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Physicochemical composition of some new craft beers consumed in Maroua town from Far North region of Cameroon

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Abstract. *Diguir M, Laya A, Wangso H, Bayang JP, Koubala BB. 2021. Physicochemical composition of some new craft beers consumed in Maroua town from Far North region of Cameroon. Asian J Nat Prod Biochem 19: 70-80.* The work aimed to investigate the physicochemical composition of various craft beers (CB) and their distillates produced in Maroua town. The beers named *"Bil-Bil", "Cochette"* and *"Furdu"* were collected both morning and evening time. Dry matter, pH, titratable acid, total dissolved solids, proteins, sugars, carbohydrates, amino acids and alcohol content were evaluated. The results showed that local beers had a pH ranged from 4.06 to 4.22, 4.15 to 3.84 and 3.53 to 3.37 for "*Furdu*", "*Cochette*" and "*Bil-bil*", respectively. The alcohol varied between 5.40 and 6.92%, 1.08 and 5.10%, 1.73 and 2.88 for "*Furdu*", "*Cochette*" and "*Bil-bil*", respectively. The sugars ranged from 11.85 to 19.05 mg/mL for "*Furdu*", from 2.20 to 9.46 mg/mL for "*Cochette*" and from 9.92 to 19.78 mg/mL for "*Bil-bil*". For amino acids, the values varied from 3.40 to 7.37 mg /mL for "*Furdu*", 3.98 to 6.01 mg / mL for "*Cochette*" and 2.95 to 3.24 mg/mL for "*Bil-Bil*". Regarding protein, the values ranged from 0.80 to 0.85 mg/mL for these three CB. The distillates of CB collected evening showed high alcohol in fraction 1. Thus, these CB analysed can be promoted for alternative beer in Maroua town. Furthermore, the unsold CB can be distilled into ethanol.

Keywords: Alcohol, craft beers, distillate, Maroua town, physicochemical

INTRODUCTION

In Africa, cereals are the most widely cultivated and consumed as a staple food in many African households. These cereals are also used to prepare many fermented by-products. A local transformation unit of these cereals has been found in many areas of Cameroon, Republic of Central Africa and Chad (Djanan et al. 2002). The enterprises are mostly performed by women who recruit at least three workers (Maoura et al. 2002). In Cameroon, especially in the Northern part of Cameroon, various cereals such as sorghum, maize, yellow millet, *S35*, rice and fonio are processed into alcoholic and non-alcoholic beverages called locally beer or ancestor drink. These local beers produced are well appreciated by numerous people of Cameroon and other countries because these are a good source of nutrients such amino acids, carbohydrates, vitamins, minerals, phenolics, etc. (Maoura et al. 1999; Bamforth 2002; Lyumugabe et al. 2012; Cirimina et al. 2018). Because of their probiotics these local beers as known as therapeutic agents. The local beer is a beverage of significant historical and cultural importance. It is gaining popularity of craft beer and is of growing interest in several countries. It is also providing alternatives to mainstream beer production (Einfalt 2021). To date, craft beer is one of the fastest-growing alcoholic beverage industries throughout the world (Gómez-Corona et al. 2016).

These local beers are known as *Bil-Bil Furdu* and *Cochette,*the most widely produced and consumed. According to the tribes, these beers have different name, "*Bil-Bil*" beer is known as "Muzum" in Guiziga; "Ouzomm" in Mada, "Zoum" in Mafa; "Balda" in Guidar; "Himi" in Moudang; "Yii" in Toupouri; "Tcheu" in Kapsiki "Mbolo" in Fali; "Mgba" in Laka; "Amgba" in Baya; "Do'di" in Dourou and "Coumouille" in Kera. However, "*Furdu*" beer is known as "Bazdltah" in Mada, "Pram" or "Bazla Babara" in Guiziga, "Mpedli" in Kapsiki. The "*Cochette*" beer is known as "*Cochette*" in almost all tribes but differs by the pronunciation except the name in Mada tribe, "*Mohosso*". The local name of *Bil-Bil* vary from one country to another as *Bili-Bili* in Cameroon and Chad, *Dolo* in Burkina-Faso, Mali and Senegal; *Tchapalo* in Ivory Coast, *Tchoukoutou* in Benin, *Pito* in Ghana, and *Impéké* in Burundi (Odunfa 1985; N'da et al. 1996; Kayodé et al. 2005). While, *Furdu* and *Cochette* are new local beers which are not documented in the literature. The energy is provided at 70% by alcohol and 30% by carbohydrates (Lariven and Rigal 2017). According to Djanan et al. (2002), one litre of *Bil-Bil* contributes significantly to the recovery of iron magnesium, manganese, phosphorus and calcium dietary allowance per day for an adult. Various studies of *Bil-Bil* beer are investigated, however, these parameters are absent for *Furdu* and *Cochette* beers. Setta et al. (2020) reported that traditional African fermented cereal-based beverages are potential probiotic carriers because of the probiotic *Lactobacillus* spp. and yeasts which are involved in the fermentation of such products, and can be used as probiotic health benefits to the majority of African populations.

The main concerns of all the local beers is their consumption for one to two days and the next day, these beers become more acidic due to the breakdown of ethanol into acetic acid (oxidation reactions). Finally, the unsold local beers are usually thrown. These unsold beers can be used in the production of quality by-products in order to have added value and solve pollution problem.

Thus, the present study was aimed to determine the physicochemical composition and distil some craft beers named *Bil-Bil*, *Furdu* and *Cochette* in order to valorize the local beers mostly consumed in Maroua town of Cameroon.

MATERIALS AND METHODS

Survey

The survey was conducted in order to find out more about the micro-enterprises in charge of the production of local beer in the town of Maroua, region of the Far North of Cameroon. A preliminary survey was carried out in all streets of the city of Maroua. We identified four streets where they produced mostly local beers such as Pitoare, Pont-vert, Ouro-tchede and Palar. During this survey, several types of local beers are consumed in the town of Maroua. However, on the basis of the most consumed in the city, we have identified three (03) types of local beers: *Furdu*, *Cochette* and *Bil-Bil*. After this first step, we conducted a survey using direct interviews with the producers and consumers of these beers. We interviewed 150 producers and 200 consumers of *Bil-Bil* beer, 20 producers and 35 consumers of *Frudu* beer and 20 producers and 40 consumers of *Cochette* beer.

