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Production processes and chemical characteristics of two beverages based on millet (*Pennisetum glaucum* L.)

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Abstract

In Senegal, fermented drinks called "*Niéniébane*" and "*Poukh*" based on millet are prépared by an ethnical group named *Seerer* from *Diobass* areas. However, data relating to their manufacture and characterization are almost non-existent. This study aims to describe their production process and to evaluate their chemical qualities. The description of the processes was made on two sites in Diass (Thiès, Senegal). Samples were then analyzed at the chemical levels. "*Niéniébane*" is a drink made from millet flour and an aqueous extract of *Boscia senegalensis* steams and matures for 9 days (soluble dry matter 5.20-5.27 g/100ml and reducing sugars 1.63-1.73 g/100ml). According to local people, "*Niéniébane*" is used for its therapeutic properties. In the case of "*Poukh*", the millet grains are macerated (4 days) then filtered. The composition of "*Poukh*" reveals a low yield of extraction of nutrients from millet during maceration (soluble dry matter 0.39-0.45 g/100ml and reducing sugars 0.21-0.23 g/100ml). These drinks have essential therapeutic virtues more than nutritional benefits. Optimization work should be considered to simplify production processes and control nutritional and hygienic qualities.

Keywords: Traditional Drink; Niéniébane; Poukh; Millet

1. Introduction

Traditional fermented drinks can be defined as fermented extracts, prepared by indigenous populations, brewed or not according to specific processes according to each locality (civilizations, terroirs) [1–4]. In many African countries, fermented drinks are prepared from cereals : "*Boumkaye*" from Senegal [5], "*Dolo*" from Burkina-Faso [6], "*Tchapalo*" from Ivory Coast [7], "*Pito*" from Ghana, "*Burukutu*" from Nigeria [8], "*Bili bili*" from Tchad [9] and "*Ikigage*" from Rwanda [10]. These drinks are often attached to traditions of hospitality and conviviality, are part of the good manners of most societies and serve to seal relationships between individuals [5,11]. In Senegal, *Seerer Diobass* of Thies region prepare fermented drinks "*Niéniébane*" and "*Poukh*" made from millet. However, data relating to their manufacture and characterization are almost non-existent. These drinks are nowadays little known and neglected due to modernization [5,6]. This study aims to describe the production process of these two beverages "*Niéniébane*" and "*Poukh*", and to evaluate their chemical qualities.

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2. Material and Methods

2.1. Diagnosis of production processes

The diagnostic work on the production of "*Niéniébane*" and "*Poukh*" drinks was carried out on two Diass sites in Thies region (Senegal) in August 2019. The production of each drink was carried out in two batches to bring out the variabilities. The quantities of raw materials, working temperatures and durations of unit operations were recorded to obtain the production process diagram.

2.2. Chemical methods

Physico-chemical analyzes made it possible to characterize "*Niéniébane*" and "*Poukh*" millet-based drinks were evaluated according to standard AFNOR methods [13]. Total polyphenols were determined by UV/Visible spectrophotometry (Analytik Jena, Specord 200 plus, Germany) according to George method, in Gallic acid equivalent [14]. The ethanol content in the drinks was determined using the AFNOR NF V 05-107 method [13]. The color indices (browning index and yellow index) were determined by the L*a*b system [15] using a Konika Minolta laboratory colorimeter (Chroma Meter C5, Japan).

2.3. Study of maturation

The raw drinks collected during the descriptions of the production processes were stored at 30°C (room temperature). Periodic monitoring at a 7 days frequency of chemical characteristics was performed to define the optimal conditions for their processes.

2.4. Data processing

The analysis of variance compares the significance of the difference observed between the samples analyzed according to the probability threshold of 0.05. Data processing was done with Minitab software version 17.

3. Results and Discussion

3.1. "*Niéniébane*" drink

3.1.1. Production process

The traditional drink called "*Niéniébane*" is prepared by formulating pearl millet flour (*Pennisetum glaucum* L.) and aqueous extract of *Boscia senegalensis* stems. This extract provides the phytochemicals associated with the therapeutic benefits of the drink. In fact, local people use the leaves and roots of *D. guineense* as an antimalarial agent and dietary supplement for pregnant women [16].

