

Stabilization of *Boumkaye*'s Drink for an Accessibility in the Markets

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Abstract

Boumkaye is a fermented drink made from millet, and prepared according to a traditional process from Casamance's region in Senegal. Still consumed for its anthelmintic properties, *Boumkaye* is obtained after maturation marked by two stages of fermentation (lactic and alcoholic). The main limits of this drink are the spontaneous nature of the fermentation and its instability. The objectives of this study is to stabilize this drink after fermentation step. For this purpose, an autoclave heat treatment at 120°C/15 minutes scale has been proposed. Two types of sterilized *Boumkaye* (crude and fermented) were kept at two temperatures (4 and 25°C) for one year follow-up. The sterilization tests on crude *Boumkaye* and fermented *Boumkaye* provided excellent microbiological and nutritional quality. No germ was detected during the entire storage period. In addition, *Boumkaye* beverages can be stored at 25°C (room temperature) for a minimum of one year while preserving all its organoleptic and therapeutic properties. This is a considerable asset for future industrial exploitation.

Keywords: Traditional drinks, Fermentation, Stabilization, *Boumkaye*

Introduction

Africa has real potential in terms of fermented cereal drinks. There is a great diversity of these local beers both in the cereals used (millet, maize, sorghum, rice) (Quin, 1959, Monjerezi et al., 2011) and in manufacturing

processes (Kayodé et al., 2005, Maoura et al., 2005, Dicko et al., 2006, Lyumugabe et al., 2012). In Senegal, a fermented millet drink called *Boumkaye* is prepared by incorporating aqueous extracts of a medicinal plant, *Abrus pulchellus*. *Boumkaye* is known for its antihelminthic properties (Cisse et al., 2018).

Major limitations of African conventional beers are at the fermentation stage and stabilization processes that can guarantee sanitary quality. Indeed, the must is inoculated with a traditional starter and the fermentation time varies between 10 and 24 hours at room temperature (Kayodé et al., 2005, Lyumugabe et al., 2010). During storage, sorghum-based beers are consumed while still in fermentation (Mwesigye and Okurut, 1995). In the case of *Boumkaye*, a maturation stage characterized by a double fermentation (lactic and alcoholic), without addition of leaven, has been established (Cisse et al., 2018).

Thus, a stabilization of *Boumkaye* drink by autoclave heat treatment will be proposed to ensure its hygienic and sanitary quality; while preserving at best its nutritional and therapeutic characteristics.

Material and methods

Production of Boumkaye drink

Boumkaye was prepared in the laboratory according to the manufacturing chart prepared by Cisse et al., (2018). This process comprises three major and distinct parts: the production of an aqueous extract by maceration of the vines of *Abrus pulchellus*; the preparation of the millet porridge and a final fermentation and maturation phase.

Samples consisted of two types of *Boumkaye*. A crude *Boumkaye* that is not fermented; and a fermented *Boumkaye*, obtained after a maturation stage of two months. The drinks were packaged in 300 ml jars (Figure 1). Analyses of each were performed in triplicate.



Figure 1. Millet-based beverages: (a) crude Boumkaye; b) fermented *Boumkaye*

Autoclave heat treatment

Autoclave heat treatment was intended to eliminate all germs that could develop in *Boumkaye*. The sterilization was carried out using a laboratory autoclave of the type Lequeux (calculation pressure 2.5 bar, internal volume 270 liters, temperature 139°C, year 1994) at the scale of 120°C/15 minutes at the pressure of 1 bar.

Physicochemical methods

pH, titratable acidity, dry matter, reducing and total sugars, and ethanol content were evaluated according to standard AFNOR methods (AFNOR, 1982). The total polyphenols were evaluated by spectrophotometric test with Folin-Ciocalteu reagent in a basic medium at 760 nm. The concentration of polyphenols is expressed in gallic acid equivalent (Georgé et al., 2005). The color indices (browning index and yellow index) were determined by the L*a*b system (AFNOR, 2011) using a laboratory colorimeter (Konika Minolta, CR C5).

