

Process Diagnosis and Aging Effects on a Traditional Millet-Based Drink: *Boumkaye*

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Abstract

Boumkaye is a traditional fermented millet-based drink (*Pennisetum glaucum* L.) produced in Casamance (region in Senegal). Unknown and circumscribed beverage, it has therapeutic properties due to aqueous creeper extracts from *Abrus pulchellus* plant and naturally present during the process. The objective of this work was to investigate the fabrication process of a millet-based beverage as an alternative source of nutrients. The diagnosis of beverage production by monitoring its physical and chemical parameters during two months of storage at room temperature was studied. The established manufacturing process, composed by a production of aqueous extracts after maceration of the *Abrus pulchellus* vines, a preparation of millet slurry, and a fermentation step to obtain the *Boumkaye*, has several features. The study of aging process showed probable lactic and alcoholic fermentations. Further, the finished *Boumkaye* was characterized by a high acidity (pH of 3), an alcohol content of 5 g/100g and contains an appreciable amount of polyphenols (54.46 mg/100g).

Keywords

Pennisetum glaucum L., *Abrus pulchellus*, Traditional Drinks, Fermentation, *Boumkaye*

1. Introduction

In Africa, many traditional beers are especially prepared from millet, sorghum,

rice and maize [1] [2]. These drinks are used in many cultural and social events showing hospitality and conviviality in lifestyle of most families. They are also used to strengthen relationships between individuals [3] [4]. Different reactions are initiated during the manufacture of traditional African beers, and usually continue until consumption according to empirical processes. In Casamance region (South of Senegal), a fermented drink called *Boumkaye* is considered to possess anthelmintic virtues related to aqueous extracts from the plant of *Abrus pulchellus*. *Abrus pulchellus* is a medicinal plant known for its many uses in traditional medicine for its pharmacological and anticancer properties, also to treat gastric problems [5] [6]. Despite its sociological importance in this southern zone of Senegal, the fabrication process of a traditional beer with *Abrus pulchellus* extracts has not previously been reported. In addition, ethnobotanical studies (Reference) revealed that many properties of *Boumkaye* drink were obtained during aging process. Therefore, the objective of this present study was to thoroughly investigate the manufacturing process of *Boumkaye* and its aging on physico- and biochemical changes that would explain traditional benefits previously mentioned. This would help to facilitate a large-scale production of this traditional fermented millet based beverage.

2. Materials and Methods

2.1. Diagnosis of Manufacturing Processes

Two production sites, AFBARD Company and traditional Baïla producers, were used in monitoring and diagnosing manufacturing of *Boumkaye* variability in the period of May to July.

Each operation unit was identified and described. Material flows and physical parameters were listed. In the sites, information was supplemented by observations, recordings (temperature, time), measurements (weight, volume), and interviews with different operators. The process description was performed twice in each production site. The same conditions were used in laboratory in order to similarly reproduce the fermented studied drink for the aging study.

2.2. Plant Material

The analyzed samples of *Boumkaye* drinks were obtained during the diagnoses. *Boumkaye* 1 was produced following AFBARD Company procedure; while *Boumkaye* 2 drinks was obtained as described in traditionally produced by Baïla producers. Two samples per site were analyzed. Analyses of each were performed in triplicate.

2.3. Analytical Methods

The pH, titratable acidity, dry matter, and the ethanol content were evaluated according to the AFNOR standard methods [7]. The reducing sugars and total

sugars were quantified by Luff Schoorl's method [7]. Total polyphenols were determined according to George method, in Gallic acid equivalent [8].

2.4. Statistical Analysis

The analysis of variance (ANOVA) tests on each factor were carried out with the STATISTICA 7.1 software. The objective was to compare significance of samples' analytical results for each parameter. Statistical differences with a probability value less than 0.05 ($P < 0.05$) were considered as significant.

2.5. Aging Study of the Fermented Drinks

The aging study was followed by monitoring and characterizing the evolution of parameters during the storage and/or manufacturing conditions. The crude *Boumkaye* obtained at the end of each diagnosis was kept at ambient temperature (25°C). A monitoring period of 7 days was carried out on each sample batch physicochemical and biochemical parameters during one month storage.

3. Results and Discussion

3.1. The Manufacturing Process

A production diagram was made following both studied sites. Thus, three different parts including the production of an aqueous extract by maceration of the creepers of *Abrus pulchellus* (Figure 1 and Figure 2); the preparation of the millet slurry and a final fermentation step to obtain the *Boumkaye* (Figure 3).

