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Traditional Processing and Characterization of "*Alme Ardeb*", an Indigenous Beverage from Far North Region, Cameroon

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Abstract

"Alme ardeb" is a conventional beverage made from sugar and tamarind, season with other ingredients and highly prized by the population of the northern regions of Cameroon. Despite the importance of this traditional drink, the manufacturing process and quality attributes are still unknown. As such, a study was undertaken to describe the manufacturing process and characterise the quality of "Alme ardeb". A survey was conducted in the Diamaré division of the Far north region. An ethnographical technique accompanied with semi-structured questionnaires and interviewing were used for collecting data needed to elaborate the production process. Forty-nine (49) samples of "Alme ardeb" were taken from 49 women producers in the different sites representing 10 samples per site and the sensory, physico-chemical, phytochemical and microbiological properties were assessed according referenced techniques. The field survey reveals that the production of "Alme ardeb" is conventional and rudimentary involving two classical units of operation, caramelisation and boiling. The pH and titratable acidity of "Alme ardeb" were insignificant ($p \geq 0.05$) except for the soluble solids, electrical conductivity and total sugar. The pH is acidic ranging between 4.06 ± 0.01 and 4.74 ± 0.05 with an oscillating titratable acidity ranging from 0.61% ± 0.022% to 0.65% ± 0.01% and an average soluble solids content of about 10.74 ˚Brix. Similarly, the total sugar content varies between 51.25 ± 0.18g·L^{-1} and 61.37 ± 0.18 g·L^{-1} with a conductivity that fluctuates around 351 µS·cm^{-1} and 707 µS·cm^{-1}. In addition, the average polyphenol, flavonoid and tannin contents were 2.2g EAG·L^{-1}, 0.58 g·EQL^{-1} and 0.36 g·ECL^{-1} respectively, with a free radical scavenging capacity of 52.18%. The beverage revealed a complete absence of Salmonella with a doubtful hygienic quality. The total aerobic plate count varied from (4.1 ± 0.014) × 10^4 CFU·mL^{-1} to (8.2 ± 0.007) × 10^7 CFU·mL^{-1}, total coliforms from (4.3 ± 0.6) × 10^2 CFU·mL^{-1} to (1.05 ± 0.7) × 10^5 CFU·mL^{-1}, faecal coliforms from non-detected to (4.1 ± 0.07) × 10^2 CFU·mL^{-1} and the fungal flora ranged from 0.0 to (6.5 ± 0.7) × 10^3 CFU·mL^{-1}. However, the panelists judged the beverage as being acidic with a brownish colour and a sweet caramelized taste. Consequently, the beverage was highly palatable and consumed with an overall score that went from 13.48 ± 3.32 to 15.81 ± 4.47.

Keywords

"Alme Ardeb", Traditional Processing, Tamarind Fruit, Physicochemical and Microbiological Qualities

1. Introduction

Beverages are liquid foods consumed for refreshment, nutrition and health related problems. They contain nutrients and other elements necessary for the body such as acids, alcohol, sugars, vitamins, antioxidants. These components can influence the growth of micro-organisms in the beverage [1]. There are artisanal beverages whose consumption is growing among African populations: in Cameroon, Senegal, Egypt, Ivory Coast… These drinks are made from locally-produced raw materials such as Guinea sorrel (bissap), ginger, passion fruit, tamarind, etc. [2]. The production of local drinks is therefore part of the food and cultural habits of the Cameroonian population in general and that of the Far north in particular [3]. The production of beverages from local resources is a very important secular activity among rural people of Cameroon. Foléré juice (*Hibiscus sabdariffa*) and "kargasok Tea" for examples are the most widely consumed homemade drinks in the Far North region of Cameroon [4] [5]. A drink of the same family is also subjected to multiple handlings and hence the hygienic aspect is often questionable [5]. Additionally to foléré and "kargasok Tea", other juices such as lemon juice, ginger juice, baobab juice, etc., are also produced [6]. These thirst-quenching drinks are only sources of income and are not part of any tradition; unlike "kounou", "Téa lémi", "billi billi" etc. which are marketed despite their strong traditional devotion. "Alme ardeb" is the drink with a sweet, slightly spicy and acidic flavour. It is brown or black in colour and is mostly consumed at social gatherings (baptism and marriage). Most often, this beverage is sold in periodic markets as substitute to most local non-alcoholic beverages [7]. Like many other traditional drinks, the conditions under which it is produced cannot guarantee to consumers a healthy product of good nutritional and sensory quality. "Alme ardeb" is likely produced under inappropriate settings. The drink obtained in these conditions is unstable and difficult to preserve. "Alme ardeb", like any drink intended for human consumption, requires the strict application of good hygienic practices throughout the process from production to consumption [2]. The objective of this study is to assess the quality of "Alme ardeb" produced and marketed in the Far north region.

2. Materials and Method

2.1. Study Zones and Field Study

The present study was conducted in the Far north region of Cameroon. To assemble data on the production of "Alme ardeb", a field survey with the aid of semi-structured questionnaires and interview was carried out among 60 women producers and 10 consumers in seven neighborhoods of the Far north region, Cameroon: Maroua I, Maroua II, Maroua III, Gazawa, Bogo, Dargala and Pétté (**Figure 1**).

