

*Full Length Research Paper*

# Processing of “Amgba”: A sorghum-maize based beer, brewed in Cameroon

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Accepted 2 August, 2012

**Amgba is an African traditional maize sorghum based opaque beer mainly considered as food than beverage by Gbaya peoples in Adamaoua region of Cameroon. Despite Amgba's importance as food, physicochemical composition as well as its process production is still not well understood. To overcome these constraints, the process production of “Amgba” was carried out in order to identify critical points and eventually standardize the production process. To do this, a cross-sectional and descriptive study, including qualitative and quantitative survey, followed by laboratory scale production were conducted. Different products were given to a panel, for sensory analysis and were used to assess physicochemical characteristics. Results show that the main process production seems similar to most African opaque beer production technologies. Irrespective of the amount of added sorghum and maize, multiple regression analyses revealed an inverse significant ( $P < 0.05$ ) relationship between aroma, taste, visual examination, and overall acceptability of beers. Physicochemical analysis results showed high alcohol content (4.5 to 7%), total titratable acidity varied from 14.4 to 16.2 mg/L, residual sugars (g/L) were found to be in the range of 1.3 to 1.5 (g/L), and total polyphenols form 772 to 802 (mg/L). This data highlights the possibilities for improvement of “Amgba” quality for industrial production.**

**Key words:** Beer, sorghum, maize, fermentation.

## INTRODUCTION

“Amgba” is an artisanal processed alcoholic opaque beverage made by a mixture of sorghum and maize in Gbaya tribe from Cameroon and Central African Republic. Traditionally, “Amgba” was made 3 to 4 times annually, during special ceremonies (Jacqueline and Woodfork, 2006). Today, Amgba is shared during special events and is an income generating activity for many poor women (Nduka, 1992). Unfortunately, the beverage is of bad hygienic quality, unstable over storage time, somewhat sour, and cloudy (Djoulde, 2011; Nduka, 1992). Despite the fact that it is made from cereals, this alcoholic beverage is not considered by Africans as beer, but regarded as food (Chevassus-Agness et al., 1979;

Jacqueline and Woodfork, 2006). It is widely consumed due to its low cost as compared to industrial produced drinks (Huetz de lemps, 2001). Unfortunately, the artisanal production process described in literature (Chevassus-Agness et al., 1979) was recorded based on data from the “popular” or unscientific methods, leading to some erroneous information. Production process of “Amgba” remains unknown.

In order to classify and improve the quality of commercial “Amgba”, it seems suitable to record information on the production process based on scientifically recognized methods and give an overview of some biochemical properties of the beverage. The objective of this paper is thus to highlight the production process of “Amgba” brewed in Northern Cameroon with the aims of mastering this process and ameliorate some steps if necessary and finally to standardize the final pro-

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duct.

## MATERIALS AND METHODS

### Data collection and process design

Rather than questionnaires, ethnographic methods as described by Schensul (1999) associated with focused group discussion method (Kumar, 1987) were used for data collection on the “Amgba” process production. Sample size and localization of groups were clustered according to Wears (2002) clustering method, within Cameroonian Gbaya’s regions, namely Adamaoua and East regions.

### Laboratory preparation of “Amgba”

Sample of the 25 interviewed women during focus groups discussions were called to assist in preparing “Amgba” according to the developed flow sheet, based on their interviews during focus group discussion. The experiments were conducted in the region of Gbaya Meiganga (Adamaoua South East). During this laboratory preparation, some steps were harmonized and corrected according to their observations. Samples of prepared beverage were collected for biochemical and sensory analysis.

### Raw material for laboratory scale production

The botanical, agronomic, and technological quality of sorghum (*Sorghum bicolor*) were described in a previous study (Djoule et al., 2008). The maize (*Zea mays*) used was produced locally and provided by women. Water was fetched from local tap water facilities.

