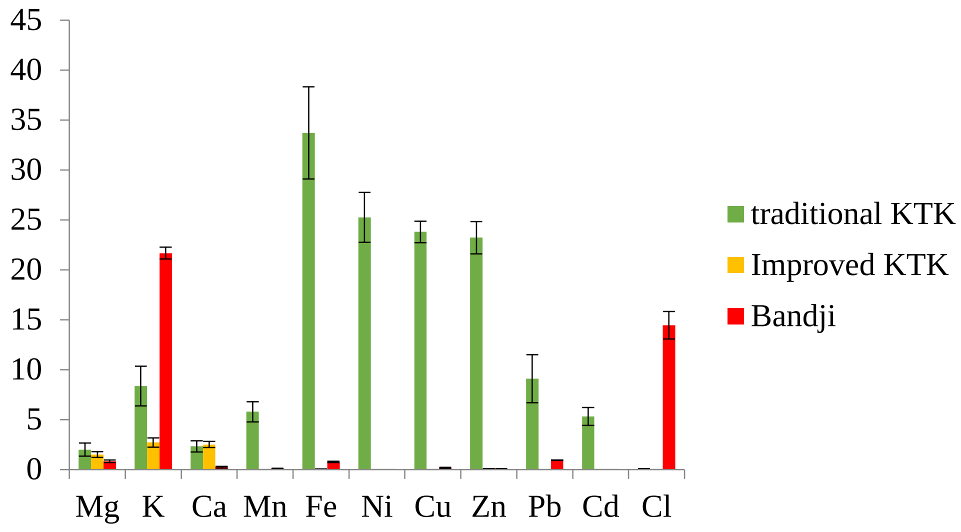

Figure 8 : Mineral composition of *KTK* and fresh *bandji*

3.7. Sensory and main component analysis

The *koutoukou* samples were subjected to a descriptive test using the following descriptors: appearance of product, smell and taste. The appearance is described by the colour and clarity of drink. It appears that traditional *koutoukou* (KTK T1 and T2) are light yellow, while improved *koutoukou* (KTK A1 and A2) are clear. The odour is described as odourless, pungent (alcoholic) and other odours. Thus, traditional *koutoukou* have strong odours (alcohol and other odours) than improved *koutoukou*. Taste is expressed by taste (acid and bitter) and flavour (alcoholic, strong, metal oxidized, and persistent). The traditional *koutoukou* is very acidic, persistent, metal oxidized and alcoholic. The improved *koutoukou* has a rather less full-bodied taste (Figure 9).

The result of main component analysis (figure 9) identified three groups of *koutoukou* depending on sensory parameters. The first group is composed of traditional *KTK* produced before ten (10) days fermentation (KTK T1) which is characterized by metallic-oxidized and persistent taste and alcool smell. The second group is the traditional *koutoukou* produced after ten (10) days fermentation (KTK T2) which is distinguished by a pungent and persistent taste, a light yellow aspect and a smell other than alcohol. Finally, the third groupconsists of improved *koutoukou* produced at ten (10) days (KTK A1) and fifteen (15) days (KTK A2) of fermentation. This group is characterized by a lessfull-bodied taste, a colourless appearance and no odour other than alcohol.