Samples

Samples of *Cochette*, *Furdu* and *Bil-Bil* beers were purchased through the various producers located in four streets (Pitoare, Pont-vert, Ouro-tchede and Palar). The collected samples in the morning (start of the sale) and in the evening (end of the sale) from the suppliers and were introduced in suitable and sterile container and then labelled (Figure 1). Samples were transported to the Biochemistry Laboratory and Biological Chemistry of the University of Maroua (LabBBC). All samples were kept at-10°C before physico-chemical analyses and distillation.

Processing flow charity of different beers preparation

All the craft beers were produced by using different cereals shown in Figure 2.

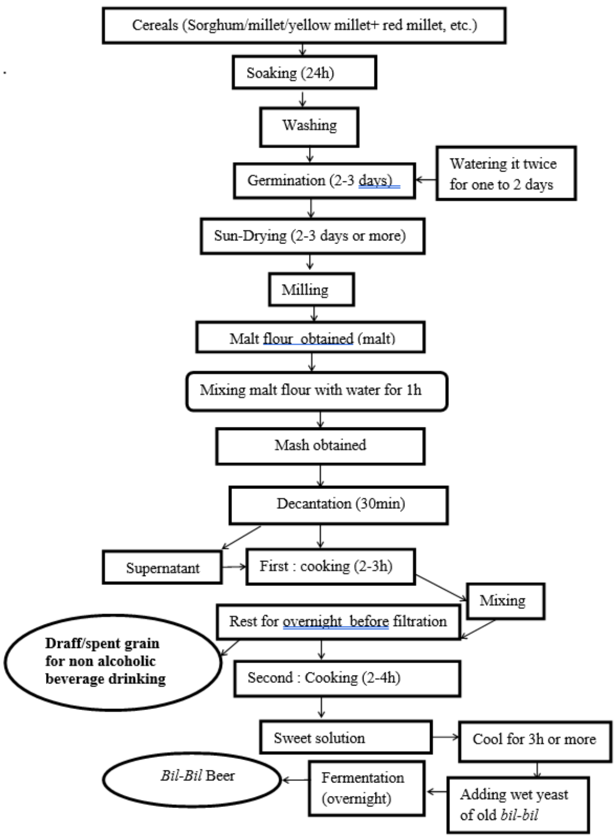
Shortly, the cereal was soaked for 24h and washed prior for germination (2-3days). The germinated cereal was then sun-dried before milling and the malt flour was mixed with water and the mash mixture was decanted for 30min. The supernatant was heated for 2-3hr and its allowed to rest for overnight. Then, the second heating was done for 2-4 to obtain the sweet wort which was cooled for 3hr or more. Finally, the wet yeast was added and fermented overnight to obtain *bil-bil beer*. Figure 2.A shows the *Bil-Bil* beer preparation.

In brief, 7.0 kg of cereal was soaked for 1-2 days before sundering for 3hrs and milling in order to obtain flour (malt). Then, mixed with water before boiling at 95°C and the mash obtained was cooled at room temperature for 3hr before adding the wet yeast. The mixture was fermented for 10-12hrs and then filtered throughout the traditional filter tissue. The filtrate was poured in jar and named *Cochette beer*. The Figure 2.B shows different steps to produce *Cochette* beer.

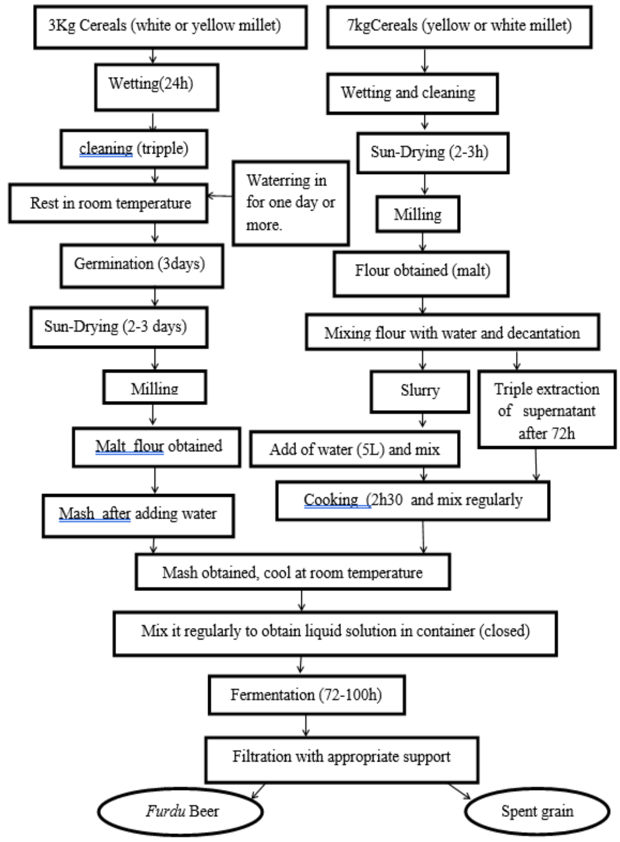
Briefly, 3-7kg of cereal was wetted, cleaned or watered and germinated for three days and sun-dried before milling and the malt flour obtained was mixed with water, heated (95°C) and the mash obtained was cooled at room temperature for 4hr. Then, the mash was fermented for 72-100hr and then filtered throughout the traditional filter mesh. The product obtained was poured in jar and the *furdu beer* was ready for drinking. Figure 2.C is showing the summary methodology to produce *Frudu* beer.

A B C

Figure 1. Sample of different craft beers mostly produced and consumed in Maroua town, Cameroon. A. Bil-bil Beer, B. Cochette Beer, C. Furdu Beer

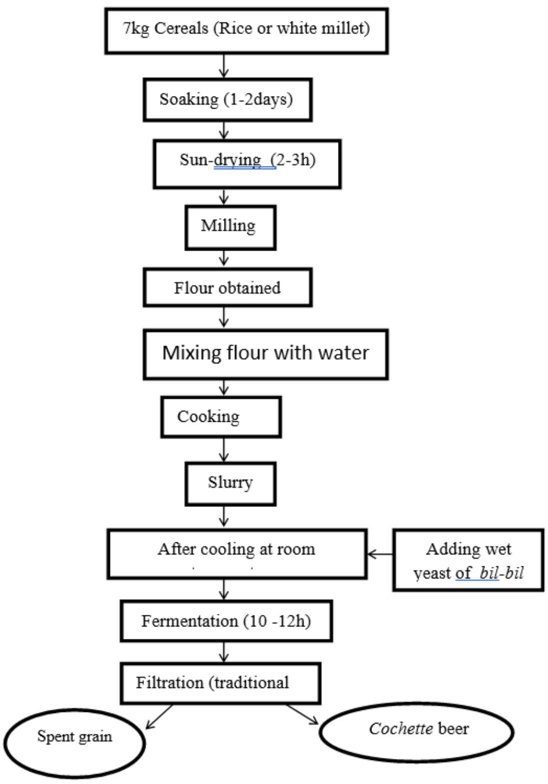


A. Bil-bil beer



C. *Frudu* beer

Figure 2. Flow charity preparation of beers in Maroua, Cameroon. A. Bil-bil Beer, B. Cochette Beer, C. Furdu Beer