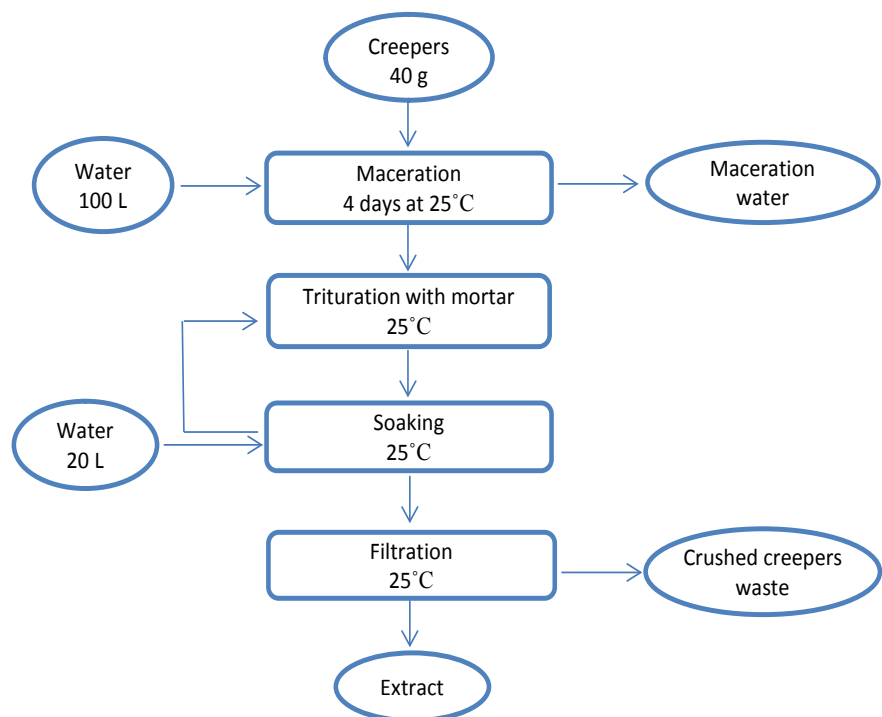


Figure 1. Diagram for obtaining the aqueous extract of the creepers of *Abrus pulchellus*.

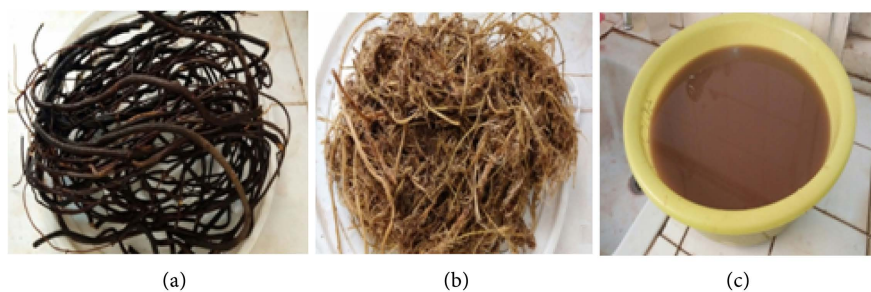


Figure 2. The creepers of *Abrus pulchellus* before (a) and after (b) trituration-soaking and aqueous extract (c).

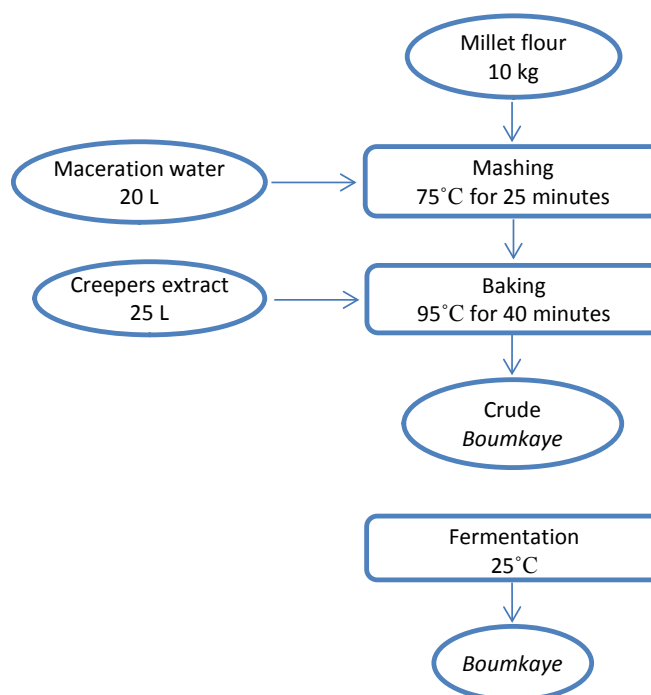


Figure 3. *Boumkaye*'s production diagram.