### Sensory analyses

Traditionally made “Amgba”, laboratory scale “Amgba” and one commercial sorghum beer purchased from the local market, were presented to a panel of experienced tasters comprising ten members of regular beer drinkers. The sensory analysis procedure suggested by Rivella (1987) was used. Each taster was given an evaluation form for each of the beer samples. The form included four sensory attributes: taste, aroma, visual examination (Color and overall appearance), and harmony (overall acceptability). Panelists were asked to assess the samples in terms of the listed attributes using a nine-point hedonic scale with 9 representing like extremely and 1 indicating dislike extremely. The tasting was carried out in a highly illuminated tasting room. Tasters were provided with water to rinse their mouth after each round of tasting and were prevented from communicating with each other to avoid undue biases. Each taster was served with 25 ml of each beer sample in different coded form.

### Statistical analysis

Data was subjected to analysis of variance and means were separated using Duncan’s multiple range test at  $P < 0.05$  (Steel and Torrie, 1980).

### Physicochemical analyses

#### pH

The pH was determined using a Kent EIL 7020 model pH meter.

The pH of the beers samples was taken in triplicates.

### Residual sugar content

Residual sugar content was assessed by determination of glucose using the enzymatic method describes by McCloskey (1978) in all beer samples.

### Total titratable acidity (as percentage w/w tartaric acid)

Total titratable acidity (as percentage w/w tartaric acid) was determined according to the Association of Analytical Chemists (1990) methods. Acidity was determined by titration with 0.1 N NaOH solution and was expressed as percentage of tartaric acid. Bromothymol blue was used as an indicator.

### Total polyphenols

Total polyphenols were assayed colorimetrically using the Folin-Dennis Ciocalteu reagent as describe by Juan et al. (1993). The results were expressed as mg/L of gallic acid.

### Volatile acidity

Volatile acidity was determined using the Mathieu method (Ribereau-Gayon and Peynaud, 1962) by titration of the volatile acids separated from the beer sample by steam distillation and titration of the distillate.

### Volatile compounds

In order to determine volatile compounds, gas chromatography analysis was performed. Acetaldehyde, methanol, 2-methyl-1-propanol, 1-butanol, 2-methyl-1-butanol, and 3-methyl-1-butanol were analyzed by the official method of OIV (1994), slightly modified, with direct injection of the diluted distillate into a Carbowax 400+Hallcomid M. 1801 classic column, as described by Soufleros et al. (2004). Higher esters (ethyl acetate, 3-methyl butyl acetate, ethyl hexanoate, ethyl octanoate, ethyl decanoate, ethyl decatetranoate, hexyl acetate, ethyl lactate, diethyl succinate, and phenyl-ethyl acetate), fatty acids (butyric, isobutyric, isovaleric, hexanoic, octanoic, decanoic, and dodecanoic), and higher alcohols (1- hexanol, trans-3-hexen-1-ol, cis-3-hexen-1-ol, trans-2-hexen-1-ol, and 2-phenylethanol) were analyzed by the official method of OIV (1994), slightly modified, after their extraction from the samples by a mixture of solvents, as describe by Soufleros et al. (2004). The vine was injected into a capillary column CP Wax 57 CB.