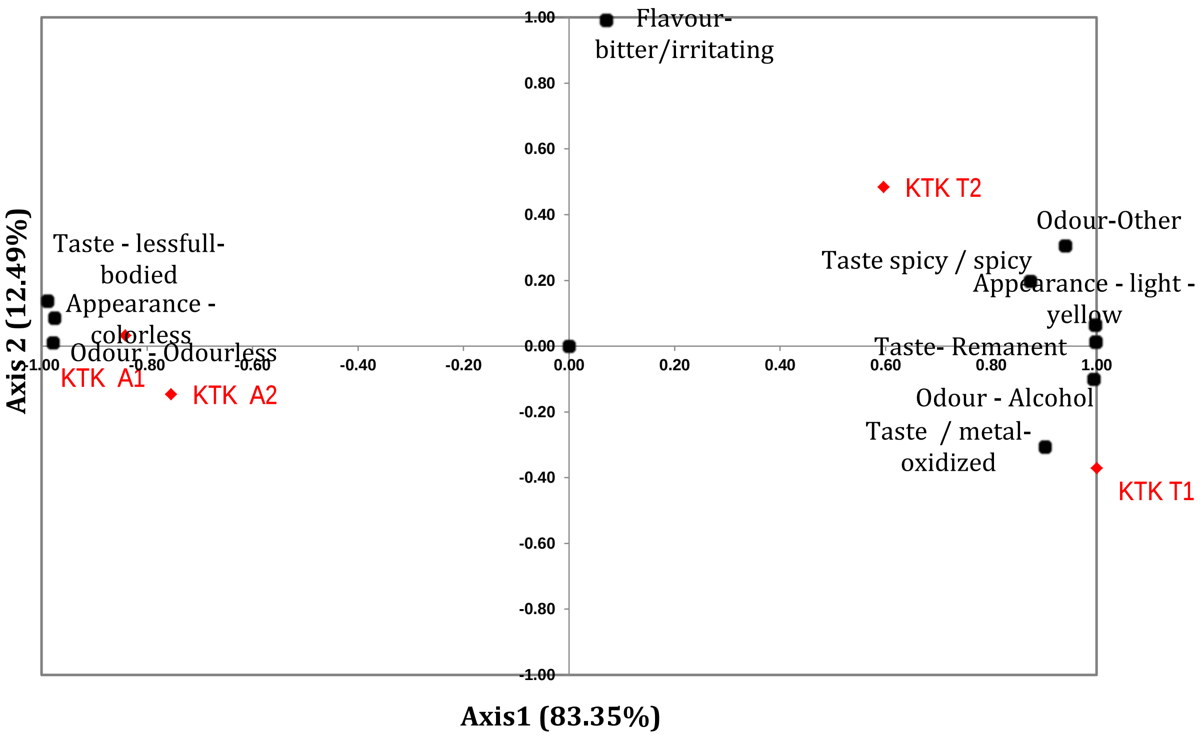

Figure 9 : Sensory profile of *koutoukou* samples
KTK A1 : Improved koutoukou produced after 10 days of bandji fermentation
KTK A2 : Improved koutoukou produced after 15 days of bandji fermentation
KTK T1 : Traditional koutoukou collected from producers (bandji fermentation time ≤ 10 days.)
KTK T2 : Traditional koutoukou collected from producers (bandji fermentation time > 10 days.)

4. Discussion

The pH of palm wine decreases with the fermentation time. According to **Akin** (**2008**), this decrease in pH during fermentation is related to assimilation of nitrogen source by the yeast. The pH decrease in palm wine studied is similar to work of **Ogbulie et *al.*** (**2007**) who noted pH between 2.10 and 3.4 for Nigerian wines during period of three to ten fermentation days. In addition, the results of improved *koutoukou* pH are agreement with values reported in the work of **Soufleros and Bertrand** (**1987**). These authors found pH values between 4.15 and 7.0 in samples of "Tsipouro", a Greek brandy distilled from grape marc.

Soluble solids represent all solids dissolved in water, including sugars, salts, proteins, alcohol, carboxylic acids, etc.... The different parameters that can influence the level of soluble solids are climate, the nature of the soil and the types of raw materials used in the production of the beverage (**Messaid, 2008**). The measurement of Brix degree in fermenting palm wine made it possible to know the sugar level in fermented must before the distillation.

The yield of improved *koutoukou* production is 27.5% at 10 and 15 days of fermentation. Indeed, palm wine is mainly made up of sugars such as sucrose, glucose and fructose (**Combet-Blanc, 1997**) is subjected to spontaneous fermentation (without the addition of yeast). Spontaneous alcoholic fermentation is carried out by indigenous yeasts that are generally present in air and on material used to harvest (**Tapsoba et al. 2011**). These microorganisms are not large number composed of *Saccharomyces cerevisiae* (**Lollier, 2003**). The latter are generally responsible for alcoholic fermentation. In addition, with a medium (palm wine) containing a lot of wild yeasts, the alcoholic fermentation process is random. The beginning of fermentation can be long, fermentation kinetics are slow, the end of fermentation is difficult to detect (**Lollier, 2003**). Thus, our results are well below the results found by **Boulal and col. (2013).** These authors obtained a yield between 50 and 65% after controlled fermentation for 3 days for two types of dates (Aghmou and Tinaceur) during alcohol production (93% vol.). However, traditional Ivorian producers have stated during an investigation that their yield does not exceed 20%.