2.2. Sampling of "Alme Ardeb" Beverage

Forty-nine (49) samples of "Alme ardeb" were taken from 49 women producers in the different sites representing 10 samples per site. All the samples collected were transported directly to the laboratory under aseptic conditions in a cooler for the various analyses. The samples were analysed on the day of collection.

2.3. Physicochemical Analyses

The pH of the samples was measured using a portable ATC pH meter (Eco Testr, Singapore) directly by immersing the electrode into 10 mL of sample [8]. The total titratable acidity (%) and total sugar content (g/L) were determined using the method described by Muyanja *et al.* [9] and Debebe *et al.* [10] respectively. Like with the pH, conductivity ($\mu S \cdot cm^{-1}$) of the samples was assessed directly using a portable multifunctional conductivity meter type "e-1 TDS & EC" according to the method described by Bayoï *et al.* [11].

2.4. Phytochemical Analyses

The content of phenolic compounds was determined by the spectrophotometric methods. Total polyphenol content was estimated by the Folin Ciocalteu method [12] and the result obtained was expressed as gram of gallic acid equivalent per liter ($g \cdot GAEL^{-1}$). The total flavonoid and total tannin contents were determined by the $AlCl_3$ and vanillin acid methods [13]. The results were expressed as gram of catechin equivalent per liter ($g \cdot CEL^{-1}$) and gram of quercetin equivalent per liter ($g \cdot QEL^{-1}$) for tannins and flavonoids respectively. The DPPH free radical scavenging activity was determined as described accordingly by Sun *et al.* [14] and the result obtained was expressed as percentage of inhibition (I%).

2.5. Microbiological Analysis

2.5.1. Preparation of the Inoculum

The inoculums were prepared using the serial decimal dilutions method. One milliliter (1 mL) of the stock solution of each "Alme ardeb" sample was pipetted

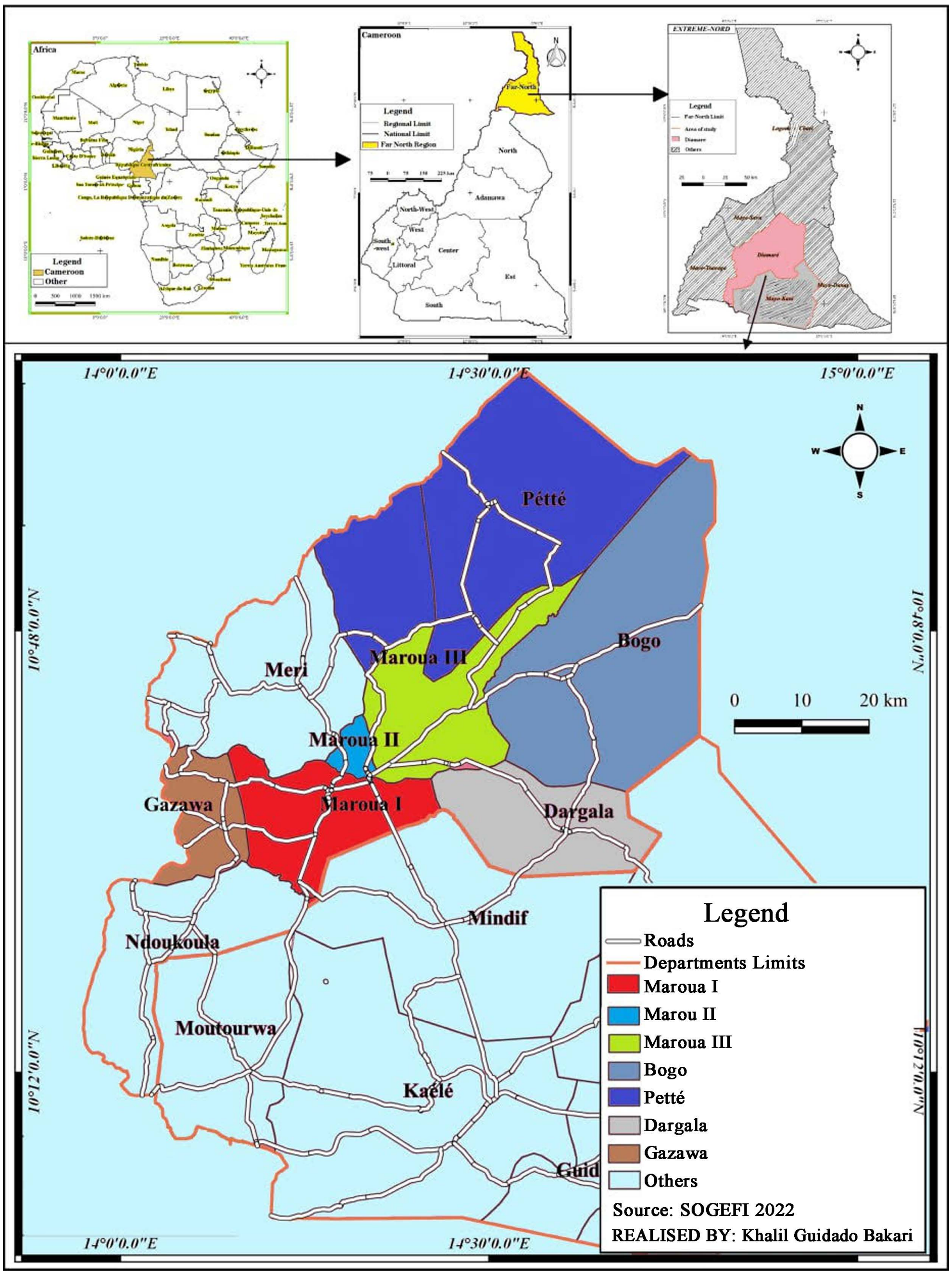

Figure 1. Map of study sites (SOGEFI 2022).

and introduced into 9 mL of sterile peptone water and the content was vortexed. This operation was repeated with the preceding tube until the desired dilution was obtained.