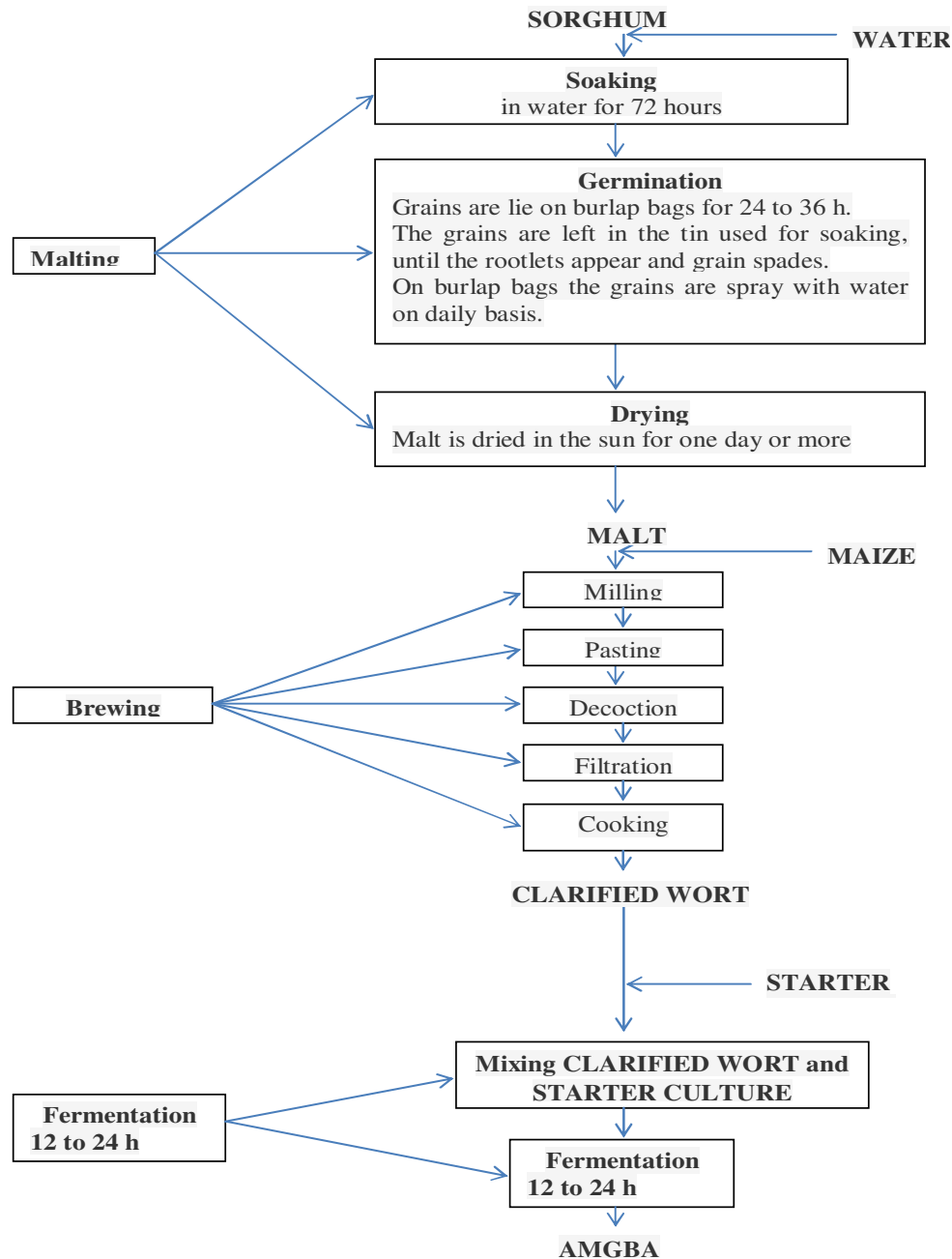
### Total ethanol

Total ethanol content was determined by the Spectrophotometric micro-method for the determination of ethanol after distillation of beer samples that was made alkaline by a suspension of calcium hydroxide (Andrea et al., 2004).

## RESULTS AND DISCUSSION

### Artisanal process production

Designing a process using artisanal technologies for rural



**Figure 1.** Artisanal process production of "Amgba".

artisanal food production with very little information about these processes was not easy. In fact, the reliability of the information from the "popular" or unscientific methods of information is sometimes questionable. This information is often the result of preconceived notions from individual observations. Errors coming from the description of methods are hardly noticeable. Rather than questionnaires, ethnographic methods as described by Schensul (1999) associated with focused group discussion methods (Kumar, 1987) were used for data

collection on the process. From data collected from clustered group discussions we assume the process production to be outlined as shown in Figure 1.

### **Malting**

Most often, populations choose a sorghum variety locally known as "mouskouari" or "djigari" variety (Djoulde et al., 2008).