Microbiological methods

Microbiological flora analyzed was related to the different fermentation reactions of *Boumkaye* beverage and the efficacy of sterilization. Germs were counted according to French standards (AFNOR, 2013).

Statistical analyses

The variance analysis tests (ANOVA) were performed with the STATISTICA 7.1 software. Statistical differences with a probability value less than 0.05 are considered significant.

Study of the stability of sterilized beverages

Millet-based beverages (crude *Boumkaye* and fermented *Boumkaye*) were sterilized and stored at two temperatures (4 and 25°C) for a 12-month follow-up. The idea was to study the stability of the samples according to a monthly evaluation of physico-chemical and biochemical parameters (pH, acidity, ethanol, color); and microbiological ones (total flora, lactic acid bacteria, yeasts and moulds).

Results

Physico-chemical characteristics of Boumkaye beverages

The initial characterization focused on millet-based beverages in order to define the impact of heat treatment on nutritional and organoleptic quality (Table 1).

Sterilization had no significant impact on physico-chemical and biochemical parameters of the crude *Boumkaye* excepted yellow and browning

indices. For the fermented one any impact was notified for ashes, dry matter and browning index. Differences were especially noted in terms of polyphenols (251 mg/100g for unsterilized, to 326 mg/100g for sterilized) and color indices which increase significantly in fermented *Boumkaye*. Other value were increased after sterilization of fermented *Boumkaye*, such us pH and titratable acidity.

Table 1. Characteristics of crude *Boumkaye* and fermented *Boumkaye* before and after sterilization

Analyzes	Crude <i>Boumkaye</i>		Fermented <i>Boumkaye</i>	
	unsterilized	sterilized	unsterilized	sterilized
pH	6.31 ± 0.01 ^a	6.31 ± 0.01 ^a	3.52 ± 0.02 ^b	3.63 ± 0.04 ^c
Dry matter (g/100g)	10.41 ± 0.24 ^a	10.64 ± 0.52 ^a	15.44 ± 0.51 ^b	14.94 ± 0.10 ^b
Titratable acidity (mEq/100g)	1.24 ± 0.00 ^a	1.09 ± 0.12 ^a	8.94 ± 0.00 ^b	7.97 ± 0.24 ^c
Ash (g/100g)	0.29 ± 0.11 ^a	0.14 ± 0.01 ^a	0.24 ± 0.03 ^a	0.24 ± 0.03 ^a
Total sugars (g/100g)	0.33 ± 0.03 ^a	0.41 ± 0.01 ^a	0.14 ± 0.00 ^b	0.16 ± 0.00 ^c
Reducing sugars (g/100g)	0.30 ± 0.01 ^a	0.37 ± 0.01 ^a	0.12 ± 0.02 ^b	0.13 ± 0.02 ^c
Polyphenols (mg gallic acid/100g)	82.95 ± 7.54 ^a	86.79 ± 8.69 ^a	251.61 ± 5.87 ^b	326.01 ± 3.17 ^c
Ethanol (g/100g)	-	-	3.04 ± 0.07 ^a	3.59 ± 0.17 ^b
Yellow index	31.71 ± 0.17 ^a	36.14 ± 0.02 ^b	42.35 ± 0.04 ^c	41.69 ± 0.00 ^d
Browning index	31.46 ± 0.25 ^a	39.08 ± 0.00 ^b	46.36 ± 0.07 ^c	46.74 ± 0.00 ^c

Efficacy of heat treatment

The efficacy of the heat treatment is evaluated by the microbiological quality of the product after autoclaving. Different germs were sought and the results obtained are recorded in Table 2.