2.5.2. Enumeration and Determination of Microbial Charge

To search for the total aerobic count, 1 mL of the inoculum was deeply plated in Plate Count Agar (PCA). The plates were incubated in an oven at 30˚C for 72 hours and the colonies obtained were counted [15]. Similarly, 1 mL of the inoculum was deeply plated into Eosine Methylene Blue Agar and the plates were incubated at 37˚C and 44˚C for the search of total and faecal coliforms respectively. After 24 hours of incubation, purple-red colonies (0.5mm in diameter with a precipitation zone) were counted [16]. The level of Salmonella and Shigella were assessed [16]. Briefly, the culturing and enumeration of Salmonella and Shigella require three distinct steps. A pre-enrichment of buffered pepton water maintains a high pH for more than 24 hours of incubation at 37˚C. Pre-enrichment in buffered pepton water at 37˚C for 24 hours, followed by incubation of 10 ml of the sample in 100 ml of Selenite Cystine broth (CM0699) or Muller-Kauffmann broth (CM0343) for 48 hours at 43˚C. However, in the case of highly contaminated samples, it is advisable to add 0.1 g of malachite green per litre of buffered peptone water. This addition is important when Salmonella, present in small quantities, have an increased generation time due to the associated flora and cannot reach a minimum number to be successfully isolated.This was immediately followed by the selective enrichment on Mueller Kauffman Tetrathionate for 24 hours at 37˚C and lastly enriched suspension was plated in Salmonella/Shigella (SS) agar medium and incubated at 37˚C for 24 hours for the search and isolation of Salmonella and Shigella.

2.6. Sensory Analysis

Preliminary training session led to the selection of 18 panelists (8 females and 11 males). The choice was based on the availability, occupation, consumption frequency of local beverages, age, and health status. The panelists were between 18 and 32 years. The test was carried out in the morning in a clean room. Each panelist was served 30 mL of the drink sample in a cup marked with the sample code with water next to it to rinse the mouth after each tasting together with an evaluation form. Bitterness, acidity, texture, taste, aroma, colour and overall acceptability were the sensory attributes mentioned in the sheet. The panelists rated the samples using a hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely) [17].

2.7. Statistical Analyses

The results were organised using the Microsoft Office/Excel 2013 worksheet and processed with STATGRAPHICS Centurion 16.1 software for Windows. Comparison of means was performed by ANOVA and then Tukey's honest significant difference (HSD) multiple comparison test was used to discriminate between pairs of significantly different means. Mean values were considered statistically significant at $p < 0.05$. At the end of the analyses, the results obtained were presented in a table in the form of Mean ± standard deviation.

3. Results and Discussion

3.1. Results

3.1.1. Traditional Production of "Alme Ardeb"

The result of the field survey led to the elaboration of manufacturing flowchart

"Alme" as presented in Figure 2. Alme ardeb production involved two different steps: caramelisation and boiling. Caramelisation is a crucial stage in the manufacturing process of this traditional African drink. Indeed, the role of this stage is to break the bond of sucrose in order to obtain glucose and fructose which will merge with other complex molecules to obtain caramel. Granulated sugar is the most used. For this, 1 Kg of sugar is used for every 5 L of drinking water. One-tenth fraction of the sugar (100 g) is caramelised and diluted with water (5 L). This is immediately followed by the addition of tamarind (50 mL of concentrated juice) or ginger (50 g of powder) depending on the choice of the producer and other optional ingredients (fever grass, cloves, etc). The mixture is boiled for at least 30 minutes at 100˚C. During the boiling process, the remaining nine