3.1.1. The Aqueous Extract of *Abrus pulchellus*

Three to four days of maceration in water of *Abrus pulchellus* creepers (**Figure 2(a)**) was done in order to soften and facilitate active ingredients' extraction. The softened lianas were then trituated with mortar in a controlled manner and then soaked in a basin of water. This operation was repeated several times in order to remove sufficiently the bark (**Figure 2(b)**). The extract was then filtered and the slurry was used in the next step of fermentation (**Figure 2(c)**).

3.1.2. Preparation of the Mixture and Fermentation Steps for *Boumkaye* Obtention

The millet flour was mixed with water from macerated *Abrus pulchellus* creepers in a ratio of 10 kg/20L (w:v) during a first cooking phase which lasts 25 to 30 minutes. In this period, a paste was formed and the dough was brought to a maximum temperature of 75°C. A second cooking phase was initiated after adding 25 liters of extract of the *Abrus pulchellus* creepers. The cooking was

carried out at 95°C for 40 minutes to obtain a crude *Boumkaye* which can be consumed. Furthermore, this intermediate product was stored at room temperature (.....°C) for (....) days, which allowed a fermentation step for the final *Boumkaye*.

Stages of malting, brewing and fermentation are the main components used in traditional (*Tchapalo*, *Dolo*) and industrial processes. The purpose of mixing was to solubilize the bioactive compounds and to produce lytic enzymes necessary for the production of fermentable sugars [9], while the fermentation takes place after adding leaven.

The manufacturing process for producing *Boumkaye* beverage is different and presents particular features different to malting, a brewing step without separation of the grains and the use of aqueous extracts of vegetable origin. The creepers of *A. pulchellus* underwent a maceration step which help softening and facilitating the trituration step. The trituration-soaking step could represent the actual extraction phase of the active compounds required during the production of *Boumkaye*. The paste formation was involved in the hydrolysis phase of the starch contained in the millet flour. It was carried out hot for enabling the activation of various enzymes, responsible of the starch conversion into simple fermentable sugars. Thus, *Boumkaye* could maintain most ingredients (nutrients and fibers) of the millet flours, and therefore constitute a real food rather than a drink. The cooking time was also reduced compared to the *Tchapalo* and *Dolo* process [10] [11]. A natural fermentation of the slurry at room temperature without adding ferments was performed. Therefore, a phase of aging was necessary where the drink acquired most of its characteristic organoleptic properties. These various biotransformations would probably be initiated by germs either endogenous to millet or derived from the extract of the creepers of *Abrus pulchellus*. In the case of *Tchapalo* and *Dolo*, extracts of okra stems *Hibiscus esculentus* are used [12]. It was tempted to deduce that the stirring step was carried out by the aqueous extract of *A. pulchellus*. This would imply the presence of hydrolytic enzymes in this extract.

3.2. Physico-Chemical Characteristics of the Raw *Boumkaye*

The *Boumkaye* drinks obtained during the diagnoses were subjected to physico-chemical, biochemical and nutritional characterizations. Results are presented in **Table 1**. Products pH was around 4 in the extracts millet based and titratable acidities were ranged from 1.62 to 3.4 mEq/100g. These results proved that the beverages were relatively non-acidic, and very favorable to the different fermentation reactions. The two production trials on *Boumkaye* revealed significant differences in the values with exception of polyphenols, dry matter and minerals.

3.3. Study of the Aging

The samples collected after the diagnosis were stored at room temperature (30°C).

Table 1. Physico-chemical and biochemical characteristics of the raw *Boumkaye*.