The distillation of improved *koutoukou* lasted between 140 and 195 minutes from the first drops collected.it was carried out using a still equipped with a thermometer to monitor the boiling temperature of the ethanol (79°C). To maintain this constant temperature, the firewood was reduced or raised in the heating system according to the indicator on thermometer. The distiller has reduced the methanol (65°C) and certain volatile comounds that make up the « head » of the distillate and eliminated the higher alcohols (>80°C) that correspond t its « tail »by opening the valves on the alembic. According to **Fahrasmane et *al.*** (**1996**), distillation has become the key step in the production spirit drinks. Thus our results are below those recorded by **Marly-Brugerolle et *al.*** (**1978**) who produced wine based brandy for about 5 and 6 hours.

Methanol is one of undesirable alcohols because of its toxicity and its harmful consequences on health of consumers. It is always present in relatively high quantities in wines and spirits (**Bertrand, 1978 ; Lamiable et *al*., 2004**). Indeed, methanol comes from the hydrolysis of pectins in the raw material during fermentation and from the production of distillates (**Chaiyasut et *al*., 2013**). According to the **International Wine and Vine Organisation (OIV) in 2012**, methanol should be reduced to 500 mg/L in spirit drinks. Thus, the methanol contents of the improved *koutoukou* samples are in accordance with the **OIV** recommendation (**2012**). No higher alcohol was detected in the samples of improved *koutoukou*. This could be due to good manufacturing practices (GMP) implemented during production. Temperature stability at 79°C and distillation control were important in production of this improved *KTK*. However, according to **Bertrand** (**1981**), alcohols in excess of small quantities (propanol and butanol) could be considered as criteria for brandies quality and their organoleptic characteristics. Acetaldehyde comes from the oxidation of ethyl alcohol produced during alcoholic fermentation and distillation (**Litchev, 1972**). The acetaldehyde content varies with alcohol beverage age (**Lafon, 1973**). Thus, the results of the analyzed samples of improved *koutoukou* are in agreement with the work of **Danilatos**

and Harvadia (**1981**). These authors found acetaldehyde values ranging from 3 to 34 g pur alcohol/ hl in cognac.

The mineral composition of improved *koutoukou* and palm wine samples composed several elements such as magnesium, potassium, calcium, manganese, iron, nickel, copper, zinc, lead, cadmium and chlorine.

Magnesium plays very important role in the body. It is used as co-factor by certain enzymes, including (hexokinase, phosphofructokinase, phosphoglycerate kinase, pyruvate kinase and enolase). These enzymes are involved in glycolysis, hence the importance of magnesium in fermentation media used for alcohol production (**Xue et al., 2008**). The average daily amount of magnesium is between 310 and 320 mg / day (**Navaro et al., 2007**). The results of our work showed a value of 1.5 mg/L in the improved KTK samples. These results are above the values found by **Navaro et *al.*** (**2007**). The latter reported in their work values of 97 µg / L in samples of traditional alcoholic beverages in Spain. Thus, the consumption of alcoholic beverages can also contribute to the recommended daily intake of magnesium. Acute heart attacks, chronic cardiovascular accidents, asthma and chronic fatigue syndrome may be due to magnesium deficiency (**Salako et al., 2016**). According to the database of US Department of Agriculture and Food, a beer fortified with magnesium and other nutrients (folate, niacin,...) has been manufactured to improve the consumer health (**Sherren, 2012**).