Table 2. Microbiological evaluation of *Boumkaye* beverages before and after sterilization in CFU/g

Germs	Crude <i>Boumkaye</i>		Fermented <i>Boumkaye</i>	
	Unsterilized	sterilized	Unsterilized	sterilized
Total flora	40000	< 10	360.10 ⁶	< 10
Lactobacilli	3300	< 10	6.10 ⁶	< 10
Moulds	< 10	< 10	< 10	< 10
Yeasts	20000	< 10	19.10 ⁶	< 10

Microbiological characterization shows a preponderance of lactobacilli and yeasts in unsterilized beverages at the expense of moulds. None germs was found after heat treatment. This proves indeed, the effectiveness of the method of stabilization with the autoclave.

Study of the stability of sterilized beverages

Stability study was designed to define the optimal temperature/duration conditions for the preservation of millet-based beverages. This results in a stability of crude and fermented *Boumkaye* throughout the duration of the monitoring, and regardless of the temperature for both physicochemical and microbiological parameters. Indeed, there were

no significant differences between the results obtained during the aging study. The temperature 4°C has the same levels of preservation as the temperature 25°C (Figure 2, 3, 4, 5 and 6). Crude and fermented *Boumkaye* were exempted from germs during the stability study.

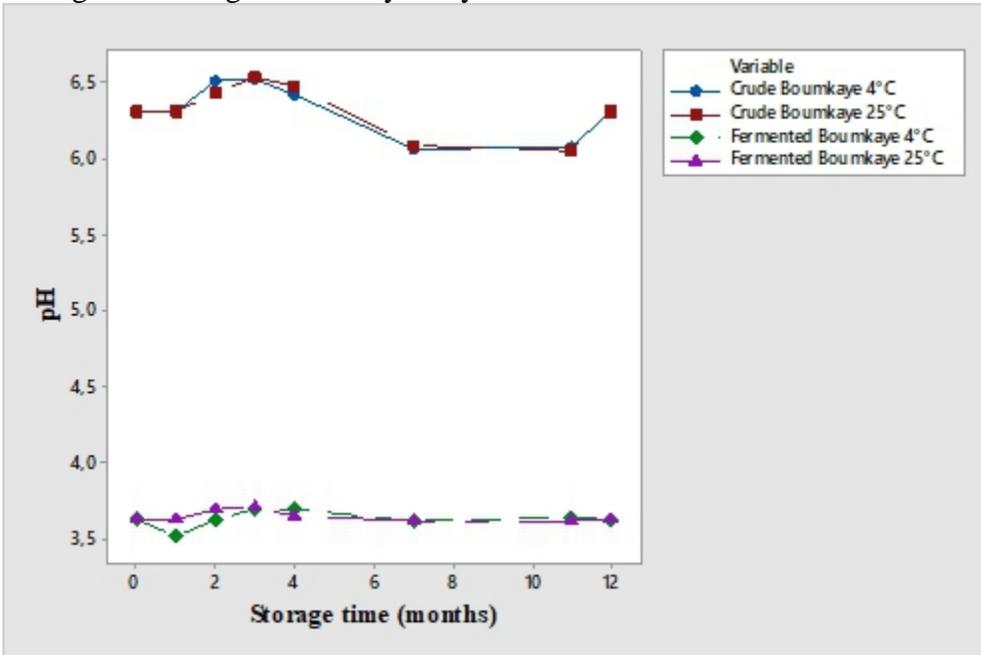


Figure 1. Evolution of the pH according to the storage period of *Boumkaye*

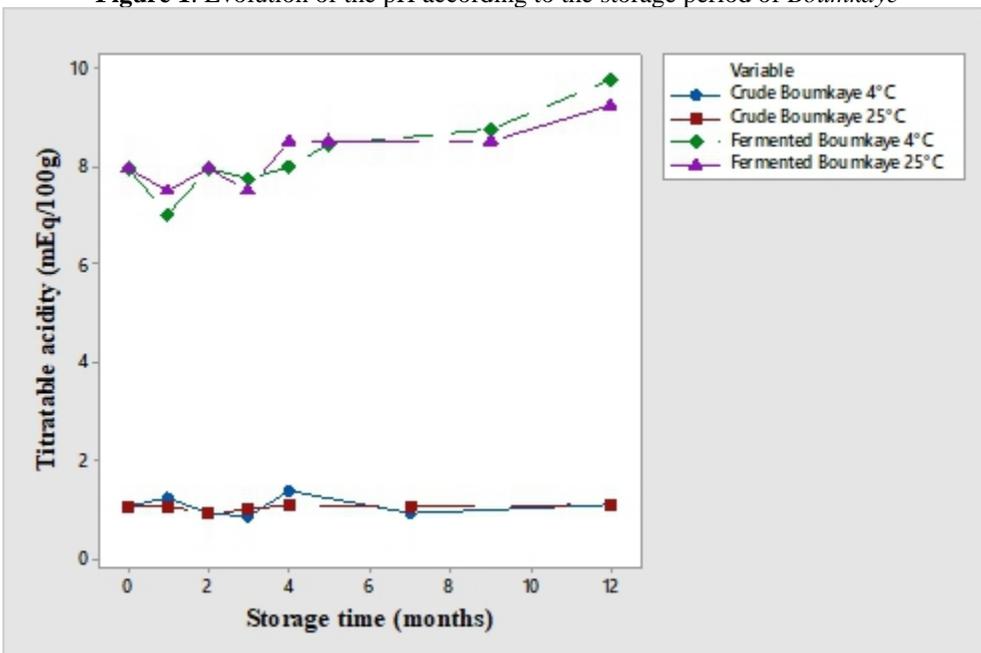


Figure 2. Evolution of the titratable acidity according to the storage period of *Boumkaye*

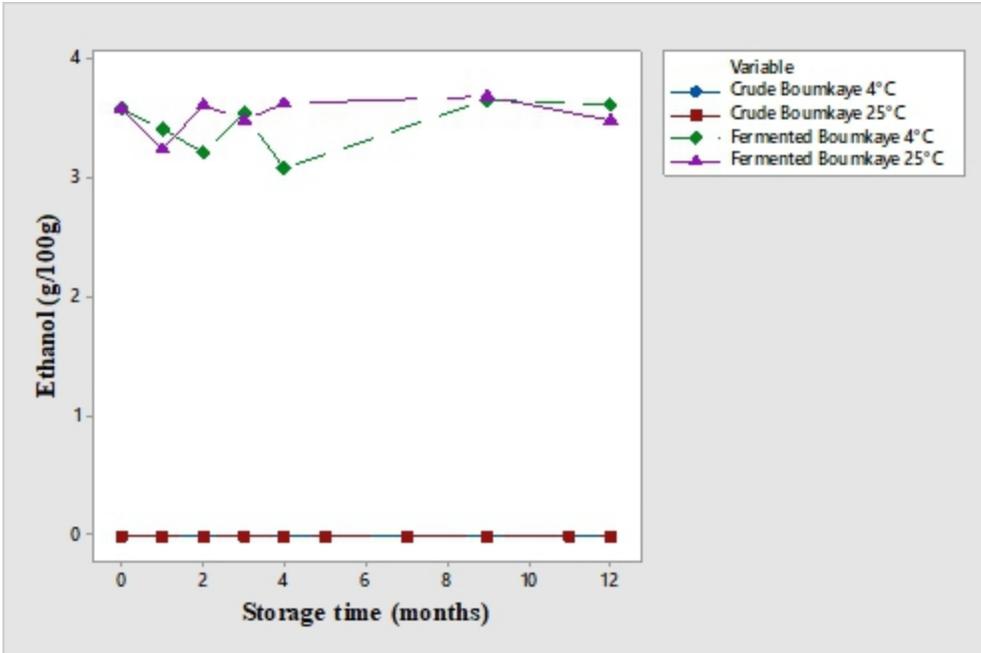


Figure 3. Evolution of the ethanol content according to the storage period of *Boumkaye*