**Soaking:** After washing, sorghum grains were soaked in water for 72 h to obtain a water content varying from 35 to 40% (w/w). This soaking is required for the germination process. Information from discussion groups, made us know that water temperature is very important for soaking process, in fact, at high temperatures ( $45 \pm 2^\circ\text{C}$ ), the soaking time is rapid ( $20 \pm 4$  h) and at low temperature ( $15 \pm 5^\circ\text{C}$ ), the soaking time is slow ( $70 \pm 2$  h).

**Germination:** Wet grains are placed on burlap bags for 24 to 36 h or the grain are left in the tin used for soaking, usually in a container until the rootlets appear and/or grain spades. On burlap bags, the grains were sprayed with water on daily basis. The disposal of grains in heaps on burlap bags allows a rise of temperature during the process, which facilitates the germination. However, many women do not follow this step, especially in the arid and hot areas, and immediately after soaking, they just place grains over a clean area (wood sheet, clay, rock). The grains are laid in  $3 \pm 0.2$  cm layers, covered with leaves that keep the grains in darkness and maintain adequate humidity. A little water is often added to speed up the process, but avoiding too intense action of fungi and molds. The germination process takes  $4 \pm 1$  days. Sometimes, women say the soaking and germination process can be conducted in jars in the dark, but emphasis that in this case, molds are more frequent and the germination process is slow. This may be explained by the low ventilation and higher humidity inside the jars. After germination, the grains are piled: the temperature rises, the amylase levels increase and eventually stop increasing when the temperature is too high.

**Drying:** This operation corresponds to kilning and brings moisture of the malt to  $18 \pm 5\%$  to keep it protected from the growth of moulds. The malt is dried in the sun for one day or more, sometimes less if it goes straight to the brewing stage.

## Brewing

**Milling:** The malt is crushed in a mortar or crushed on a flat stone when in rural area without access to electric or gasoline millers. In urban areas, the malt is ground in a motorized mill to obtain coarse flour.

**Pasting:** The ground malt is mixed with water with a gelatinous or mucilaginous agent (okra or sap of various trees, especially *Triumfetta* species, which is said by women to enhance flocculation and filtration of insoluble materials. This operation is like "bonding" for clarification in "high gravity" fermentation beer process (Bvochora and Zvauya, 2001). After 1 or 2 h of concentration, the liquid phase is removed at temperature varying from  $25 \pm 2$  to  $35 \pm 1^\circ\text{C}$  according to regions and season. It already

contains some of the soluble malt sugars.

**Decoction:** The lower phase containing the undissolved malt flour is cooked slowly to boil in order to obtain a "cooked starch" with porridge consistency. The cooking process can be extended over an hour, but the upper phase liquid is then mixed with the slurry to be saccharified more easily than if it had not been cooked (Taylor et al., 2006). This may be due to the fact that the diastatic action is most effective on cooked starch than that of raw starch (Shipra et al., 2011). The temperature of the mixture is around 65 to  $70^\circ\text{C}$ , "Amgba" brewing is therefore a one level quenching, as one stage of temperature is observed. At the brewing stage of "Amgba" process production, some women add a mucilaginous agent to promote emulsion. The filtration process commences about an hour after the mucilaginous agent is added. The sorghum malt is rich in alpha-amylase and is particularly effective at  $72$  to  $76^\circ\text{C}$  (Taylor et al., 2006). It breaks the chains of starch leading to various sugars ranging from glucose to other heptaholosides (Wall and Blessing, 1970; Beta et al., 2001). According to Wolfgang (2007), it is the malt amylase which is solely responsible for the saccharification, not those amylases of micro-organisms that accompany the fermentation. This information seems obvious today as many research works has proven that, both plant and microbial enzymes are important in the process (Ashok et al., 2000). In fact, amylases of *Aspergillus flavus* and *Mucor rouxii* play an important role. Kleyn and Hough (1971) showed that using sterilized corn during the processing of beer, saccharification is less important if corn is sterilized than with unsterilized corn. This observation suggests that fungal and malt amylases are both important for good diastatic action during "Amgba" processing.

