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Traditional Mead "Bessoudioury" from Senegal: Process and Characterization

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Abstract

Mead is a beverage obtained by alcoholic fermentation of honey, with an ethanol content of 8% to 18% by volume. In Africa, mead manufacturing methods rely on heating honey and adding extracts of fruits, herbs or spices. "Bessoudioury" mead is then prepared according to the traditional process of the *Bassari* and *Bedick* peoples of Kedougou (Senegal). This work on "Bessoudioury" aims to describe and characterize the manufacturing processes. It was also to evaluate the chemical and microbiological characteristics. The study focused on three Kedougou production sites. The manufacturing process of "Bessoudioury" includes a honey heating, a formulation step by adding wine of either *Borassus aethiopicum* Mart. or *Elaeis guineensis*. This step is followed by a fermentation's one during two days. Wine is considered as the essential sources of yeasts for the production of alcohol. "Bessoudioury" has an ethanol content of 8% (v/v). Moulds and *Streptococcus* were not detected in this mead. According to its polyphenols content, this mead has a nutritional interest, but the process deserves to be reviewed to preserve nutrients.

Keywords

Honey, Mead, Fermentation, Bessoudioury

1. Introduction

Meads are beverages obtained by alcoholic fermentation of honey, with an ethanol content of 8% to 18% by volume [1] [2]. In Africa, bibliography indicates that mead would even be anterior to fermented cereal beverages. The mead was then used as a holiday drink [3] [4] [5]. In Senegal, mead is known under the name of "Bessoudioury". "Bessoudioury" (*Bessou* = drink, *dioury* = honey) is prepared according to the ancestral process of *Bassari* and *Bedick* peoples of the Kedougou's region (Senegal).

African mead-making processes typically rely on heating honey [6] and adding fruit, herb or spice extracts [7]. These methods of preparation depend on local traditions [2]. "Kuri" of Cameroon and "Ogol" of Ethiopia are prepared from artisanal starters according to ancestral practices [8] [9]. "Bessoudioury" of Kedougou (Senegal) presents a particularity that this work proposes to describe for the first time from the point of view of diagnosis as biochemical and microbiological composition.

2. Materials and Methods

2.1. Diagnosis of Manufacturing Processes

The manufacturing processes of "Bessoudioury" mead were monitored and studied at three production sites in Kedougou's region in December 2017. The process description was carried out twice at each production site. Each unit operation is identified and described. On the transformation sites, the information is then enriched by observations, records (temperature, duration), measurements (weight, volume), and interviews with operators.

2.2. Samples of Bessoudioury Mead

The products to be analyzed consisted of two types of meads formulated either with *Borassus* palm wine or palm wine. They were sent to the laboratory for biochemical and microbiological analyzes.

2.3. Physicochemical and Biochemical Analyzes

PH, titratable acidity, soluble solids content, reducing and total sugars, and ethanol content were evaluated according to standard AFNOR methods [10]. The volatile acidity of "Bessoudioury" was determined according to Mathieu's method, by distillation and titration of volatile acids [11]. The total polyphenols were characterized by UV/Visible spectrophotometry (Analytik Jena, Specord 200 plus, Germany) according to the method of Georgé [12]. The color indices (browning index and yellow index) were determined by the L*a*b system [13] using a Konika Minolta laboratory colorimeter (Chroma Meter C5, Japan). Antioxidant activity was determined according to the percentage inhibition of honey-based extracts on the DPPH radical [14].

2.4. Microbiological Methods

The microbial floras sought for the characterization are total flora, yeasts, moulds and *Streptococcus*. Germs were counted according to French standards [15].

2.5. Statistical Analyzes

The analysis of variance compares the significance of the difference observed between the samples analyzed according to the probability threshold of 0.05. Principal Component Analysis (PCA) aims to define, by a geometric approach, the correlations between fermented honey extracts and physicochemical parameters. Data processing was done with Minitab software version 17.

3. Results and Discussion

3.1. Traditional Bessoudioury Manufacturing Process

The diagnosis of "Bessoudioury" process allows establishing the manufacturing diagram below (**Figure 1**). The method of preparation of "Bessoudioury" consists of heating the honey, a formulation step by adding *Borassus* palm wine or palm wine followed by fermentation.

The production of the Bassari mead begins with a 1/1 (v/v) dilution of the honey with water. The mixture then undergoes cooking for 1 h 30 mn at a maximum temperature of 100˚C. Then, this intermediate product is cooled to 30˚C (room temperature), ideal for the incorporation of *Borassus* palm wine or palm wine. Finally, this extract is stored at room temperature (30˚C) for a fermentation and maturation stage of 2 days (**Figure 2**).