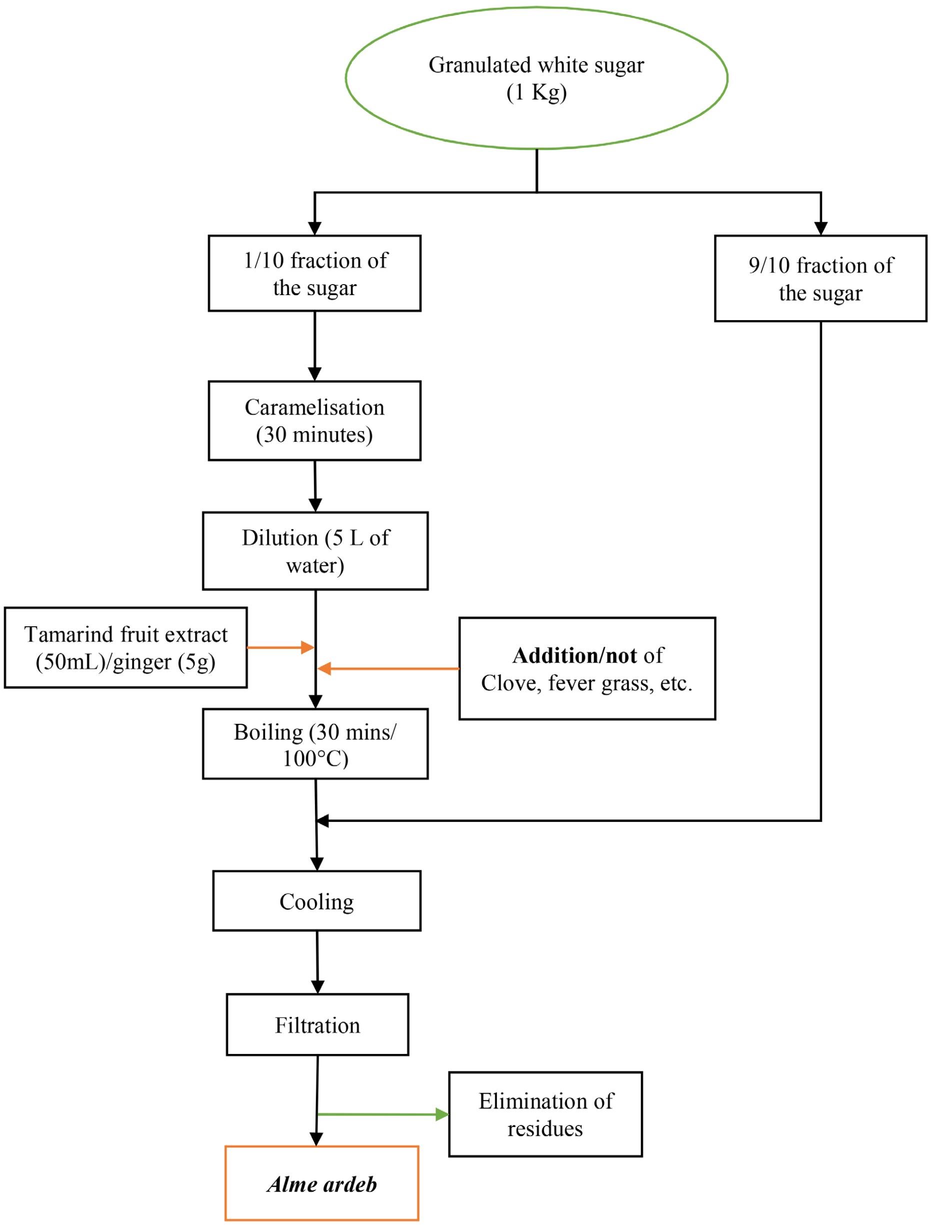

Figure 2. Traditional flowchart of "Alme ardeb".

tenth fraction (0.9 kg) of the sugar is added and the mixture is allowed to cool. After cooling, the drink is filtered through a cotton cloth. The filtrate obtained is called "Alme" and is packaged in clean plastic or glass bottles and ready to be sold.

3.1.2. Physicochemical Quality

The physicochemical profile of "Alme ardeb" samples is presented in **Table 1**. The pH of the analysed samples varies insignificantly ($p \geq 0.05$) between 4.06 ± 0.01 and 4.74 ± 0.05 from one site to another. The highest pH was recorded with samples from Bogo (4.74 ± 0.05) and the least was recorded with samples from Maroua III (4.06 ± 0.01). Irrespective of the sampling site, the pH remains acidic with an average pH of 4.48 ± 0.01. Hence, "Alme ardeb" can be regarded as an acidic beverage with a sour taste. Like with the pH, the total titratable acidity remains insignificant from one site to another. The total acidity varies between 0.61% ± 0.02% and 0.65% ± 0.01% with an average of 0.63% ± 0.01%. "Alme ardeb" sample from Maroua III had the highest total acidity (0.65% ± 0.01%) jointly followed by samples from Dargala, Petté, Maroua I and II (0.63% ± 0.01%), Bogo (0.62% ± 0.02%) and lastly by Gazawa (0.61% ± 0.02%).

On the other hand, the conductivity, soluble solids and total carbohydrates vary significantly ($p < 0.05$) from one site to another (**Table 1** below). The conductivity varies between 351.0 ± 36.39 $\mu S \cdot cm^{-1}$ and 707.66 ± 9.81 $\mu S \cdot cm^{-1}$. There were no significant differences ($p \geq 0.05$) between samples collected from Dargala (412.33 ± 92.63 $\mu S \cdot cm^{-1}$) and Maroua II (482.33 ± 1.15 $\mu S \cdot cm^{-1}$), Petté (618.33 ± 8.02 $\mu S \cdot cm^{-1}$), Bogo (707.66 ± 9.81 $\mu S \cdot cm^{-1}$) and Gazawa (683 ± 16.52 $\mu S \cdot cm^{-1}$) and Maroua I (352 ± 40.95 $\mu S \cdot cm^{-1}$) and Maroua III (351 ± 36.39 $\mu S \cdot cm^{-1}$) but between the pairs, there were significant differences ($p < 0.05$). As for the soluble solids, "Alme" sample from Maroua III registered the highest soluble solids content (12.43 ± 43 ˚Brix) with the least being the sample from Bogo (9.6 ± 0.1 ˚Brix). Similarly, Maroua III sampled beverage recorded the greatest total sugar content (61.37 ± 0.18 $g \cdot L^{-1}$) and Maroua II samples recorded the lowest total sugar content (51.25 ± 0.18 $g \cdot L^{-1}$).

Table 1. Physicochemical properties of "Alme ardeb".