Analyzes	<i>Boumkaye</i> 1	<i>Boumkaye</i> 2
Dry matter (g/100g)	9.84 ± 0.07 ^a	11.47 ± 0.01 ^b
Ash (g/100g)	0.69 ± 0.19 ^a	0.88 ± 0.19 ^a
pH	4.62 ± 0.13 ^a	4.26 ± 0.00 ^b
Titratable acidity (mEq/100g)	1.62 ± 0.17 ^a	3.40 ± 0.20 ^b
Polyphenols (mg galic acid/100g)	31.86 ± 0.01 ^a	54.46 ± 0.01 ^a
Reducing sugars (g/100g)	0.94 ± 0.00 ^a	1.90 ± 0.22 ^b
Total sugars (g/100g)	1.04 ± 0.00 ^a	2.10 ± 0.02 ^b
Protein (g/100g)	2.39 ± 0.00 ^a	10.37 ± 0.00 ^b

The analyzed parameters were related to fermentation reactions and the aging of *Boumkaye*. Thus, pH (**Figure 4**), titratable acidity (**Figure 5**) and ethanol content (**Figure 6**) were followed in several batches of *Boumkaye* crude. The values obtained from studied products reflected a lower pH (how much?). This pH value could be explained by sugars consumption through the fermentation process. During the aging, increase of acid contents could be explained by a lactic fermentation, a conversion of reducing sugars into acids (**Figure 5**). At the same time, an alcoholic fermentation took place, explaining the increase of alcohol content (average of 5 g/100g) (**Figure 6**).

Many reactions occur during fermentation resulting of a decrease of reducing sugars. The consumption was reflected in decrease of pH during aging (maturation), due to combined effects of ethanol and organic acids. The pH firstly exerts a selective action on the microflora likely to develop in the medium. The increase of low pH protects the beverage from the development of any pathogenic flora without inhibiting the activity of the yeast. In addition, some authors stated that an important inhibition would occur at a very acidic pH (pH below 3) [13] [14]. Consequently, the decrease in pH by a production of fermented products (acid or alcohol) reduced the consumption rate of the carbonaceous substrate (reducing sugars) and consequently reduces productivity [10]. Therefore, ethanol becomes toxic to microorganisms beyond a certain value. This justifies the limiting pH of *Boumkaye* 3 found mostly in traditional African drinks [11] [15] [16] [17], unlike industrial beers which contain hops [18]. Two types of traditional beers were found according to composition and appearance during the sensory evaluation. These could be ranged from sweet, relatively light, non-acid with little material and acid beers, brown and opaque, resembling fluid porridge. The main difference between these two categories of beer was related to the duration of lactic fermentation [19]. Also, work on Rwandan *Ikigage* showed beneficial influence of the yeast from *Saccharomyces cerevisiae* species and lactic acid bacteria (*Lactobacillus fermentum*) on taste and aroma [20]. While in Ivorian *Tchapalo*, the production of bacteriocins by lactic acid bacteria inhibits the development and growth of many pathogenic germs of the genus

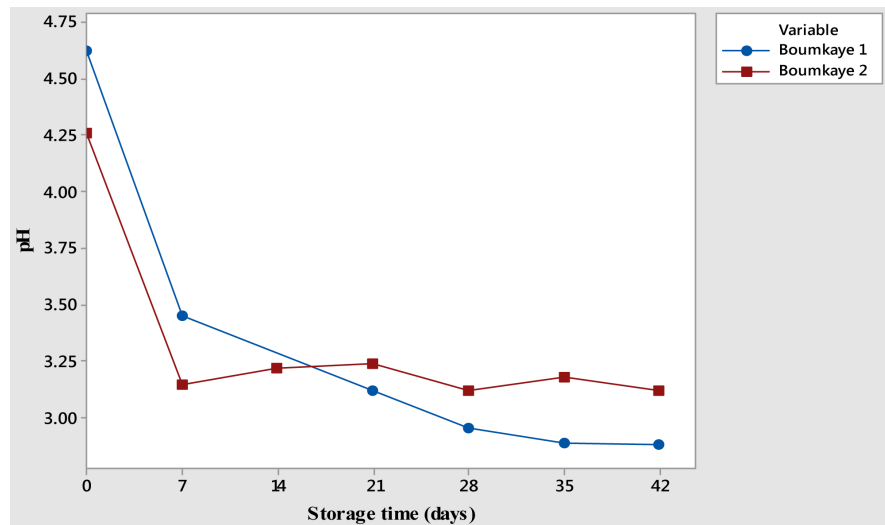


Figure 4. Evolution of the pH during the maturation of *Boumkaye*.