Copper is metal essential to the body for its functioning and metabolic process. It is an enzyme cofactor for certain enzymes such as cytochrome C oxidase or Cu^{2+}- Zn^{2+} superoxide dismutase used to detoxify yeast (**Stehlik-Tomas et al., 2004**). However, this ion has a reduced optimal range (0.1 and 0.6 ppm) and becomes toxic as soon as its concentration exceeds this range (**Azenha et al., 2000**). There is no copper recommendation for alcoholic beverages. The daily limit recommended by the WHO as a benchmark is 1.3 mg / L (**WHO, 1996**). Thus, our results show that only palm wine (the raw material of the improved *KTK*) has a value of 0.17 mg/L. This result is above the values reported in the work **of Woldemariam and Chandravanshi** (**2011**). These authors found copper contents ranging from 0.5 to 0.15 mg/L in samples of wines sold on the Ethiopian market.

Iron is essential for proteins to maintain their structures. It is involved in oxidation-reduction reactions within the cell. Indeed, this element is essential for electron displacement such as oxygen transport by red blood cells (**Bothwell et al., 1964**) and reactions including oxygen such as the sterols or unsaturated lipids production (**Kaplan et al., 2006**). Iron is generally present in two states in the media, the ferrous state (Fe2+) and the ferric state (Fe3+). Ferrous iron (Fe2+) is usable by the cell, while ferric iron is inaccessible to yeast because it is present in the form of salts or bound to organic molecules (**Stehlik-Tomas et al., 2003**). There are no recommended iron standards for alcoholic beverages (**Bothwell et al., 1964**). However, the level of iron in alcoholic beverages is strongly affected by utensils and ingredients such as the type of water, barrels (traditional stills) and other metallic materials involved in the manufacturing process (**Daniel et al., 2011**). Thus, the iron concentration found in improved *koutoukou* samples is below the limit of iron allowed in drinking water which is 0.2 mg/L defined by the European Union (**EU, 1998**). These results are below the values reported by **Salako et *al.*** (**2016**). These authors found iron levels between 1.093 and 2.455 mg /L in alcoholic beverages imported into Nigeria (Red bull, Heineken,...).

Zinc plays essential role as an enzyme cofactor and contributes to structural stability of many proteins (**Tosun and Ergun, 2007**). This ion increases cell viability, ethanol production, yeast growth rate, ergosterol and trehalose production, which are stress protective molecules (**Chandrasena and Walker, 1997; Stehlik-Tomas et al., 2004**). Zinc is important in the human system. It has several functions in the human body: maintenance of good vision and curative injuries, prostaglandin production, bone mineralization, fetal growth, sperm production, homeostasis, protein synthesis, and cell activation (**Sherren, 2012**). However, excess zinc leads to an overall decrease in fermentation activity and yeast growth (**StehlikTomas et al., 2004**), becomes highly toxic and constitutes a health problem for humans (**Arnanda et al., 2008**). Thus, the results of analyses of the improved kutukou are below the levels reported by **Udota et *al.*** (**2011**). These authors reported values between 0.33 and 5.00 mg /L in samples of locally manufactured "ufofop" gin in Nigeria. This mineral could enter the product through contact with metallic material containing zinc or treatments with synthetic fungicides containing zinc salts.

Nickel is one of heavy metals generally present in trace form in the environment. This limit concentration in drinking water is 0.07 mg/L (**WHO, 2011**). High and frequent consumption of nickel-containing beverages over a long period of time could cause diseases that affect the kidney, bones, thyroid glands (**Salako et al., 2016**). The role of nickel in the human body is not fully defined (**Landre-lyanda et al**., **2012**). Thus, the results of improved *koutoukou* samples are below the nickel standard set at 0.07 mg / L in drinking water by the World Health Organization (WHO) in 2011.

Potassium plays essential role in many vital cellular functions: osmotic cell regulation, ion charge balance, ion regulation and transport, and phosphorus assimilation (Tosun and Ergun, 2007). Potassium allows the yeast to reject sodium outside the cell. Indeed, even at low concentrations, sodium causes competitive inhibition of potassium assimilation, resulting in an overall loss of cellular activity (**Garcia et al., 1997**). Optimal potassium concentrations range from 80 to 7900 ppm (**Jacques et al., 2003**). The results of the *koutoukou* samples analyzed are lower than the values reported by **Woldemariam and Chandravanshi** (**2011**). The latter found potassium (K) levels ranging from 694 to 766 mg / L in Ethiopian wines.