Parameters	Sampling sites							
	Dargala	Bogo	Gazawa	Pette	Maroua I	Maroua II	Maroua III	Mean
pH	4.53 ± 0.01^a	4.74 ± 0.05^a	4.66 ± 0.01^a	4.52 ± 0.05^a	4.58 ± 0.01^a	4.25 ± 0.01^a	4.06 ± 0.01^a	4.48 ± 0.01
Total acidity (%)	0.63 ± 0.00^a	0.62 ± 0.02^a	0.61 ± 0.02^a	0.63 ± 0.01^a	0.63 ± 0.00^a	0.63 ± 0.04^a	0.65 ± 0.01^a	0.63 ± 0.00
Conductivity ($\mu S \cdot cm^{-1}$)	412.33 ± 92.63^b	707.66 ± 9.81^c	683.0 ± 16.52^c	618.33 ± 8.02^c	352.0 ± 40.95^a	482.33 ± 1.15^b	351.0 ± 36.39^a	515.23 ± 17.4
Total sugar ($g \cdot L^{-1}$)	57.17 ± 0.27^c	54.28 ± 0.04^b	56.09 ± 0.54^c	53.83 ± 0.13^b	53.70 ± 0.13^b	51.25 ± 0.18^a	61.37 ± 0.18^d	55.39 ± 3.12
Soluble solids (˚Brix)	9.93 ± 0.15^a	9.76 ± 0.06^a	9.60 ± 0.10^a	11.86 ± 0.06^b	11.66 ± 0.28^b	9.96 ± 0.06^a	12.43 ± 0.75^c	10.74 ± 0.14

Mean values not followed by the same letter (a, b, c) on the same line are significantly different ($p < 0.05$).

3.1.3. Phytochemical and Antioxidant Activity of "Alme Ardeb"

Table 2 shows the phytochemical and antioxidant properties of "Alme ardeb". The total polyphenols content had an insignificant variation ($p \geq 0.05$) from one site to another except the "Alme ardeb" beverage sampled from Gazawa site. The sample from Gazawa site had the highest polyphenol content (2.5 ± 0.00 $g \cdot GAEL^{-1}$) as compared to those collected in other localities which fluctuate between 2.2 ± 0.01 $g \cdot GAEL^{-1}$ and 2.3 ± 0.01 $g \cdot GAEL^{-1}$. Inversely to the total polyphenols content, the total flavonoid content varied significantly from one site to another. The total flavonoid content varies between 0.30 ± 0.00 $g \cdot QEL^{-1}$ (Bogo) and 0.73 ± 0.01 $g \cdot QEL^{-1}$ (Maroua I). As for the total tannins content, there were no significant differences between samples from Dargala (0.42 $g \cdot CEL^{-1}$), Bogo (0.39 $g \cdot CEL^{-1}$) and Maroua I (0.43 $g \cdot CEL^{-1}$), Petté (0.26 $g \cdot CEL^{-1}$), Maroua II (0.23 $g \cdot CEL^{-1}$) and Maroua III (0.22 $g \cdot CEL^{-1}$) and Gazawa (0.55 ± 0.01 $g \cdot CEL^{-1}$). "Alme ardeb" sample from Gazawa locality had the highest tannins content (0.55 ± 0.01 $g \cdot CEL^{-1}$) compared to those collected in other localities, which vary between 0.22 ± 0.01 $g \cdot CEL^{-1}$ and 0.43 ± 0.01 $g \cdot CEL^{-1}$.

Despite the varying level of secondary metabolites, the beverage samples expressed a significant inhibitory DPPH scavenging power which varied between 44.75% ± 0.15% and 61.09% ± 0.73%. "Alme ardeb" sample from Gazawa (61.09% ± 0.73%) had the greatest free radical scavenging activity meanwhile the lowest activity was registered with samples from Bogo locality (44.75% ± 0.15%). Between the sites, there were no significant differences among samples from Dargala, Gazawa, Petté, Maroua I and Maroua II, Bogo, Gazawa and Maroua II except for Maroua III (53.52% ± 0.07%) whose free radical activity was significant ($p < 0.05$) with all the sites.

Table 2. Bioactive and antioxidant properties of "Alme ardeb".

Parameters	Sampling sites							
	Dargala	Bogo	Gazawa	Pette	Maroua I	Maroua II	Maroua III	Mean
TPC ($g \cdot GAEL^{-1}$)	2.3 ± 0.01^{a}	2.3 ± 0.01^{a}	2.5 ± 0.00^{b}	2.2 ± 0.01^{a}	2.2 ± 0.01^{a}	2.2 ± 0.00^{a}	2.3 ± 0.01^{a}	2.2 ± 0.09
TFC ($g \cdot QEL^{-1}$)	0.58 ± 0.00^{c}	0.30 ± 0.00^{a}	0.45 ± 0.00^{b}	0.72 ± 0.01^{ab}	0.73 ± 0.01^{ab}	0.68 ± 0.00^{ab}	0.65 ± 0.00^{ab}	0.58 ± 0.15
TTC ($g \cdot CEL^{-1}$)	0.42 ± 0.00^{b}	0.39 ± 0.00^{b}	0.55 ± 0.00^{c}	0.26 ± 0.00^{a}	0.43 ± 0.00^{b}	0.23 ± 0.01^{a}	0.22 ± 0.01^{a}	0.36 ± 0.12
Scavenging power (%)	49.92 ± 0.10^{b}	44.75 ± 0.15^{a}	61.09 ± 0.73^{ab}	47.22 ± 0.13^{b}	48.80 ± 0.44^{b}	59.97 ± 0.21^{ab}	53.52 ± 0.70^{c}	52.18 ± 6.06

Mean values on the same line not followed by the same letter (a, b, c) on the same line are significantly different ($p < 0.05$). TPC: Total polyphenol content, TFC: Total flavonoid content, TTC: Total tannin content.