**Filtration:** The filtration system used for "Amgba" production is similar to that of the "tank-filter" system with the use of vegetables refuse or grass, that serve as supports to the filtering agent, especially cereal straws used in a large wicker basket with large meshes. The entire phase or sometimes the lower phase mash is filtered. The draff is rinsed with cold or warm water according to the brewer's ability. Sometimes, filters are made from thin straws or spent grain using plant fibers. The draff removed by the filters is normally used to feed livestock. Sometimes, people let the mash ferment before filtration so that it can be stored for a longer period of time. This step of acidification makes African beer very different from common European beer.

**Cooking:** The aim of cooking is mainly to clarify the wort by breaking the insoluble material like proteins (Bvochora and Zvauya, 2001). It is done by skimming and stopping the operation according to several subjective criteria such as clarity or color of the wort. Often, women pour into the

liquid few red embers to complete the boiling process. Explanation of this process is that beer will be good if it is made by a "pure" woman, that is, a woman that has not had sex the day before soldering and flames purification, and if this drawback: the steam coming off symbolizing the end of the elimination of water, will give a final liquid gas with a fine mousse, is avoided. For the same purpose at this stage, the Gbaya woman, a tribe from Northern Cameroon sometimes add a small amount of cassava flour. Coals can be used to tint the liquid when cooking is short. No products such as aromatic hops are added.

### **Fermentation**

The wort is cooled either spontaneously or by successive decanting operations. When the temperature of wort is around 30°C, it is mixed with an ongoing "affouk" fermentation used as starter culture. It is also common to use an old fermentation tank containing remaining beer from previous fermentation. Fermentation lasts from 12 to 24 h, but sometimes when the temperature is low it can last for two days, especially the beer brewed in December for consumption during Christmas festivities. It is therefore important to have highly concentrated wort. The fermentation process of "Amgba" is rapid, similar to that of the "top fermentation" (Luca et al., 2011). In many ethnic groups of Cameroon, the starter culture is recovered from the bottom of fermentation tanks. The cake is sun dried and kept as starter culture for new production. Some women also say that for newly started brewing business, they can purchase starter from neighbouring brewers or use a commercial bread starter culture *Saccharomyces cerevisiae*. It is also said that starters can be inherited from mother to daughter or given as a wedding gift by the husband's family. Some starters are said to be specific and give best beer than other. Beer brewed with "affouk" starter can be immediately consumed after filtration, without stopping the fermentation process. The fermented liquor is then allowed to undergo second spontaneous lactic acid fermentation for a few hours to a full day. The wort then develops a sour taste. This acidification is essential in the production of local beer and is said to induce a second saccharification.