B. Cochette beer

Reagents and chemicals

Bovine Serum Albumin (BSA), Ninhydrin, Alanine, glucose, and 3,5-Dinitrosalicyclic Acid (DNSA). Sulfuric acid, Ethanol, Chloridric acid Acetic acid, Nitrochromicacid, Iodic of potassium blue of coomassie, Sodium of thiosulfate, and all other solvents were obtained from Sigma-Aldrich (Iowa, USA) and Fisher commercial source (New Jersey, USA).

Kinetics of distillation

Sample of beer was collected both in the morning and in the evening from different streets (Pitoare, Pont vert, Ouro tchede and Palar) of Maroua town. The kinetics of distillation was evaluated as affected by the time and temperature. 400 mL of sample was introduced in 500mL rotavapor flash and it was allowed to heat until boiling and at the end two fractions of distillates were collected for analyses.

Physicochemical analyses

Total dissolved solids (TDS), Dry matter content (DM), pH

TDS was determined in triplicate by using TDS instrument and the values were expressed in ppm, however, dry matter content and pH were evaluated as described by AOAC (2000) method.

Titratable acidity

Titratable acidity was determined as described by Ranganna (1979). The values were expressed in milligram equivalent oxalic acid per 100 grams of sample beer.

Evaluation of reducing sugars content

Reducing sugars content was determined using the dinitrosalicylic acid as described by Miller (1972). The results were expressed in mg per mL of sample beer.

Evaluation of total carbohydrates content

Total carbohydrates content was determined as described by Dubois et al. (1956). The results were expressed in mg per mL of sample beer.

Determination of total amino acids, proteins and alcohol content

Total amino acids content was determined using ninhydrin (1 %) reagent as described by Michel and Hannequart (1968). The results were expressed in mg of amino acids per mL of sample beer.

Total soluble proteins content was determined using Bradford (1976) method. The results were expressed in mg of BSA per mL of beer sample.

The content of alcohol in sample beer was determined as described by Caputi et al. (1968).

Statistical analyses

SPSS 20.0 Statistical Package for Windows (SPSS Inc., Chicago, IL, USA) was used to perform all statistical analysis. Experiments were done in triplicate and one-way analysis of variance (ANOVA) was performed. Tukey's (HSD) test was used to determine any significant difference between different beers and the significance was accepted at level $p < 0.05$. The results were expressed as means ± standard deviation.

RESULTS AND DISCUSSION

Sociodemographic profile of producers and consumers of local beers

The results of survey revealed that women aged between 20 and 40 represent the majority of the brewers (Table 1). They are predominantly catholic Christians, followed by Protestants and a few animists for all beers. Most of women are married (≥ 60%), followed by widowed, single or divorced. Their education level varies from primary to secondary school and illiterate as well (Table 1). In Moundou, Tchad, similar results were reported by Djitod (2002) on *Bil-bil* beer who found that the majority of producers are catholic Christians (87%), aged between 26 and 35 years. Also, they are married women (65%), divorced (15%), widows (13%) and single (7%). The producers of local beers in Maroua town were mainly women suggested that men are only the consumers that is consistent with the Northern tradition of Cameroon.

Results also showed that the youngest people aged between 20 and 40 years (75%) are mainly consume *Bil-Bil* beer (Table 1). Also, it found that *furdu* is more consumed by Protestants (57.7%) than others. However, *Bil-bil* (52%) and *Cochette* (50%) are mostly consumed by catholic Christian (Table 1). Then, other Christians such as Pentecostist, Adventist, Presbyterians and Muslims are consumed all types of beers. The consumers are predominantly married (≥ 50%) for all the beers than widowed, single and divorced. They have a level of education mostly between secondary and higher education and a few proportion of primary and illiterate (Table 1).

Furdu and *Cochette* beers are mostly consumed by people with a primary level of education. Pupils (32%) and students (27.5%) are the consumers of *Bil-Bil* beer. *Furdu* and *Cochette* are mostly consumed by the elder person aged between 40 and 60 years with a percentage of 63% and 45%, respectively, followed by the youngest people who aged between 20 and 39 years (Table 1). Also, according to our survey, low-income men and married people, unemployed and rich people are consumed the local beers in different streets of Maroua town every day from the morning (5 a.m.) to the evening (8 p.m.). The consumption of all these craft beers may be due to their traditional value, interested in tasting (Einfalt 2021), therapeutic value and lower cost than the commercial beers (modern beer). Fact, certain untypical flavors in craft beers even have the potential of being perceived by the consumer as having higher quality compared to commercial beer (Ascher 2012).

Different cereals used for production of local beers in Maroua town

The results of survey revealed that various cereals are used to produce local beers *(Bil-Bil, Furdu* and *Cochette)* in Maroua town. Cereals mostly used are maize, rice, fonio and sorghum. Rice and white sorghum were the main cereal for *Cochette* (40%) and for *Furdu* beer, it was white sorghum (85%) (Figure 3). While, *Bil-Bil* was the mixture or all of these different cereals. The mixture of red and yellow sorghum (46%) followed by red and white sorghum (38%), red sorghum, S35 and red-yellow sorghum and S_{35} were the most used by *Bil-Bil* producers, respectively (Figure 3). The present results are consistent with the results found by Charles et al. (2018), who reported that in the North Cameroon, red sorghum ("djagari") was the main cereal for the production of *Bil-Bil* beer. The results of the survey regarding producers show that *Bil-Bil* beer which produced with the mixture of red sorghum exhibited a better drinking though beer of red sorghum was absent in Maroua town, while, yellow and withe sorghum were the best cereal for production of *Bil-Bil* beer (Figure 3).

Therefore, many factors can affect the quality of these local beers such as quality of heat during preparation (33%), type and germination of grain (18%) and other factors (Figure 4). These are consistent with the results reported by Olaniran et al. (2017) who stated that the quality of the final product (beer) is influenced by several variables, such as the quality of the raw material, type of malting, the applied preparation method of the wort, type of hops, type and quality of yeast, fermentation time, maturation, and pasteurization and filtration, among others.