3.1.4. Hygienic Quality of "Alme Ardeb"

The hygienic quality of "Alme ardeb" is presented in Table 3. The analysis of the latter reveals that the total aerobic count of the samples varied significantly ($p < 0.05$) from one site to another. These loads went from (4.1 ± 0.014) × 10^4 $CFU \cdot mL^{-1}$ (Maroua II) to (8.2 ± 0.007) × 10^7 $CFU \cdot mL^{-1}$ (Bogo) likewise the total coliform load varied from (4.3 ± 0.6) × 10^2 $CFU \cdot mL^{-1}$ (Maroua II) to (1.05 ± 0.7)

× 10^5 CFU·mL^{-1} (Dargala and Bogo), values that are well above the standard value of 10^3 CFU·mL^{-1}. Furthermore, the faecal coliforms in the varied between (1.6 ± 0.01) × 10^2 CFU·mL^{-1} (Petté) and (4.1 ± 0.07) × 10^2 CFU·mL^{-1} (Bogo) which is slightly above the standard 10^2 CFU·mL^{-1}. However, these faecal coliforms were not detected in "Alme ardeb" sampled from Maroua sites (I, II and III). In the same train, the concentration of yeasts and moulds vary between (3 ± 0.07) × 10^2 CFU·mL^{-1} (Maroua II) and (6.5 ± 0.7) × 10^3 CFU·mL^{-1} (Bogo) except the "Alme ardeb" sampled from Maroua III that shows no sign of fungal growth. At least one of the aforementioned flora was detected contrary to Salmonella which was completely not detected in all the samples of "Alme ardeb".

Table 3. Microbiological profile of "Alme ardeb".

Microbial flora (CFU·mL^{-1})	Sampling sites							
	Dargala	Bogo	Gazawa	Pette	Maroua I	Maroua II	Maroua III	AFNOR standard
Total plate count	(1.39 ± 0.01) 10^{7ac}	(8.2 ± 0.01) 10^{7bc}	(3.40 ± 0.00) 10^{6c}	(6.25 ± 0.07) 10^{6ab}	(3.39 ± 0.01) 10^{6c}	(4.10 ± 0.01)10^{4a}	(1.13 ± 0.01) 10^{6b}	<10^6
Total Coliforms	(1.1 ± 0.7) 10^{5ac}	(1.1 ± 0.7) 10^{5ac}	(7.6 ± 0.03) 10^{4ab}	(7.7 ± 0.07) 10^{4ab}	(3.3 ± 0.03) 10^{3b}	(4.3 ± 0.6) 10^{2a}	(1.4 ± 0.00) 10^{4c}	<10^3
Fecal coliforms	(1.7 ± 0.03) 10^{2a}	(4.1 ± 0.07) 10^{2b}	(2.3 ± 0.03) 10^{2a}	(1.6 ± 0.01) 10^{2a}	ND	ND	ND	<10^2
Total fungi	(8.8 ± 0.01) 10^{2c}	(6.5 ± 0.7) 10^{3ac}	(1.4 ± 0.10) 10^{3ab}	(6.1 ± 0.00) 10^{2b}	(7.9 ± 0.05) 10^{2c}	(3 ± 0.07) 10^{2a}	ND	<10^5
Salmonella/Shigella	ND	ND	ND	ND	ND	ND	ND	0/25 mL

Means not followed by the same letter (a, b, c) on the same line are significantly different ($p < 0.05$). ND: Not detected.

3.1.5. Sensory Analysis

The sensory attributes of "Alme ardeb" are summarised in Table 4 below. This result shows that there is no significant difference ($p < 0.05$) between the overall acceptability and score of "Alme ardeb". Despite these non-differences, beverage sample from Petté had the best score (15.81 ± 4.47) which is slightly higher than those from the other sites with values fluctuating between 13.48 ± 3.32 and 14.59 ± 4.76. "Alme ardeb" beverage from Petté was highly graded for it colour (7.3 ± 1.11), texture and odour (7.1 ± 1.28), sourness (6.5 ± 1.56), bitterness (6.8 ± 1.38), aroma (7.3 ± 0.85) and taste (7.4 ± 0.84). These attributes greatly affected its overall acceptability and score. Similarly, the panelists turn to prefer "Alme" with a medium bitter flavour more in terms of taste. Even though, all the drinks had better scores for overall acceptability (>5), the beverage from Petté site is much more appreciated (7.4 ± 0.96).

3.2. Discussion

The traditional production of "Alme Ardeb" comprises two main classic stages: caramelisation and boiling. This process is based on traditional know-how

Table 4. Sensory quality of "Alme ardeb".