3.1.2. Extraction of phytochemicals from Boscia senegalensis stems

The extraction phase begins with a step of crushing the stems of *Boscia senegalensis* in a mortar to remove the bark. The stems are then soaked in water then crushed again using a wooden mortar. The aqueous extract of *Boscia senegalensis* stems is obtained after filtration (Figure 1).

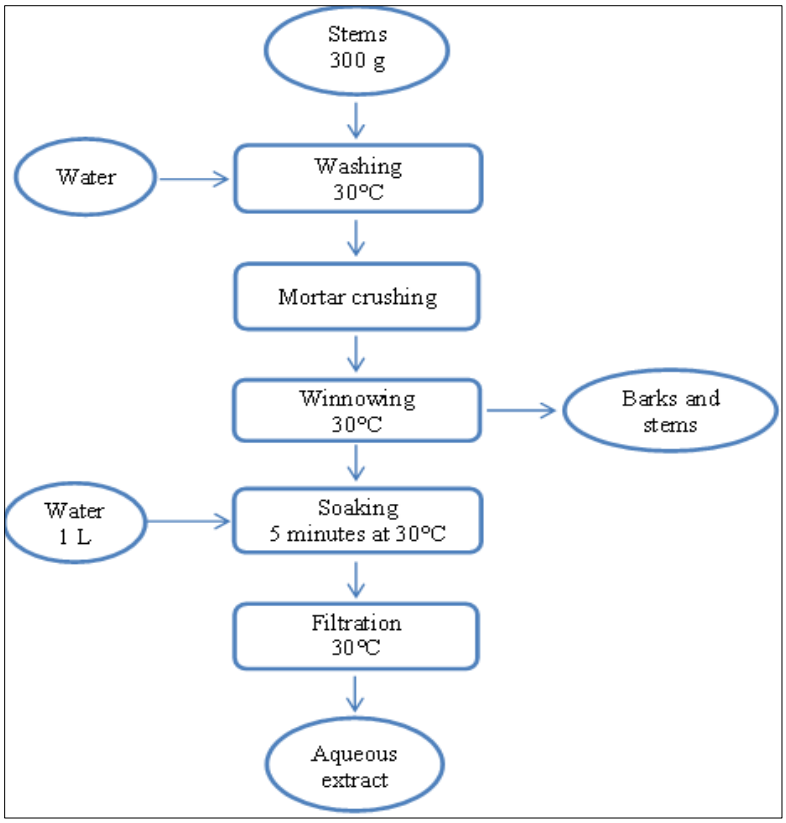

Figure 1 Diagram for obtaining the aqueous extract from the stems of *Boscia senegalensis*

3.1.3. Production of the drink "Niéniébane"

The millet flour is first mixed with the aqueous extract of the stems of *Boscia senegalensis* at a 1/1 ratio. To this mixture is added 20 liters of hot water corresponding to the mash. Finally, fermentation for 2 to 3 days produces the drink called "*Niéniébane*" (Figure 2).