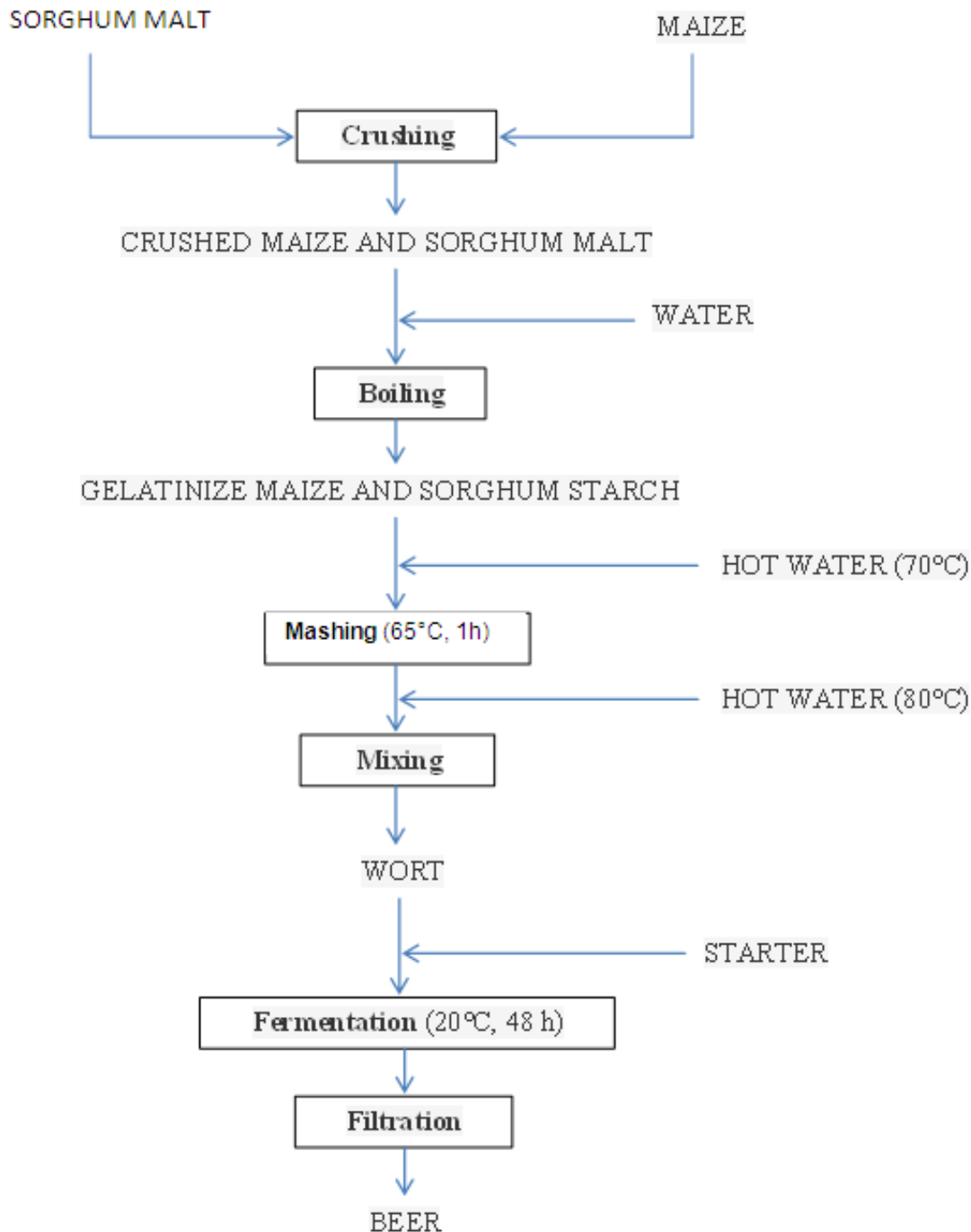
### **Laboratory scale modified artisanal process production**

It was difficult to describe objectively a process developed by people without reference to scientific data to interpret and understand the principles related to "Amgba" process production. However, these sources should be based on an experimental study. The experimental study of the process was thus necessary for