Manganese, due to its chemical properties close to magnesium, competes with the latter in the role of enzymatic cofactor (**Blackwell et al., 1997**). Manganese plays an essential role in the proper functioning of the body. It is involved in oxidative phosphorylation, metabolism of cholesterol, mucopolysaccharide, and in the activation of some enzymes (**Prashanth et al., 2015**). Optimal manganese concentrations are between 0.06 and 0.12 ppm (**Stehlik-Tomas et al., 2004**). The results of the improved *koutoukou* samples are in line with the work of **Iweala et *al.*** (**2014**). These authors reported no traces of manganese in samples of traditional herbal alcoholic beverages (Agbo Jedi Jedi) in Ota State, Nigeria.

Lead is present in the environment. It is emitted by anthropogenic activities such as fossil burning, paint production, battery production, etc. (**Izah et al 2016**). According to Quebec Alcohol Society (SAQ), the lead concentration limit for spirits, liqueurs and brandies is 0.2 mg / L. Therefore, the results of improved *koutoukou* samples are below the values reported by **Koffi and col** (**2017**). These authors showed lead concentrations ranging from 0.16 to 0.38 mg / L in the traditional *koutoukou* samples from palm wine and from sugar cane.

Cadmium is heavy metal toxic to human tissues even at low concentrations. This mineral is naturally present in the environment and in several industrial products (**Ubuoh, 2013**). The maximum concentration of cadmium allowed in alcoholic beverages is 0.05 mg/L (**OIV, 2012**). Thus, the results of the improved *koutoukou* samples are below the values found by **Ubuoh** (**2013**). This author found cadmium contents between 0.08 and 0.15 mg / L in samples of beer cans imported (Turborg, Guiness,...) into Nigeria.

Tasting is art of carefully tasting a product in order to appreciate its quality. It is used for both food and alcoholic beverages (brandies) (**Martinez et al., 1991**). According to **Leglise** (**1976**), the terms used in the field of alcoholic beverages were imaginary and did not allow the organoleptic characteristics of product to be described precisely and objectively. Nevertheless, **Koster's** (**1987**) work has allowed a reorientation of tasting tests that has made it a real "scientific instrument" based on humans. However, according to **Siegrist** (**1988**), the choice of descriptors for brandies can be linked to "false tastes" and "possible defects" that may appear as a result of poor technology or the use of defective raw materials. Thus; the results of our work show that the improved *koutoukou* has a "less full-bodied" taste, a "colourless" and "odourless" appearance that is characteristic. These results are close to the parameters reported by the work of **Martinez and col**. (**1991**). These authors found descriptors such as "pleasant taste", free of "acidity", "astringency" and "bitterness" in samples of commercial liqueurs in Spain making its liqueurs into quality drinks. The removal of the head and tail fractions during distillation avoids the pungency and oxidation of these drinks considered as possible defects.

5. Conclusion

The application of Good Hygiene and Manufacturing Practices (GHP/GMP) in *koutoukou* production has improved this drink. This improvement has been achieved by changing the rudimentary equipment and modern equipment such as the stainless steel still equipped with thermometer and other measuring devices and by GMP techniques such as the application of ratio fermentation time and yield, the stability of distillation temperature at 79°C and the monitoring fermentation time from the first drops collected from the distillate.

Thus, 27.5% of improved *koutoukou* was produced in 140 min from 200L of bandji fermented at room temperature for ten (10) days. In general, the improved *koutoukou* produced contains 50% vol., a less acidic pH, methanol levels below the recommanded threshold, higher alcohols and almost non-existent heavy metals. The analysis of all these parameters has contributed to a healthy product for the consumer. Thus, the descriptive test revealed that this drink is less full-bodied, colourless and has no aromatic odour. It could therefore be used as a maceration drink to produce flavoured liqueurs.

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