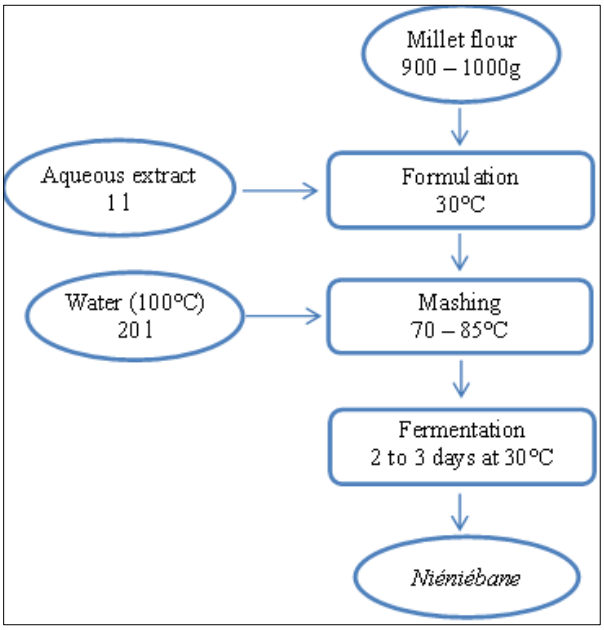

Figure 2 "*Niéniébane*" manufacturing diagram

The process of "*Niéniébane*" has many similarities with that of Diola drink "*Boumkaye*" [5]. The extract from the stems of *Boscia senegalensis* is used for their antiparasitic properties and to combat constipation. Indeed, such properties of *B. senegalensis* stems have been reported in the literature [10,11].

Mashing in a brewery is the phase of extraction and hydrolysis of starch into glucose by amylases and proteins into amino acids by proteases. This implies a stage of production of hydrolytic enzymes, occurring during the germination of cereal grains. The mashing technique in the preparation of "*Niéniébane*" is reminiscent of the infusion brewing process which has the advantage of better preserving nutrients. This is the case of the drink "*Ikigage*" [17] and unlike "*Tchapalo*" and "*Dolo*" where the mashing is done at room temperature [7,18].

Plants constitute essential raw materials in the manufacture of traditional African beers. These aqueous extracts are generally used as a coagulant to facilitate the filtration of the must before fermentation [7,19]. In the case of "*Niéniébane*" drink, *Boscia senegalensis* extract could provide the enzymes necessary for the lysis of starch and proteins in millet flour.

3.1.4. Physicochemical characteristics of "Niéniébane"

"*Niéniébane*" drink is characterized by its acidic pH (3.41 ± 0.14) with a titratable acidity of 8.83 ± 1.66 mEq/100ml (Table 1). The ethanol content remains very low (0.87 ± 0.01 g/100ml). This suggests acidification and production of alcohol by fermentation. Polyphenols are also present in drinks at interesting concentrations (23.96 mg gallic acid/100ml).

Table 1 Biochemical characteristics of "*Niéniébane*"

Analyzes	**« *Niéniébane* » Sample 1**	**« *Niéniébane* » Sample 2**
pH	3.41 ± 0.14[a]	3.01 ± 0.10[a]
Titratable acidity (mEq/100ml)	8.83 ± 1.66[a]	9.17 ± 1.03[a]
Soluble dry matter (g/100ml)	5.20 ± 0.01[a]	5.27 ± 0.01[a]
Polyphenols (mg gallic acid/100ml)	23.96 ± 0.68[a]	20.26 ± 0.43[b]
Reducing sugars (g/100ml)	1.63 ± 0.03[a]	1.73 ± 0.02[b]
ethanol content (g/100ml)	0.87 ± 0.01[a]	0.89 ± 0.01[b]
Browning index	231.38 ± 45.44[a]	233.58 ± 23.77[b]
Yellow Index	77.21 ± 3.37[a]	75.31 ± 3.03[b]

3.1.5. Study of the maturation of "Niéniébane"

Monitoring of pH, titratable acidity and ethanol content of "*Niéniébane*" verified the different biochemical reactions during maturation (Table 2). These parameters indicate a predominant lactic fermentation with maximum pH values of 2.81 and titratable acidity of 20.23 mEq/100ml after 9 days of storage at room temperature (30°C). In addition, ethanol concentrations are low during the maturation period (0.75-0.93 g/100ml).