Table 1. Results of survey (%) of the local beers collected from consumers and producers from different street of Maroua town. Values are rated answer concerning the consumption or production of *Bil-Bil*, *Cochette* or *Furdu* beers.

Parameter		*Bil-Bil*		*Cochette*		*Furdu*	
		Consumers	Producers	Consumers	Producers	Consumers	Producers
School level	Primary	22.5	39	50	60	57.1	50
	Secondary	32	41	20	20	22.9	20
	Higher	27.5	0	12.5	0	10	0
	Illiterate	10	20	17.5	20	10	30
Matrimonial status	Married	50	63	60	75	69	50
	Single	40	14	10	15	11	20
	Widow	4	20	17.5	10	20	30
	Divorced	6	3	12.5	0	0	0
Religion	Animist	4	7	12.5	15	22.9	20
	Protestant	33	13	30	5	57.1	0
	Presbyterian	1.5	0	0	0	0	0
	Muslim	3	0	0	0	0	0
	Pentecost	6.5	0	0	0	0	0
	Catholic	52	80	50	80	20	80
	Adventist	0	0	7.5	0	22.9	0
Age	[0-20[	10	3	20	5	8.5	10
	[20-40[	75	77	35	50	28.5	60
	[40-60[	15	20	45	45	63	30

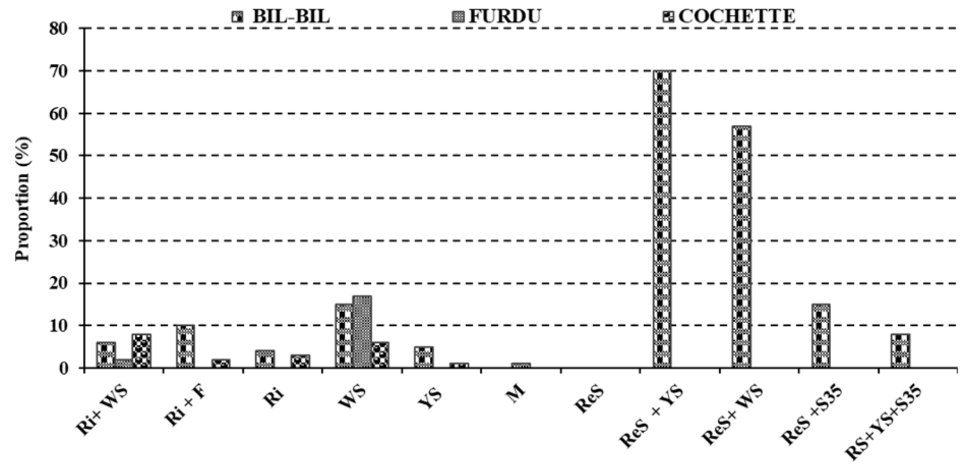


Figure 3. Proportion of the various combination of cereals used according to producers for craft brewery. Ri + WS = Rice + White *Sorghum*; Ri + F = Rice + *Fonio*; Ri = Rice, WS = White *Sorghum*, YS = Yellow *Sorghum*; M = Maize; RS = Red *Sorghum*; RS+YS = Red *Sorghum* + Yellow *Sorghum*; ReS + WS = Red *Sorghum* + White *Sorghum*; ReS+YS+S35 = Red *Sorghum* + Yellow *Sorghum* + S35.

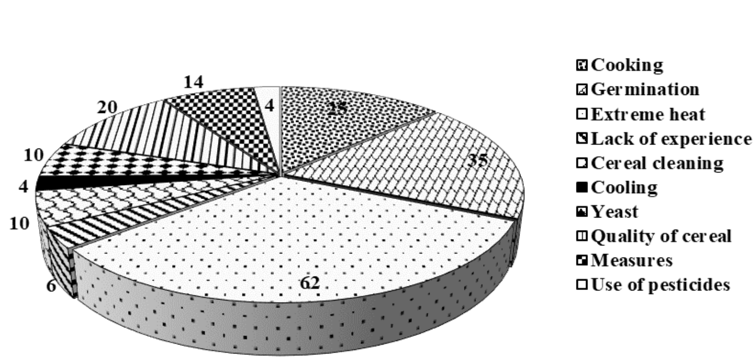


Figure 4. Factors influencing the craft brewery.

The influence of time and temperature on the volume of distillate

Figure 5.A-B showed the evolution of distillation of beers collected both morning and evening. The curve (Figure 5.A) showed many stages during the distillation. The curve showed that in the start time, all craft beers had a significant amount of alcohol. According to Anderson (2012) in a binary, tertiary or quaternary non-azeotropic mixture, the most volatile constituents are those whose boiling point is the lowest at constant pressure, which qualified as light at 1atm, and the least volatile constituent is the one with the highest boiling temperature at constant pressure qualified as heavy at 1atm. From the point of boiling temperature of methanol (64°C), ethanol (78°C), propan-2-ol (82°C), propana-1-ol (97°C) of water (100°C) and other products resulting from oxidation such as acetone (56°C). Samples CPiM, BPaM, CPvM, FHoM and BPvM for those collected in the morning (Figure 4.A) and BPvE, FHoE, CPvE, and BPaE for those of the evening (Figure 5.B) and specially at different time intervals lets us believe in their presence. Other samples FPvM (71°C) and BPiM (72°C) for those from the morning and FPvE (75°C) and BPiE (73°C) for those from the evening and their distillation time at a value of maximum boiling temperature strictly lower than that of ethanol is what also leads us to believe in an abundance of methanol, acetone and others.

These differences are due to the raw materials used, to the brewing methodology and the time and period of inoculation of the yeasts to obtain a perfect fermentation of alcohol. Fact, at temperature values strictly below and above the boiling point of ethanol there is no more ethanol to distillate in the local beer but many alcohols and other mixed products. Higher alcohols (2-methyl-1-propanol, 2-methyl-1-butanol and 3-methyl-1-butanol) derived from the catabolism of amino acids and sugars via the Ehrlich pathway are common in fermented and distilled beverages (Hazelwood et al. 2008; Nascimento et al. 2008). Gas chromatography (GC-FID) and GC-MS method for the detection and quantification of these different alcohols and other compounds in mixture has not been carried out in the present study, so we believe that there are many other compounds may be present. Recent works show many volatile compounds namely aldehydes, esters, alcohols and acids have been identified by using different chromatography method in cassava spirit and traditional sorghum beer (Attchelouwa et al. 2020; Coelho et al. 2020) which derived from the fermentative metabolism of yeast and can be further concentrated during the distillation.