this paper to complete data collected from primary source. From the artisanal process production described and using literature on industrial beer production, we set up and tested at laboratory scale, a new flow chart for "Amgba". Some steps were harmonized and corrected according to occidental beer processing methods (Figure 2). The principal ingredients used for the processing of "Amgba" at laboratory scale were a mixture of sorghum and maize, as these are the principal ingredients used to brew industrial opaque beer similar to "Amgba". Industrial versions of opaque beer actually contain very little sorghum, the remainder being unmalted maize (Odunfa and Adeyele, 1985; Maoura et al., 2005, 2006). Traditionally, malted grain sorghum comprises at least half of the grain bill in home and village-brewed versions, the other half being millet or maize. The essential steps modified for laboratory scale production of "Amgba" are: sour mashing, boiling, sugar mashing, alcoholic fermentation, and straining (Figure 2). For the purpose of laboratory scale production, the sour mashing and sugar mashing steps were kept simple. Souring in particular is very difficult to control as seen in traditional processing, and "Amgba", when freshly consumed, should have just a hint of sourness. The laboratory scale production recipe is as follow for 8 L: 1/2 kg of sorghum malt, 1/2 kg of unmalted maize, and 200 g of Red Star baking yeast. The maize was crushed and boiled in water for about 15 min to gelatinize starch. The crushed sorghum malt and maize was then drained and added to the mashing vessel. Water (4 L) at 70°C at the time of mixing was added to reach mashing temperature of approximately 65°C. Mashing was allowed for 1 h. The liquid portion of mash was then transferred to the fermentation vessel by pouring the entire contents of mash vessel through a fine-mesh wire basket. Grains were then sparged with sufficient hot water (~80°C) to obtain 8 L of wort. The wort was left to cool naturally overnight or until reaching room temperature. Depending on the age and condition of the sorghum malt (which has fairly low diastatic power), a small amount of corn sugar was added to bring the gravity up to this level. The yeast was then added after being rehydrated in a little warm water. One cup of additional crushed sorghum malt was also added to further induce lactic fermentation. The mixture was stirred vigorously to combine ingredients and oxygenate the wort. The fermentation was then allowed for 2 days at room temperature (20°C is optimum), then the beer was filtered through a wire basket once again into storage vessels. The new beer was cooled by refrigeration at around 4°C to stop fermentation. The obtained "Amgba" beer, when fresh, is opaque, slightly pink-colored, and yeasty.

### **Sensorial analyses**

The sensory qualities of traditional and laboratory made



**Figure 2.** Laboratory scale process production of “Amgba”

“Amgba” and commercial beer are summarized in Table 1. The sensorial properties of “Amgba” were significantly different ( $P < 0.05$ ) according to brewing method and as comparing to industrial sorghum beer, “Amgba” presented the best score for overall acceptance ( $7.4 \pm 0.3$ ). This may be due to high levels of acidity recorded (Table 2). We can notice a strong correlation ( $r = 0.91$ ) between the composition of raw material and the

panelists’ choice based on taste. In fact, we have more sorghum in beer, which is appreciated more by the panelist. This may indicate that sorghum amount is the main ingredient driving consumer’s choice in “Amgba” beer. As regard to the appearance, industrial sorghum beer seemed to be better than locally brewed one (traditional and laboratory). However, the used panel seems to dislike laboratory made “Amgba” more for its,

**Table 1.** Sensory test of traditional “Amgba” and laboratory made “Amgba”.

Sample	Visual examination*	Odor	Flavour and taste	Harmony
Traditional “Amgba”	3.0 ± 0.7 <sup>a</sup>	6.1 ± 0.6 <sup>c</sup>	5.1 ± 0.5 <sup>a</sup>	7.4 ± 0.3 <sup>c</sup>
Laboratory “Amgba”	4.2 ± 0.5 <sup>a</sup>	3.5 ± 0.7 <sup>a</sup>	5.7 ± 0.7 <sup>a</sup>	6.9 ± 0.2 <sup>b</sup>
Industrial sorghum beer	6.7 ± 0.4 <sup>b,a</sup>	3.7 ± 0.9 <sup>a</sup>	4.1 ± 0.3 <sup>a,b</sup>	4.2 ± 0.8 <sup>a</sup>

Visual examination = Color and overall appearance; Harmony = Overall acceptability.

**Table 2.** Comparative study of the chemical compounds obtained for local made traditional “Amgba” and laboratory made “Amgba”.

Sample	Total titratable acidity (mg/L)	Volatile acidity (g/L)	Total alcohol (%)	pH	Residual total sugars (g/L)	Total polyphenol (mg/L)
Industrial sorghum beer	8.2 ± 0.6	0.3 ± 0.00	5 ± 0.9	6.2 ± 0.6	0.2 ± 0.0	521 ± 25
Laboratory made “Amgba”	14.4 ± 0.14	0.2 ± 0.00	7 ± 0.7	2.9 ± 0.0	1.5 ± 0.1	772 ± 39
Traditional “Amgba”	16.2 ± 0.10	0.2 ± 0.00	4.5 ± 0.2	2.5 ± 0.0	1.3 ± 0.3	802 ± 67

**Table 3.** Comparative study of the alcohols and acetaldehydes obtained for local made Traditional and Laboratory made “Amgba”.