Table 2 Monitoring of the physicochemical parameters during the maturation of "*Niéniébane*"

Storga duration (days)	**pH**	**Titratable acidity (mEq/100mL)**	**Ethanol (g/100mL)**
0	4,40 ± 0.01	4,92 ± 0.12	0
2	4,32 ± 0.01	7,45 ± 0.05	0
4	2,95 ± 0.02	8,63 ± 0.08	0,75 ± 0.01
9	2,82 ± 0.01	20,23 ± 0.11	0,74 ± 0.01
15	2,81 ± 0.01	19,90 ± 0.23	0,93 ± 0.03

Many African drinks are characterized by lactic fermentation upstream of alcoholic fermentation [7,9,18]. This is an acidification initiated by lactic acid bacteria which is responsible for certain organoleptic qualities [20]. This acidification ensures the stability of traditional fermented drinks by inhibiting pathogenic flora at pH below 3 [21,22]. This results in very acidic drinks despite alcohol contents of 5.03 g/100 mL for "*Tchapalo*" [7]; 2.3 g/100 mL for "*Dolo*" [23] and 4.18 g/100 mL for "*Bili bili*" [9]. In the case of the drink "*Niéniébane*", alcoholic fermentation is not evident. Information and interviews with producers suggest that "*Niéniébane*" is consumed primarily as food. In fact, the product retains all the nutritional values of millet, especially since fermentation allows more polyphenols to be solubilized and more bioavalaible [24].

3.2. "*Poukh*" drink

3.2.1. Production process

"*Poukh*" drink has the particularity of using millet grains as a material. Production monitoring made it possible to establish a manufacturing diagram (Figure 3).

The manufacturing processes for traditional cereal-based drinks start with the soaking of raw grains at 30°C (room temperature) for 3 to 4 days. Maceration of cereals helps moisture recovery and induces germination. However, the grains need a minimum quantity of oxygen for their growth and to avoid any risk of asphyxiation [7,9,23]. Then the grains are reduced to flour added with water and "*Poukh*" drink is then obtained after filtering the must.

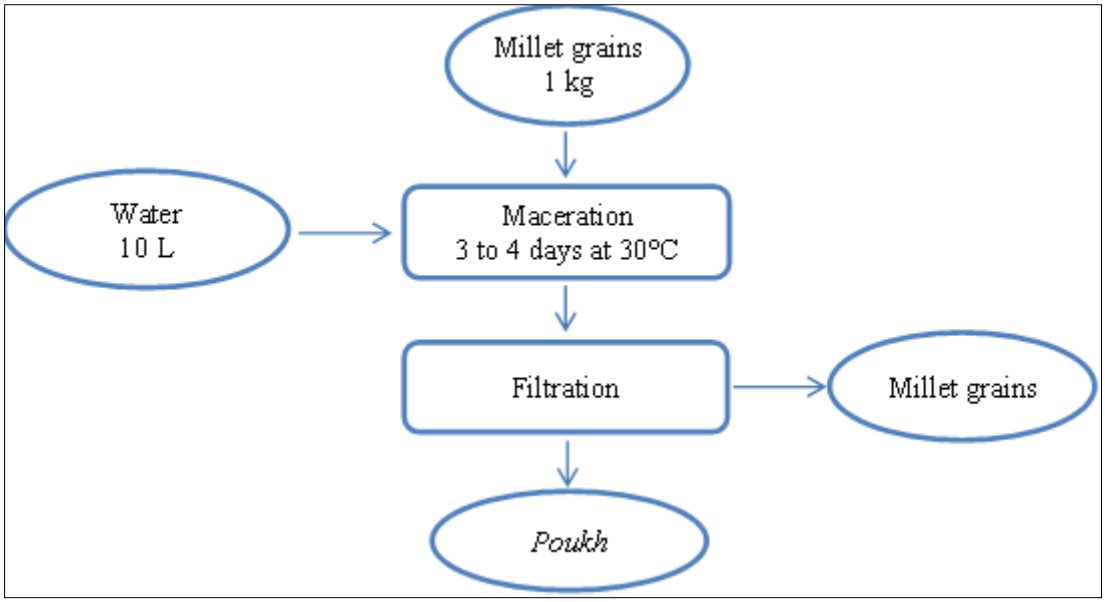

Figure 3 Production diagram for "*Poukh*" drink

The amylolytic and proteolytic enzymes produced are directly related to the degree of germination and the nutritional composition of the finished beers. In the case of "*Poukh*", soaking is followed by filtration. Which is incompatible with the extraction of nutritional constituents from millet. In this sense, "*Poukh*" is more of a macerate of millet grains than a drink in the technological and biochemical sense of the term. Howerver, germination is essential for the work of starch saccharification and protein degradation during brewing [26]. Germination conditions (temperature, time, grain moisture content) have a significant impact on metabolic processes. In cereal grains in particular, germination induces the disintegration of cell walls (made up of lignin, pentosans and pectic materials) under the action of complex enzymes such as cellulase, cellobiase and pectase [26–28].