Figure 5.C-D showed the evolution of the volume of distillate of various beers collected at different times (morning and evening). We noticed that the increase in volume at different times and temperatures varied in respect with the types of beers. All samples of beers from the morning to the evening had maximum boiling temperature with values greater than or equal to 78°C (T ≥78°C) showed the highest value in terms of volume, 15.9 mL (BPvM), 15.8mL (CPiE) for low value and 20.85mL (CPiM), 21.3mL (BPvE) for high values. Almost ethanol content of sample beer was collected in different fractions, with distillation efficiency close to 100% (Coelho et al. 2020). On the other hand, we did not collect all the ethanol which was found in some samples, those whose boiling point was strictly below 78°C. We think it might take a longer time than we defined or at least there was not enough ethanol but other alcohols in those initial samples of beers.

Therefore, we obtained the smallest values in terms of volume with the value of 13.65 mL (BPiM) and 15.8 mL (FPvM) for the morning sample (Figure 4.C) and 15.8 mL (CPiE), 16.84 mL (BPiE) and 18.55 mL (FPvE) for those of the evening (Figure 4.D).

In general, the volume of distillate from the evening was significantly greater than those from the morning. This variation in volume between the samples collected in the morning and those from the evening may be due to the influence of the brewing technology, the raw material used (Humia et al. 2019) and the quality of yeast (Einfalt 2021) as well as time of maturation which have an effect on the fermentation of the different beers. This difference proves sufficiently that regardless of the temperature values greater than or equal to, less than or equal to the boiling temperature of ethanol $50 \leq Tb \leq 90$, we do not only collect ethanol and other alcohols mixed but also a significant amount of water. In short, at high temperature of around 100 °C, the distillate to be recovered consist of maximum water content and very low alcohol content.

Variation of some physicochemical characteristics in local beers

The physicochemical characteristics of *Bil-bil*, *Furdu* and *Cochette* are showed in Table 2. Statistical analysis showed a significant ($p<0.05$) difference among samples (Table 2). The results showed that TDS of all the investigated beers vary among them, however, *Furdu* beer has the highest TDS value (1688-1978 ppm), while the lowest was showed by *Cochette* (513-1409 ppm). The present results are in agreement with those reported by Coulibaly et al. (2020), who found in traditional sorghum beer (Tchapalo) in Ivory Coast a value of 15.60 °B which was variable than our values. This difference must be linked to the methodology using and the type of cereal to produce local beer. While, dry matter content of the beers varied between 4.24 to 6.98% *(Bil-Bil),* 2.83 to 6.96 % *(Furdu),* and 5.17 to 8.06 % *(Cochette)*. Compared to the result obtained by Amane et al. (2005), the local beers investigated had a similar dry matter (7.87 %) of Sorghum *Tchapalo* produced in Ivory Coast. Similar results were also obtained by Chevauss-Agnes et al. (1976) who found that *Ambga* beer had 7.2 % of dry matter. These differences may be due to practices of production and the variety of cereals used in the processing of these beers.