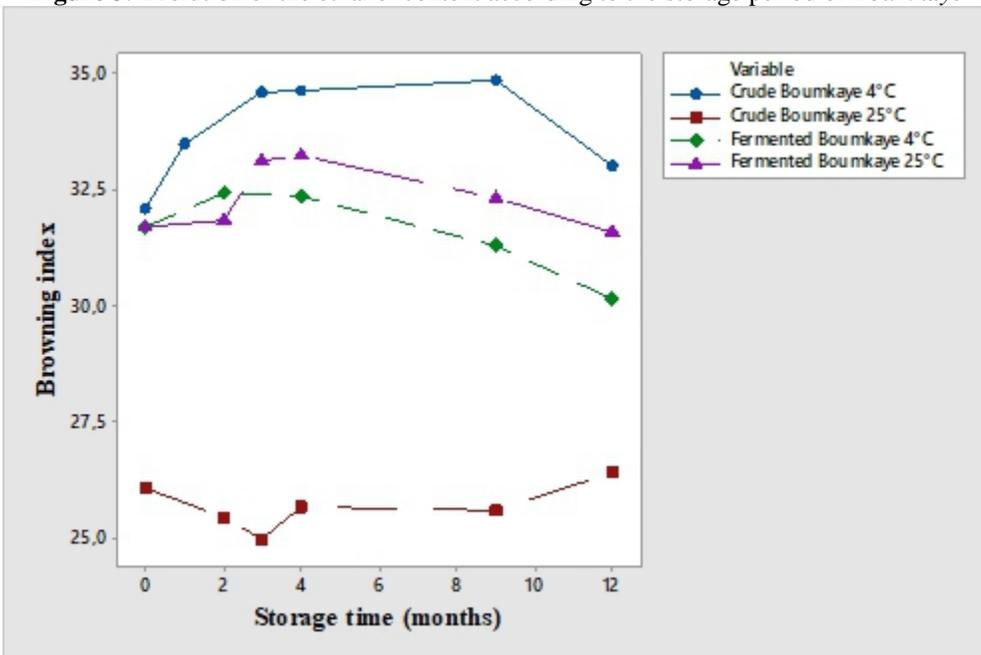


Figure 4. Evolution of the browning index according to the storage period of *Boumkaye*

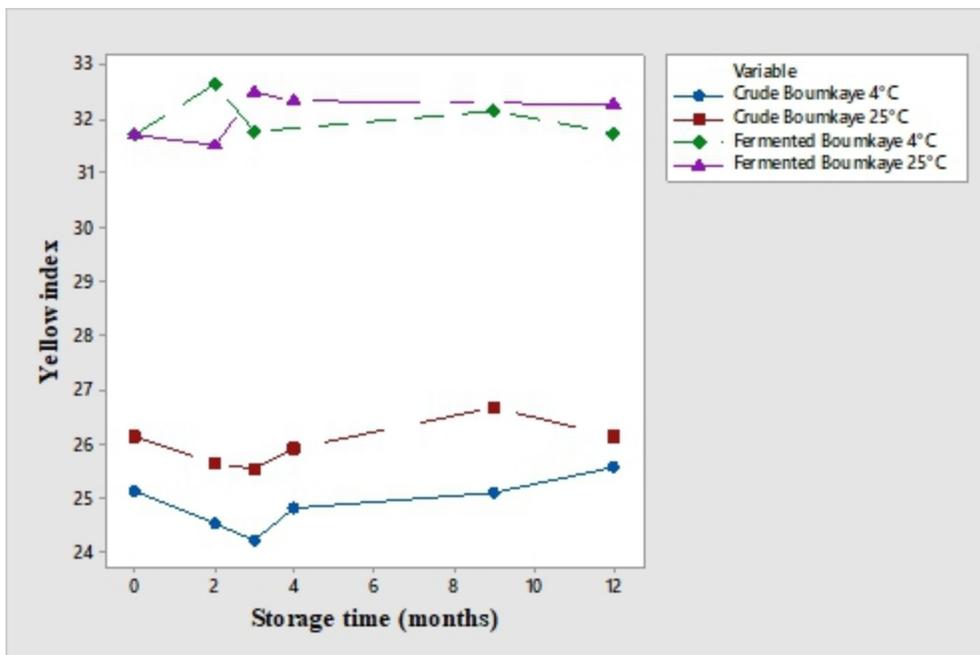


Figure 5. Evolution of the yellow index according to the storage period of *Boumkaye*