3.2.2. Physicochemical characteristics of "Poukh"

The physicochemical composition of "*Poukh*" correlates with the hypotheses made in the restitution of the manufacturing process. The soluble dry matter content (0.45 g/100ml) immediately demonstrates a low extraction yield of millet components during maceration. The reducing sugar concentration of 0.23 g/100ml reflects a low hydrolysis of the starch carried out at the pasting stage by lytic enzymes. However, the polyphenol content of 29.56 mg/100 ml is interesting, especially since cereals are not the best sources of phenolic molecules (Table 3).

Table 3 Biochemical characteristics of "*Poukh*"

Analyzes	**« *Poukh* » Sample 1**	**« *Poukh* » Sample 2**
pH	5.19 ± 0.01[a]	5.57 ± 0.01[b]
Titratable acidity (mEq/100ml)	1.18 ± 0.04[a]	1.01 ± 0.02[b]
Soluble dry matter (g/100ml)	0.45 ± 0.01[a]	0.39 ± 0.01[b]
Polyphenols (mg gallic acid/100ml)	29.56 ± 2.26[a]	30.56 ± 2.26[a]
Reducing sugars (g/100ml)	0.23 ± 0.03[a]	0.21 ± 0.03
Browning index	11.51 ± 0.03[a]	12.51 ± 0.01[a]
Yellow index	15.33 ± 0.03[a]	13.33 ± 0.04[a]

The drinks studied in this work are consumed for religious and cultural considerations. They can present other advantages sought by local populations such as better digestion of meat during the tabaski festival ("*Niéniébane*" and "*Poukh*) and deworming ("*Niéniébane*").

The fermented drinks "*Niéniébane*" and "*Poukh*" are brewed according to traditional methods carried out by women using local resources (domestic equipment, local know-how). The production of "*Niéniébane*" drink involves a stage of incorporation of an aqueous extract of Boscia senegalensis in order to benefit from their therapeutic virtues. These same properties have been stated for "*Boumkaye*" characterized by the incorporation of an extract of *Abrus pulchellus* [5]. These medicinal plants rich in phytochemical compounds (polyphenols and tannins) are involved in the use of these drinks as "medicine". Furthermore, "*Niéniébane*" is a very nutritious drink with similarities to the drinks "*Dolo*" and "*Ikigage*" due to their respective protein contents of 0.65 g/100 [18] and 0.92 g/100g [20]. On the other hand, "*Poukh*" presents major differences in the production processes of traditional African drinks [5,11,20,23,27]. The latter are prepared from flour by germination of cereal grains which solubilize the amylolytic enzymes and growth factors (sugars, minerals, vitamins) essential for fermentation. Which explains the low ethanol content of "*Poukh*" compared to 3-5 g/100g for "*Boumkaye*"[5] ; 4.1-5.03 for "*Tchapalo*" [9,25,29] ; 2.3 for "*Dolo*" [23] and 2.2 for "*Ikigage*" [25]

4. Conclusion

The fermented drinks studied are produced by *Seerer* Diobass of Thies by empirical processes marked by the incorporation of an aqueous extract of *Boscia senegalensis* in the case of "*Niéniébane*" and a maceration of millet grains in the case of "*Poukh*". These drinks are good sources of protein, polyphenols (20-29 mg/100 mL) and are low in alcohol (0.7-0.9 g/100 mL). Furthermore, they are considered by local populations as "medicines" or nutraceuticals. Optimization work should be considered to simplify production processes and control nutritional and hygienic qualities.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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