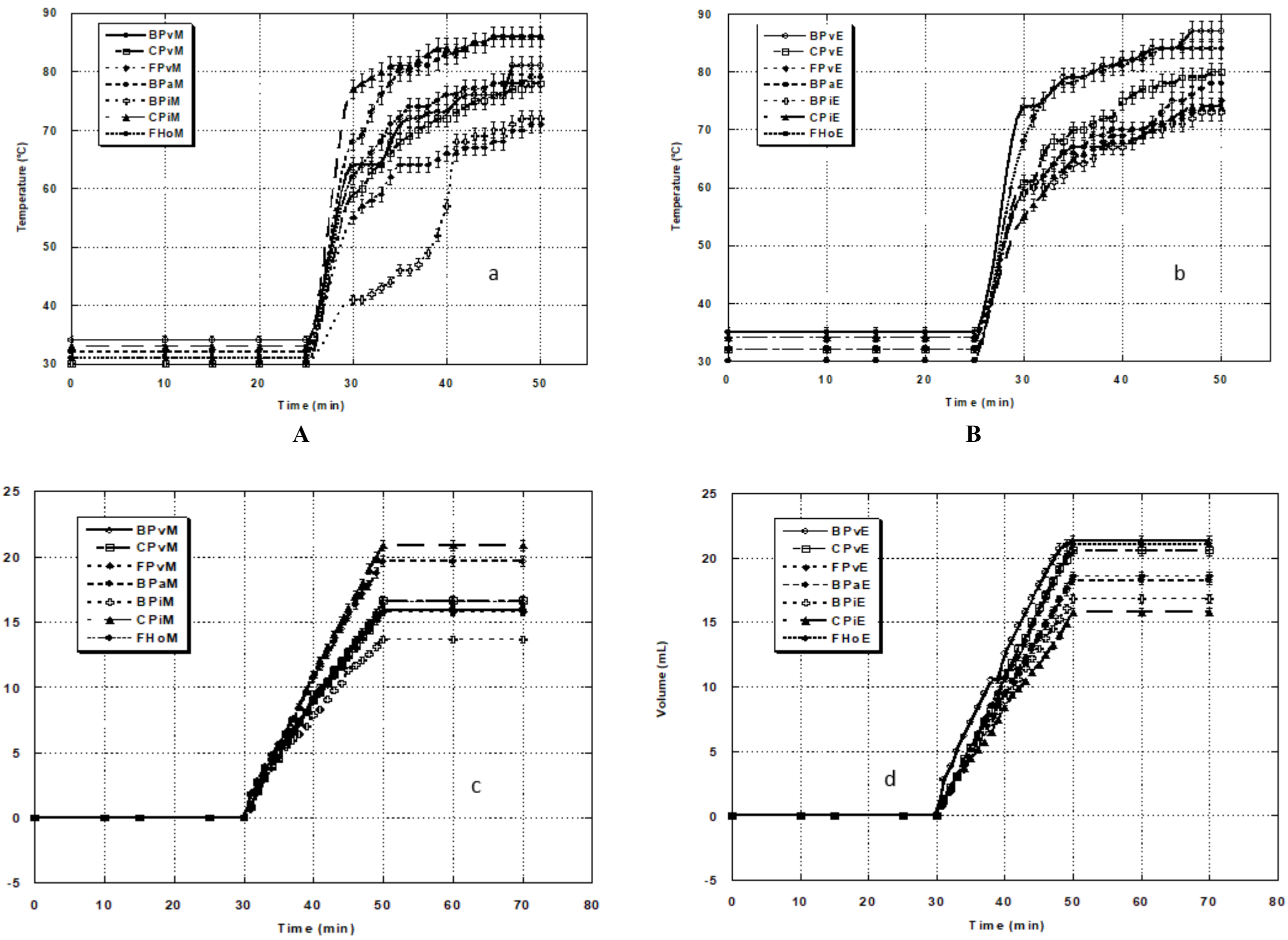


Figure 5. The distillation temperature and distillate volume according to the time of the local beers collected. A-B. Evolution of the distillation temperature according to the time of local beers collected (A. collected morning, B. collected evening). C-D. Increase in distillate volume according to the time of the local beers collected (C. collected morning, D. collected evening). Note: FHo: *Furdu* beer collected in *Ouro tchédé* street; FPv: Furdu beer collected in *Pont vert* street, CPv: *Cochette* beer collected in *Pont vert* street, CPi: *Cochette* beer collected in *Pitoaré* street, BPv: *Bil-Bil* beer collected in *Pont vert* street, BPa: *Bil-Bil* beer collected in *Palar* street, BPi: *Bil-Bil* beer collected in *Pitoaré* street. Those beers were collected in the evening (E).

The pH value of different beers varied among them as shown in Table 2. It varied from 3.53 to 3.37 *(Bil-Bil),* 3.84 to 4.15 for "Cochette" and 4.06 to 4.22 for furdu beer. Compared to the values obtained by Roger et al. (2013) in Amgba beer (pH 2.5), *Tchapalo* (pH 3.4) by Aka et al. (2008), *Dolo* (pH 3.5) by Abdoul-latif et al. (2013), *Pito* (pH 3.66) by Fadahunsi et al. (2013) and *Burukutu* (pH 3.94) by Eze et al. (2011) and sorghum safari (Tchapalo) (pH 3.5 to 4.5) by Coulibaly et al. (2020), all produced in Cameroon, Ivory Coast, Burkina-Faso, Nigeria and Ghana, respectively, our investigated beers had similar values. Also, it showed that all our local beers had similar pH value both in the morning and in the evening, which is in accordance with those reported by Maoura et al. (2006) in Chad, where the pH value of *Bil-Bil* had not changed during the alcoholic fermented process. However, the results revealed that all the sample beers had acidic pH range which can explained the fact that acidic medium is one of the main condition factors for the developing of yeast without any modification of pH (Maoura et al. 2006). The pH values of our local beers were within the desirable parameters, generally between 3.8 and 4.7, protecting the product against pathogens as reported by Suzuki et al. (2006). The difference in pH value may be attributed to the processing methods, quality of raw material and measure or quantification (Coulibaly et al. 2011). All values of pH of our different local beers produced in Maroua town is within the value of CODEX (2005), which reported that beer with a pH lower than 4.5 could be the good quality for the consumers.

The titratable acid of the local beers varied also significantly among samples ($p< 0.05$) (Table 2). *Bil-Bil* had the highest value (4.89-6.25 mg/mL), however *Frudu* had a value of 3.04-4.58 mg/mL, while *Cochette* had the lowest value (2.31-3.40 mg/mL). The values of titratable acid found in *Bil-Bil* beer are lower to the value (0.06mg/mL) reported by Coulibaly et al. (2020) in sorghum safari (Tchapalo). Similarly, these values are lower than those reported by Ourega et al. (2015), who found that plantain beer had a titratable acid content ranged from 0.08 to 0.9.3 mg/mL suggesting that the raw material had influence on the beers.

For the alcohol content, results summarized in Table 2 revealed that the alcohol value varied significantly among beers ($P < 0.05$). The sample of *Furdu* beer had the contents varied between 5.40 and 6.92 %, while it folds from 1.08 to 5.10 % for *Cochette* and between 1.73 and 2.88 % for *Bil-Bil.* The *frudu* beer had alcoholic value higher than *Cochette* and *Bil-Bil* suggesting high flavour and aroma compounds (Einfalt 2021). However, the alcohol content in *Bil-Bil* beer was significantly higher than the value reported by Muyanja et al. (2010) on *Pito* (3.09 %), however lower than *Tchapalo* (5.22 %) processing with sorghum in Kenya, Nigeria and Ivory Coast, respectively. The rice and white millet used for the processing of *Furdu* (6.16%) and *Cochette* (3.09 %) had higher alcohol content than *Bil-Bil* (Table 2). These differences observed in terms of alcohol content are due to the types or quality of yeasts used to ferment. These are consistent with the results of Einfalt (2021) who found that the alcohol content varied significantly with the type of yeast used for beer fermentation. However, the alcohol levels obtained in our different beers are obviously within the range of the French legal classification of types of beers ranging from table beer to special beers brochures of brewers of France (Hencké 2000).

Reducing sugars content of *Furdu* varied between 11.85 and 19.05 mg/mL, while it fold from 2.20 to 9.46 mg/mL for *Cochette* and 9.92 to 19.78 mg/mL for *Bil-Bil* (Table 3). The present results showed that *Bil-Bil* beers had higher content of reducing sugars than *Tchapalo* (0.4 mg/mL) from Ivory Coast (Amane et al. 2005). This difference may be due to the reducing sugar content of sorghum used to process the local beers. Also, the contents of total carbohydrates varied among these beers (Table 3). The carbohydrates content in *Furdu* beer fold from 16.05 to 46.35 mg/mL, while in *Cochette* beer, it varied between 15.39 mg/mL and 42.53 mg/mL and for *Bil-Bil* the values varied from 12.12 to 168.53 mg/mL. It revealed that Bil-bil beer had lower and higher value of carbohydrates than that obtained in *Furdu* and *Cochette,* respectively. Cortacero-Ramírez et al. (2003) stated that beer should contain between 3.3 to 4.4 g/100 of carbohydrates. However, value is higher than that reported by Chevassus-Agnes et al. (1976) in *Ambga* and *Affouk* beers (19 mg/mL) consumed in the North region of Cameroon. The differences in carbohydrate values are linked to the variety of cereals and their technologies used for processing.