Sample	Alcohols other than ethanol (in g/hl absolute alcohol)		
	Industrial sorghum beer	Laboratory made “Amgba”	Traditional “Amgba”
Methanol	161.0 ± 19	396.7 ± 14	549.2 ± 15
Butanol-1	3.03 ± 0.1	6.34 ± 0.09	6.31 ± 0.16
2-methyl 1-propanol	42.59 ± 1.44	18.57 ± 1.23	14.59 ± 1.17
2-methyl 1-butanol	15.49 ± 1.55	14.49 ± 1.22	16.64 ± 1.24
3-methyl 1-butanol	62.4 ± 2.9	46.1 ± 2.9	44.1 ± 3.7
1-Hexanol	1.12 ± 0.09	0.90 ± 0.05	0.88 ± 0.07
cis-3-Hexen-1-ol	1.86 ± 0.07	0.62 ± 0.02	0.63 ± 0.08
trans-3-Hexen-1-ol	0.70 ± 0.03	0.51 ± 0.1	0.50 ± 0.1
trans-2-Hexen-1-ol	0.09 ± 0.01	0.05 ± 0.01	0.04 ± 0.00
2-phenyl-ethanol	3.02 ± 0.09	4.94 ± 0.1	4.11 ± 0.2
Total higher alcohols (g/hl AA)	279.8 ± 76.1	245.2 ± 48.0	232.9 ± 58.4
Acetaldehydes (g/hl AA)	134.5 ± 20.4	210 ± 27.6	270 ± 32.9

odour while industrial sorghum was more appreciable for its colour than the two beers. The flavours of traditional “Amgba” and laboratory made “Amgba” seem alike as compared to industrial sorghum beer. Irrespective of the amount of sorghum added, multiple regression analyses revealed an inverse significant ( $P < 0.05$ ) relationship between aroma, taste, visual examination, and overall acceptability of beers. Titratable acidity was also associated significantly ( $r = 0.4$ ;  $P < 0.05$ ) with taste.

### Biochemical analyses

Comparative study of the chemical composition of local made traditional “Amgba”, laboratory made “Amgba”, and industrial sorghum beer (Table 2), showed that the first two beverages are more or less alike as compared to industrial sorghum beer as regard to the six

physicochemical analyses. The total alcohol, volatile acidity, and total polyphenols levels seems not significantly different, however, we notice a significant difference ( $P < 0.05$ ) between industrial sorghum beer and the two other for pH, total titratable acidity, and residual sugars (Table 3).

Concerning different types of alcohols and acetaldehydes levels (Table 3), alcohols other than ethanol levels are significantly different ( $P < 0.05$ ) when comparing the industrial sorghum beer to the locally brewed opaque beers. Total higher alcohols seem alike and acetaldehyde levels are different from industrial sorghum beer. Kayodé et al. (2007), studying the impact of process unit operations on phytate, phenolic compounds, and zinc and iron *in vitro* solubility indicate that the manufacturing process reduces the phytate content by nearly 95%, particularly during germination, mashing-boiling, and fermentation. The level of reactive

phenolic groups increased as a result of germination and fermentation as well as from a shift in dry matter composition (Haggblade and Holzapfel, 2004)

## Conclusion

The process of "Amgba" production is still very artisanal and does not follow Hazard Analysis and Critical Control Point (HACCP) rules for good quality. However, biochemically analyzed samples indicate broadly a good quality of components recorded for industrial European beers. Thus, the final product cannot present a risk to consumers in regard with biochemical components. Setting a laboratory scale production flow chart has shown that it is technically possible to brew "Amgba" on a larger scale (industrial) without drastically altering its sensorial properties. However, further work is needed in order to set up a hazard control of critical point to ensure good hygienic quality beer for broader use by populations and to classify and improve the quality of commercial "Amgba".

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