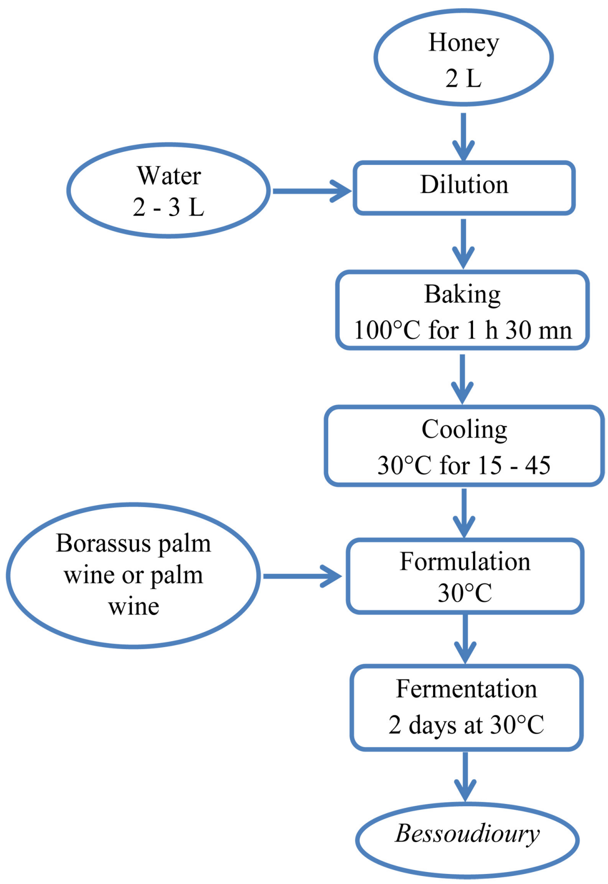

Figure 1. Production diagram of "Bessoudioury" mead.

Figure 2. Bessoudioury.

African artisanal methods are essentially a dilution of honey in water, followed by a fermentation step and a clarification step [8] [16]. The dilution reduces the osmotic pressure in the honey and then favors the fermentation step by yeasts. This step is important because osmotic pressure of honey inhibits the activity of the yeasts [6]. This ratio of honey/water varies from 1/1 for "Bessoudoury", 2/5 for the Ethiopian mead "Tej" [17] and 1/3 for the Ethiopian mead "Ogol" [9]. The aim of the cooking step is to eliminate the bitterness compounds, and the autochthonous flora of honey. These flora is such us bacteria (*Bacillus*, *Micrococcus*), yeast (*Saccharomyces* spp.) and fungal (*Aspergillus*) [6]. This step certainly reduces the risk of spontaneous fermentations. Nevertheless, it may occures the degradation of the thermosensitive compounds such as the phenolic acids and the flavonoids of the honey [18]. Also, there is formation of 5-hydroxymethylfurfural (HMF) which is an intermediate product of Maillard reactions due to high temperatures [19], [20]. The duration of cooking (1 h 30 mn) then justifies the low antioxidant activities compared to the Polish meads where the rate of inhibition of DPPH varies from 30% to 70% [21]. In perspective of the work, it would be necessary to optimize the cooking time of "Bessoudioury".

The water/honey mixture is inoculated with traditional leaven for 1 to 3 day fermentation at room temperature [8] [9] [17] followed by a maturation stage of 15 to 20 days for "Tej" [17] and 7 to 14 days for "Kuri" [8]. For the "Bessoudioury" production, this step of additional ferments is replaced by adding wine. In fact, yeasts are present in *Borassus* palm and palm wines [22] [23] [24] The presence of yeasts and lactic acid bacteria is well confirmed by our results at values of 2.4×10^5 at 5.8×10^6 CFU/mL for yeasts and 3.2×10^4 at 44×10^5 CFU/mL for lactic acid bacteria (**Table 1**). Any mould nor *Streptococcus* were found in "Bessoudioury". The lactic acid bacteria and yeasts counted in the

Table 1. Microorganisms counted in fermented extracts (CFU/mL).