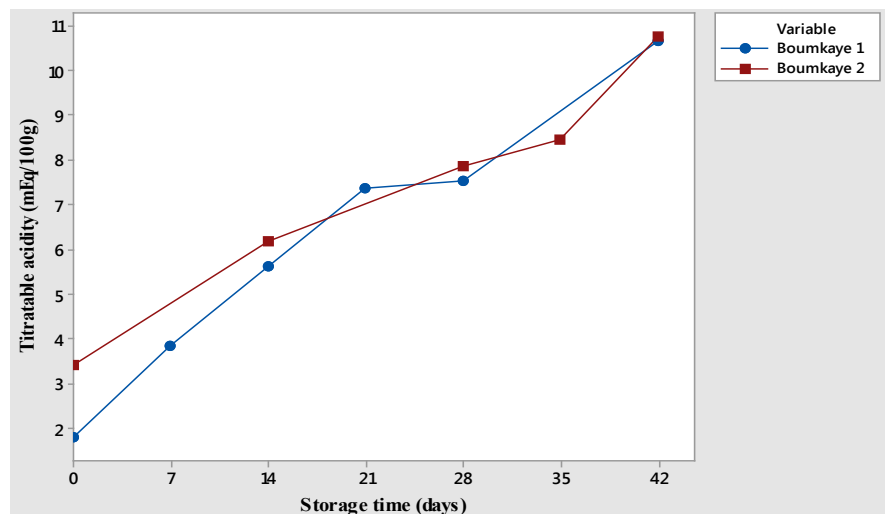


Figure 5. Evolution of the titratable acidity during maturation of *Boumkaye*.

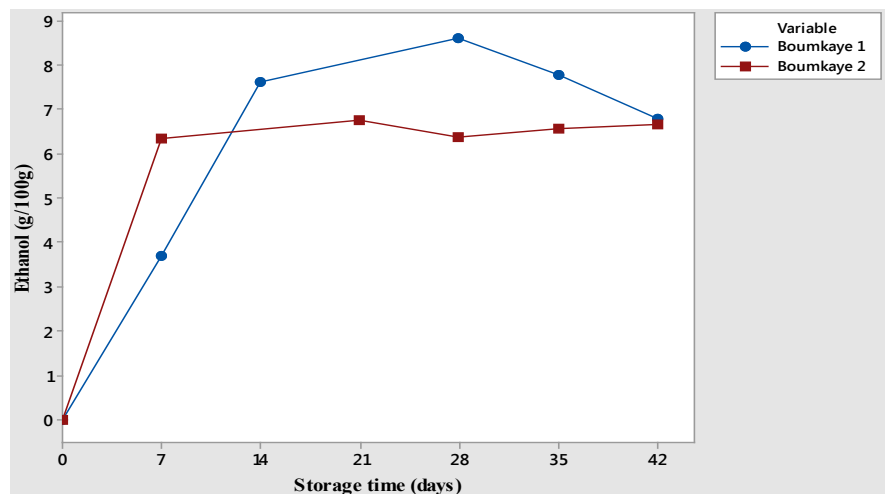


Figure 6. Evolution of the ethanol content during the maturation of *Boumkaye*.

Lactobacillus, *Listeria*, *Enterococcus*, *Streptococcus* [21]. The fermented *Boumkaye* was characterized by an ethanol content comparable to sorghum-based *Tchapalo* (5.03 ± 0.77 g/100g) [11] [12], unlike *Dolo* (2.3 ± 0.25 g/100g) [22]. In short, the *Boumkaye* acquires its characteristic properties from a relatively long aging (42 days), corresponding to a double fermentation. The same conclusions have been drawn from many empirical processes for the manufacture of traditional fermented beverages [12] [15] [22].

4. Conclusion

Boumkaye is a traditional fermented millet-based drink associated with an extract of the creepers of *Abrus pulchellus*, known for its numerous therapeutic virtues. This beverage has a maturation cycle linked to a double fermentation: lactic and alcoholic. Compared to a few local African beers, the *Boumkaye* is similar in its alcohol content, but its process was free of malting and brewing. This work provides a better knowledge of this traditional beer and paves the way for possible studies on the biotechnological role of *Abrus pulchellus* extract during storage. The optimization of each step of the process is necessary in order to increase the productivity and to improve the technological aspects of *Boumkaye* for a better use by producers.

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