Attributes	Sampling sites							
	Dargala	Bogo	Gazawa	Petté	Maroua I	Maroua II	Maroua III	Mean
Colour	6.0 ± 1.58[a]	6.2 ± 1.64[a]	5.8 ± 1.59[a]	7.3 ± 1.11[b]	6.4 ± 1.33[a]	6.8 ± 1.64[a]	6.6 ± 1.19[a]	6.4 ± 1.48
Texture	6.6 ± 1.26[a]	6.4 ± 1.45[a]	6.0 ± 1.58[a]	7.1 ± 1.28[b]	6.2 ± 1.42[a]	6.5 ± 1.56[a]	6.2 ± 1.23[a]	6.4 ± 1.40
Odour	6.0 ± 1.08[b]	5.6 ± 0.96[a]	5.7 ± 1.11[a]	7.1 ± 1.28[c]	6.8 ± 1.30[c]	6.5 ± 1.39[b]	6.3 ± 1.32[b]	6..3 ± 1.29
Acidity	5.5 ± 0.97[a]	5.5 ± 1.27[a]	6.1 ± 1.57[a]	6.5 ± 1.56[a]	5.8 ± 1.40[a]	6.1 ± 1.07[a]	5.8 ± 1.23[a]	5.9 ± 1.31
Aroma	6.7 ± 0.75[a]	5.7 ± 1.03[a]	6.5 ± 1.20[a]	7.3 ± 0.85[b]	6.9 ± 1.26[a]	6.7 ± 1.44[a]	7.1 ± 0.99[a]	6.7 ± 1.17
Taste	6.7 ± 1.38[a]	6.5 ± 1.20[a]	7.1 ± 1.04[a]	7.4 ± 0.84[a]	6.8 ± 0.99[a]	6.5 ± 1.33[a]	6.4 ± 1.56[a]	6.8 ± 1.22
Bitterness	6.3 ± 1.49[a]	6.1 ± 1.40[a]	6.3 ± 1.38[a]	6.8 ± 1.42[a]	6.1 ± 1.11[a]	6.3 ± 1.03[a]	5.8 ± 0.93[a]	6.6 ± 1.26
Overall acceptability	6.5 ± 0.88[a]	6.4 ± 1.04[a]	7.0 ± 1.00[a]	7.4 ± 0.96[a]	7.1 ± 0.69[a]	7.1 ± 1.32[a]	6.7 ± 1.25[a]	6.9 ± 1.06
Overall score/20	13.97 ± 4.67[a]	13.48 ± 3.32[a]	14.02 ± 4.46[a]	15.81 ± 4.47[a]	14.51 ± 4.38[a]	14.59 ± 4.76[a]	14.14 ± 4.32[a]	14.36 ± 3.46

Means followed by the same letter (a, b, c) and on the same line are not significantly different (p > 0.05).

which remain empirical and rudimentary like most traditional drinks. The terminal unit operations involved in the production of "Alme Ardeb" are similar to those used in the production of "Rob" produced in Algeria [18]. Furthermore, the production flowchart of "Alme Ardeb" shows differences in the stages compared to the production process of some conventional beers such as "Amgba" and "Téa lémi" [19] from Cameroon and "Siko" from Chad [20]. However, the production of "Alme Ardeb" is characterised by a short boiling time without the use of ferments and consequently no fermentation. This production stages are contrary to those of the aforementioned beers whose boiling can exceed 3 hours and often associated with the use of exogenous or non-exogenous ferments.

The physicochemical analyses of "Alme" showed that there were no significant differences between the drinks from the different sites. Despite the empirical production procedure, the invariability could be explained by the fact that the producers have kept the traditional reflexes and habits with precision. "Alme" has an average pH of 4.48 making this drink to be acidic as such not be consumed with an empty belly. According to CODEX STAN 247 [21], a beverage is considered acidic if it has a pH ≤ 4.5. Like with other drink, the pH of "Alme ardeb" is closely related to that obtained on orange juice (pH 4.49) [22] produced in Algeria and ginger juice (pH 4.4) produced in Mali [23]. However, it is less acidic than "Foléré" juice (pH 1.57) obtained from *Hibiscus sabdariffa* in Cameroon [4] and cashew apple juice (pH 3.81) produced in Ivory Coast [24]. The total titratable acidity vary between 0.61% ± 0.02% and 0.65% ± 0.01% which corroborates with those obtained on "Kounou" [25] which varied from 0.60% ± 0.03% to 0.65% ± 0.08%. This acidity is much lower than that of orange juice (3.1 ± 0.51 $g \cdot L^{-1}$) [24], and higher than those of "Zoom Koom" which varies between 0.06 ± 0.01 and 0.49 ± 0.05 in Burkina Faso [26]. This variation could be justified by the nature of the raw material used for the production and brewing technique. Indeed tamarind is a tropical plant whose fruits are known to be rich in organic acids and phenolic acids [27]. The sugar content plays an important role in the soluble solids content of beverages. An average soluble solid of 10.74 ± 0.14 ˚Brix was registered for the "Alme ardeb" beverage. The soluble solids are higher than that of cashew apple juice (7 ± 0.03 ˚Brix) [24] and "kounou" (8.19 ± 0.59) [25], but lower than that of date juice (16 ˚Brix) [28]. The results show that the "Alme" contains a total sugar content lower than that found by on "foléré" juice (160.6 $g \cdot L^{-1}$) [4], and much higher than those found on fruit juice in Algeria (12.15 $g \cdot L^{-1}$) [29]. Finally, the conductivity of the different samples is clearly lower than that found by on apple juice in Ivory Coast [24], which varies from 1031 $\mu S \cdot cm^{-1}$ to 3900 $\mu S \cdot cm^{-1}$. Supposedly, "Alme ardeb" might contain little or just trace of electrolytes. Furthermore, the phytochemical analyses revealed that the average total polyphenol content (2.2 ± 0.01 $gEG \cdot L^{-1}$) of "Alme ardeb" is lower than that found with "Kounou" [25] which has an average content of 11 $g \cdot L^{-1}$ and higher than that of cashew apple juice (1.8 $g \cdot L^{-1}$) produced in Ivory Coast [24]. The difference observed between these values is probably related to the nature of the raw material (sugar, sorghum and cashew apple) used to prepare these drinks. Flavonoids are a group of phenolic compounds common in plants and of low molecular weight. The total flavonoid content of "Alme ardeb" ranged from 0.30 to 0.73 $g \cdot L^{-1}$. This result confirms this chemical class is the major constituent of the polyphenol fraction. It is lower than that of the red beer kapsiki which varies between 0.75 $g \cdot L^{-1}$ and 1.3 $g \cdot L^{-1}$ [30] and higher than that obtained on strawberry juice in Algeria [31]. This observed difference could be justified by the contents of total polyphenols, geographical, climatic and genetic factors could also influence the content of phenolic compounds. The free radical and antioxidant activity of the beverages was therefore relatively dependent on the total polyphenol and flavonoid content, the more flavonoids a beverage has, the more it is considered a good antioxidant. There is a close relationship between the polyphenol content of a drink and its antioxidant capacity [32].