The values of soluble amino acids and total soluble proteins was not found varied significantly ($p > 0.05$) among the samples (Table 3). The soluble amino acids amount of the local beers were followed, *Furdu* had 3.40 to 7.37 mg/mL, *Cochette* contains 3.98 to 6.01 mg/mL, while *Bil-Bil* had 2.95 to 3.24 mg/mL. However, *Furdu* beer had the highest amino acid contents than *Cochette* and *Bil-Bil*. Considering the total proteins, local beers had high values ranged from 0.80 to 0.85 mg/mL which was higher than those obtained in *Kaffir* beer (0.05 mg/mL) (Busson et al. 1970), in *Amgba* (0.07 mg/mL) (Chevassus-Agnes et al. 1976) (Table 3). For Ferreira and Guido (2018), the contents of soluble amino acids determine the quality of beer suggesting the good quality of our sample beer analyzed.

The alcohol contents of distillate fractions from the morning and evening samples showed that the alcohol contents varied significantly ($p < 0.05$) among different samples of beers named FHoE, FPvE, CPiE, BPvE, and BPaE, however there is no significant difference among FHoM, FPvM, CPvM, CPiM, BiPvM and BPiE (Figure 6). The values of alcohol content revealed that the first fraction (F1) of the distillate had higher alcohol content than the second fraction (F2) (Figure 6).

Table 2. Total dissolved solids (TDS), pH, dry matter, titratable acid (TA) and alcohol contents of local beers (*Furdu*, *Cochette*, *Bil-Bil*) collected in the morning and evening from various streets in Maroua town.

Sample	TDS (ppm)	pH	Dry matter (g/100g)	T A (mg/mL)	Alcohol contents (g/100 mL)
FHoM	1771 ± 70^{b}	4.06 ± 0.03^{c}	6.96 ± 0.22^{b}	3.04 ± 0.19^{i}	5.38 ± 0.13^{b}
FHoE	1688 ± 23^{c}	4.06 ± 0.04^{c}	2.83 ± 0.08^{h}	3.80 ± 0.06^{g}	6.92 ± 0.28^{a}
FPvM	1939 ± 28^{a}	4.04 ± 0.02^{d}	6.96 ± 0.22^{b}	4.58 ± 0.32^{e}	5.47 ± 0.26^{b}
FPvE	1978 ± 20^{a}	4.22 ± 0.03^{a}	6.61 ± 0.32^{bc}	4.21 ± 0.06^{f}	5.40 ± 0.15^{b}
CPvM	1409 ± 26^{f}	4.15 ± 0.02^{b}	8.06 ± 0.08^{a}	2.63 ± 0.13^{j}	1.08 ± 0.23^{h}
CPvE	1310 ± 33^{g}	4.13 ± 0.06^{bc}	5.84 ± 0.08^{e}	3.40 ± 0.06^{h}	4.71 ± 0.21^{cd}
CPiM	625 ± 34^{h}	3.84 ± 0.03^{e}	6.09 ± 0.24^{d}	2.72 ± 0.13^{j}	4.31 ± 0.31^{d}
CPiE	513 ± 28^{i}	3.80 ± 0.03^{e}	5.17 ± 0.89^{f}	2.31 ± 0.06^{k}	5.10 ± 0.25^{c}
BPiM	1442 ± 18^{e}	3.46 ± 0.02^{g}	6.98 ± 0.37^{b}	5.07 ± 0.26^{d}	2.55 ± 0.25^{f}
BPiE	1434 ± 11^{ef}	3.45 ± 0.05^{g}	5.42 ± 0.44^{ef}	5.84 ± 0.32^{bc}	2.90 ± 0.23^{e}
BPaM	1495 ± 24^{d}	3.44 ± 0.02^{g}	4.88 ± 0.10^{f}	4.89 ± 0.26^{de}	1.73 ± 0.13^{g}
BPaE	1647 ± 29^{c}	3.53 ± 0.03^{f}	6.31 ± 0.07^{c}	5.66 ± 0.06^{c}	1.82 ± 0.26^{g}
BPiM	1483 ± 34^{de}	3.42 ± 0.04^{gh}	4.24 ± 0.09^{g}	6.25 ± 0.13^{a}	1.92 ± 0.13^{g}
BPiE	1441 ± 11^{ef}	3.37 ± 0.02^{h}	5.95 ± 0.38^{de}	5.93 ± 0.06^{b}	2.88 ± 0.21^{ef}

Values are means ± standard deviation of tree replicates (n= 3). In the same column, values followed by different superscript letters are significantly different ($p < 0.05$). Note: FHo: *Furdu* beer collected in *Ouro tchédé* street; FPv: *Furdu* beer collected in *Pont vert* street; CPv: *Cochette* beer collected in *Pont vert* street; CPi: *Cochette* beer collected in *Pitoaré* street; BPv: *Bil-Bil* beer collected in *Pont vert* street; BPa: *Bil-Bil* beer collected in *Palar* street; BPi: *Bil-Bil* beer collected in *Pitoaré* street. Those beers were collected in the morning (M) or evening (E).

Table 3: Reducing sugars, total amino acids, total carbohydrates, and total proteins of local beers (*Furdu*, *Cochette*, *Bil-Bil*) collected in the morning and evening from various streets in Maroua town. The values are expressed in mg/mL of sample.

Sample	Reducing sugars	Carbohydrates	Total protein	Amino acids
FHoM	16.35 ± 0.45[d]	16.05 ± 0.27[h]	0.80 ± 0.05[b]	4.29 ± 0.19[c]
FHoE	17.33 ± 0.63[c]	37.75 ± 0.99[d]	0.83 ± 0.03[ab]	3.40 ± 0.13[e]
FPvM	11.85 ± 1.02[f]	46.35 ± 1.14[b]	0.84 ± 0.02[a]	6.00 ± 0.16[a]
FPvE	19.05 ± 0.63[a]	44.71 ± 1.50[bc]	0.83 ± 0.02[ab]	7.37 ± 0.15[a]
CPvM	8.30 ± 0.54[h]	35.97 ± 1.17[d]	0.83 ± 0.06[ab]	5.83 ± 0.17[b]
CPvE	9.46 ± 0.37[gh]	42.53 ± 0.63[c]	0.84 ± 0.05[a]	3.98 ± 0.15[d]
CPiM	2.20 ± 0.58[j]	28.34 ± 0.89[e]	0.83 ± 0.04[ab]	6.01 ± 0.07[b]
CPiE	5.56 ± 0.22[i]	15.39 ± 0.55[h]	0.83 ± 0.04[ab]	4.44 ± 0.09[c]
BPvM	13.06 ± 0.65[e]	19.00 ± 0.80[g]	0.81 ± 0.02[b]	3.15 ± 0.17[f]
BPvE	9.92 ± 0.41[g]	12.12 ± 0.69[i]	0.81 ± 0.02[b]	3.03 ± 0.13[gf]
BPaM	17.51 ± 0.84[bc]	18.81 ± 0.43[g]	0.83 ± 0.04[ab]	3.02 ± 0.16[gf]
BPaE	16.32 ± 0.71[d]	168.53 ± 1.52[a]	0.83± 0.02[ab]	3.01 ± 0.04[g]
BPiM	18.02 ± 0.48[b]	24.49 ± 0.79[f]	0.85 ± 0.03[a]	2.95 ± 0.08[g]
BPiE	19.78 ± 0.58[a]	27.80 ± 1.04[e]	0.80 ± 0.02[b]	3.24 ± 0.10[ef]