Discussion

The characteristics of the autoclaved *Boumkaye* beverages reflect the effectiveness of the sterilization which certainly must ensure a sanitary quality but while preserving the nutritional properties. In fact, the heat treatments lead essentially to physicochemical and biochemical changes that are more or less significant depending on the parameter considered. The differences noted between crude and fermented beverages are related to maturation in fermented *Boumkaye*. A maturation stage marked by a double fermentation (lactic and alcoholic) was detected, responsible for its high acidity and alcohol content (Cisse et al., 2018). Crude *Boumkaye* is considered as an intermediate product but may contain the same therapeutic properties (antihelminthic, antioxidant) as fermented *Boumkaye*. Crude *Boumkaye* drink is non-alcoholic which is an asset against cultural barriers.

In addition, from its primary use as an alcoholic beverage, fermented *Boumkaye* has more nutritional properties because of its much higher polyphenol content. Previous cereal research has indicated that a significant portion of the phenolic compounds is present in conjugated, soluble or bound form, insoluble. The heat treatment induces the hydrolysis of the conjugated phenolic compounds, resulting in the release of the free phenolic acids and thus increases the amount of bio-available phenolic compounds (Dewanto et al., 2002, Randhir et al., 2008, Ranilla et al., 2009). Chromatic indices noted and correlated with the yellow color, would significantly increase its sensory

acceptance. Hop industrial beers offer a wide range of colors from pale gold to black. Color is much more than a classification criterion but of quality in terms of aromas and taste.

Most traditional African beers pose many health risks due to the spontaneous nature of fermentation (Kayodé et al., 2005, Lyumugabe et al., 2010). The musts are mostly inoculated with a traditional leaven (Maoura et al., 2005, Kayodé et al., 2005, Hounhouigan and Nout, 2007, Lyumugabe et al., 2010). The resulting beer has a dubious health quality due to the lack of control of the present germs. The manufacture of the drink *Boumkaye* has the particularity of incorporating a medicinal species *Abrus pulchellus*, which has positive effects on the stability and selection of *Boumkaye* flora (Cisse et al., 2018).

African autochthonous beers are characterized by infection and proliferation of yeasts and multilevel bacteria (F. Lyumugabe et al., 2012). These undesirable microorganisms (*Acetobacter*) produce acetic acid, volatile aromas, fruity scents and dandruff that make the taste, odor and texture unacceptable to consumers (Walt, 1956). Also, there are no differentiated stabilization methods for these local beers resulting in continued fermentation to consumption (Mwesigye and Okurut, 1995). In the case of the sorghum-based *Tchapalo*, an alcoholic fermentation takes place, accompanied by a natural lactic fermentation. The beers thus obtained can only be kept cool in order to reduce microbial growth (Dahouenon-Ahoussi et al., 2012). The autoclaved *Boumkaye* is free of germs until the end of monitoring and the drink can be stored at 25°C (room temperature) for at least 1 year. This is a considerable advantage for future industrial exploitation, especially since Pils-type industrial beers must be kept refrigerated (4°C) for a maximum of 6 months.

Conclusion

Results show an effectiveness of heat treatment (120°C/15mn) which has preserved all the nutritional and therapeutic properties of *Boumkaye*. Also, no germ was detected during the follow-up. The stability study showed that crude *Boumkaye* (unfermented) and alcoholic fermented *Boumkaye* can be stored at 25°C for at least one year.

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