On the other hand, the microbiological analysis of "Alme ardeb" samples revealed a high rate of total aerobic plate count except for the Maroua II site. It should be noted that the high load of aerobic mesophilic flora is much more noticeable in the rural sites (Bogo, Dargala, Gazawa and Petté), which can be explained by the lack of hygiene awareness of the rural population. These results corroborate those obtained on "foléré" juices in three towns in the Far North region of Cameroon [4], but are inferior to those obtained on "Zoom koom" in Ivory Coast [2] and on "kounou" in Cameroon [25]. The total coliforms vary significantly from one site to another. The highest value of total coliforms was observed in "Alme ardeb" sampled from Dargala and Bogo sites, which could be justified by post-production contamination, the quality of the water used and also at the time of sale. These results are similar to those obtained on "zoom-koom"

[33] where the coliform rate varied between 1.10 CFU·mL^{-1} and 1.0 × 10^{5} CFU·mL^{-1}, and higher than those obtained with "kounou" [25]. The presence of faecal coliforms in certain samples can be explained by exogenous contamination of faecal origin. They are evidence of defective hygiene during or after processing [34]. However, during the bottling of "Alme ardeb", hands are involved, which would play a considerable role in the contribution of microorganisms, given the lack of respect for personal hygiene and also the doubtful origin of the bottles could be a factor. These results are similar to those obtained on "zoom-koom" [33] where the number of colonies varied between 10 CFU·mL^{-1} and 5.4 × 10^{4} CFU·mL^{-1}. However, the varying load of coliforms implies a poor hygienic quality of the "Alme ardeb" samples from the four rural sites (Dargala, Bogo, Gazawa, Petté) in contrast to those from the urban site (Maroua). On the other hand, the fungal flora in the samples was below the AFNOR standard (10^{5} CFU·mL^{-1}) and completely absence in beverage samples from Maroua III. The presence of fungal flora in some samples could be explained by the fact that the acidic nature of the drinks favouried the growth of yeasts [35]. Yeasts and moulds have an optimum pH between 4.5 and 6.5 [36]. This pH is in line with those registered with "Alme ardeb" in the course of this study (between 4.25 ± 0.01 and 5.74 ± 0.05).

Fortunately, all the beverage samples were palatable with a high degree of appreciation. The non-significant observed in the overall scores of "Alme" from different sites would be a sign of homogeneity and perfect mastery of the manufacturing process among brewers. This homogeneity seems surprising since the production is empirical. In addition, the presence of the ingredients (ginger, lemon grass and cloves) contributed to the significant improvement of the sensory characteristics of "Alme ardeb". The fresh taste and strong aroma noted could be due to the aromatic compounds contained in this drink. The aroma enhancement in a beverage can also be correlated to their organic acid content [37]. It can therefore be confirmed that "Alme ardeb" is an acidic drink with a characteristic brownish colouration and sweet caramelized taste.

4. Conclusion

The traditional production and characterisation of "Alme ardeb" made in the northern regions, Cameroon was investigated. The production of "Alme ardeb" remains conventional and rudimentary with uncontrolled addition of some ingredients, hence most operations is critical. Despite this empirical production, the pH was acidic with varying total acidity, soluble solids, conductivity and total sugar. Apart from its nutritional potentials, "Alme ardeb" seems to exert biological functions as it contains a broad of phenolic compounds. The beverage presents doubtful microbiological aspects with varying loads of hygienic indicators. However, the beverage is seen to be well praised and cherished by the local population most especially for it colour, taste, acidity and aroma. To bring more light on the quality and to determine the critical control points, a traceability study from production to sale as well as the isolation and identification of the different microbial strains present in this drink could be envisaged, for a better knowledge of the contamination factors and the types of microorganisms encountered in the "Alme ardeb".

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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