Values are means ± standard deviation of tree replicates (n= 3). In the same column, values followed by different superscript letters are significantly different ($p < 0.05$). Note: FHo: *Furdu* beer collected in *Ouro tchédé* street; FPv: *Furdu* beer collected in *Pont vert* street; CPv: *Cochette* beer collected in *Pont vert* street; CPi: *Cochette* beer collected in *Pitoaré* street; BPv: *Bil-Bil* beer collected in *Pont vert* street; BPa: *Bil-Bil* beer collected in *Palar* street; BPi: *Bil-Bil* beer collected in *Pitoaré* street. Those beers were collected in the morning (M) or evening (E).

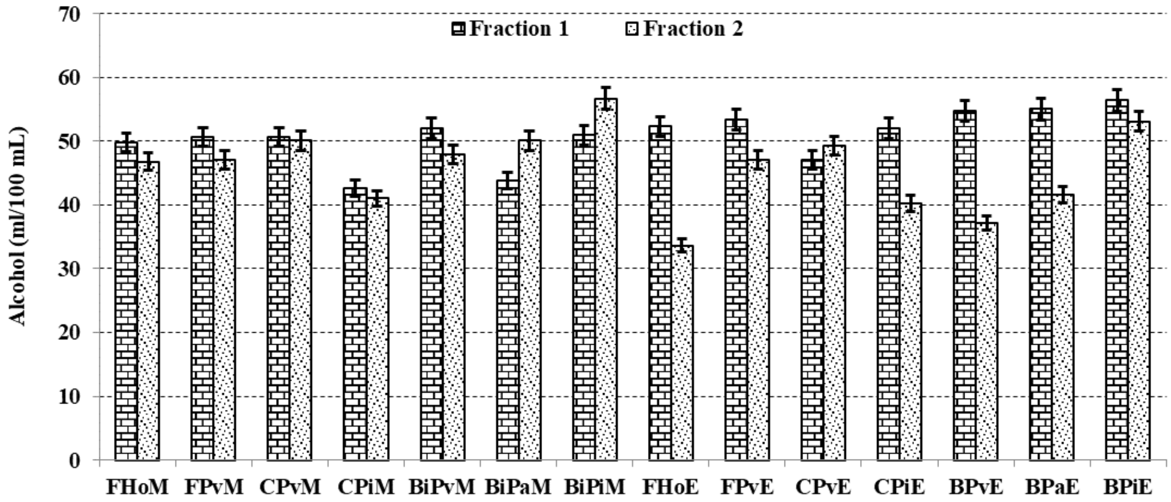


Figure 5. Alcohol contents (mL/100 mL) of distillate obtained from local beers (*Furdu*, *Cochette*, *Bil-Bil*) collected in the morning and evening from serval streets in Maroua town, Cameroon. Note: FHo: *Furdu* beer collected in *Ouro tchédé* street; FPv: *Furdu* beer collected in *Pont vert* street; CPv: *Cochette* beer collected in *Pont vert* street; CPi: *Cochette* beer collected in *Pitoaré* street; BPv: *Bil-Bil* beer collected in *Pont vert* street; BPa: *Bil-Bil* beer collected in *Palar* street; BPi: *Bil-Bil* beer collected in *Pitoaré* street. Those beers were collected in the morning (M) or evening (E).

This result may be due to the fact that at the start of the distillation, a strong alcohol type has been collected with very strong odor with a sour taste and a characteristic aroma which relatively increased the alcohol content (Aka et al. 2008). On the other hand, at the end of the distillation, we observed an increase in temperature and consequently an alteration of the distillate and other volatile compounds which decreased the alcohol content by water interference. In general, ethanol was the main constituent of distillate, however this does not characterize the quality of the distillates. As indicated by Huot and Roy (1999), other flavors from many organic substances such as esters, aldehydes and other alcoholic compounds must also interfere in the alcoholic degree of the distillates. These compounds may influence the quantity and quality of distilled ethanol. An ethyl acetate which had also been found in cassava spirits indicated that the distilled beverages such as whiskey, rum and Cachaça affected the quality of them (Coelho et al. 2020).

At less significant values, samples of distillates collected in the evening are richer in alcohol than those obtained in the morning, suggesting that this fraction was rich in flavor compounds. Fact, the principal high alcohol in alcoholic beverages include 1-propanol, 2-methyl-1-

propanol (isobutanol), 3-methyl-1-butanol (isoamylol) and 2-phenylethanol (Zhou et al. 2020). Likewise, some sample saw their second fraction more concentrated than the first one (Figure 6). This difference could be due specially to the yeast inoculation time (Einfalt 2021) and the fermentation time because early in the morning some local beers had not reached their fermentation or maturation threshold and can affect the quality of the distillate. Fact, the fermentation process develops with an increase in the alcohol level (Périsse et al. 1959).

In conclusion, the aim of this present study was to investigate the physicochemical characteristics of various local beers produced and consumed in Maroua town as well as the types of cereals used to produce these craft beers. Various cereals (red sorghum, white sorghum, maize, yellow millet, S35, rice and fonio, etc.) are the mainly used to process different local beers. The volume of distillate increased by time and depend on one beers to another. The sample of BPiM and CPiM had the lowest and the highest temperature values during distillation, respectively. *Furdu* beer had the highest TDS value (1688-1978 ppm), pH value (4.06-4.22) and high level of alcohol (5.40-6.92 %). However, *Cochette* had the highest level of dry matter (5.17-8.06 %). *Bil-Bil* had the highest titratable acid value (4.89 mg/mL-6.25 mg/mL). The distillate of the local beers had high alcohol levels and varied from beer to another and one fraction to another, with the values varied between 30 and 58.03%. These results revealed that various cereals would be suitable as raw materials for the production of quality beers such as white beers, beers, and spirits and provide a basis to foster the production of value-added products from these cereals. This study shows that the local beers are rich in nutriment and could offer a greater source of benefit to consumers.

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