	Borassus palm wine	Palm wine	MB	MP
Total flora	1×10^6	1×10^5	3.2×10^5	1.6×10^5
Lactic acid bacteria	44×10^5	3.2×10^4	2.5×10^5	1.8×10^4
Yeasts	58×10^5	2.4×10^5	3.3×10^5	1.4×10^5
Moulds	0	0	0	0
Streptococcus	0	0	0	0

CFU: colony forming unit. MB: mead "Bessoudioury" prepared with added wine *Borassus* palm. MP: mead "Bessoudioury" prepared with added wine palm.

wines are directly involved in the process of spontaneous fermentation of the extracts of *Borassus* palm and palm [24] [25] [26]. Those two types of wine are obtained by extraction and fermentation of the sap of the tree. Their ethanol concentration varies between 5.5 and 8% (v/v) [24] [26]. Lactic acid bacteria are also involved in reducing the acidity of a wine by malolactic fermentation. Malolactic erosion accentuates the sensory profile of wine in terms of taste and aroma [27].

3.2. Physicochemical Characteristics of the Extracts of the Manufacturing Process

3.2.1. Main Components of Honey

Analysis of honey components (**Table 2**) confirmed its very high content of reducing sugars (80 g/100g), which is quite similar to the values found in samples of various origins: 78.9 - 81.2 g/100g for Romanian honey [20]; 70 - 73 g/100g for Brazilian honey [19]. The honey pH value of 4.06 is within the standard limit (pH 3.40 - 6.10) proposed by *Codex Alimentarius* [16]. The browning index and the brightness L determined by the L*a*b system are 16.2 and 20.82. The comparison with the results obtained by Kus (25.05) shows a higher level of browning. The fundamental difference lies in the brightness L with a value of 79.9 [18]. However, the yellow index of 18.02 is much lower compared to the Oroian data on honeys harvested in different plant species (37.6 - 57.0) [28].

The polyphenol content of the honey used for "Bessoudioury" production expressed in gallic acid equivalent is 75 mg/100 g). This concentration varies from 26 to 100 mg/100 g in Brazilian honeys [29]; from 32.17 to 119.42 mg/100 g for honeys from Tunisia [30]; and 54.30 mg/100 g for Cuba samples [31].

3.2.2. Physicochemical Characteristics of Bessoudioury

"Bessoudioury" end-product with *Borassus* palm wine (MB1 and MB2), and one with palm wine (MP1 and MP2) were evaluated at the, biochemical levels (**Table 3**). All *Bessoudioury* samples have an acid pH (3.56 - 3.79) comparable to the values found in the traditional African meads "Kuri" (pH 3.0) [8], "Ogol" (pH 3.8) [9], "Tej" (pH 3.02 - 4.90) [17]. There are no significant differences in terms of titratable acidity between palm and palm wines, and formulated fermented

Table 2. Physicochemical and biochemical characteristics of honey.

Analyzes	Honey
pH	4.06 ± 0.01
Soluble dry matter (g/100 g)	81.8 ± 0.00
Titratable acidity (g tartaric acid/100 g)	1.57 ± 0.21
Browning index	16.46 ± 0.36
Yellow index	18.02 ± 1.02
Total sugars (g/100 g)	90.71 ± 0.00
Reducing sugars (g/100 g)	81.58 ± 1.97
Polyphenols (mg gallic acid/100 g)	75.75 ± 8.89

Table 3. Characteristics of *Borassus* palm wine, palm wine and meads "Bessoudioury".

Analyzes	*Borassus* palm wine	Palm wine	MB1	MB2	MP1	MP2
pH	3.96 ± 0.01^a	3.81 ± 0.01^b	3.79 ± 0.00^c	3.69 ± 0.00^d	3.57 ± 0.01^e	3.56 ± 0.0^e
Soluble dry matter (g/100 mL)	3.15 ± 0.07^a	3.1 ± 0.00^a	14.85 ± 0.07^b	19.55 ± 0.07^c	9.5 ± 0.00^d	9.5 ± 0.00^d
Titratable acidity (g tartaric acid/100 mL)	1.05 ± 0.14^a	1.07 ± 0.14^a	1.41 ± 0.78^a	1.42 ± 0.00^a	1.56 ± 0.14^a	1.58 ± 0.49^a
Volatile acidity (g H_2SO_4/100 mL)	0.18 ± 0.02^a	0.16 ± 0.02^a	0.08 ± 0.02^b	0.03 ± 0.01^b	0.18 ± 0.01^a	0.19 ± 0.01^a
Ethanol (mL/100 mL)	2.41 ± 0.12^a	1.49 ± 0.11^b	8.88 ± 0.17^c	8.18 ± 0.05^c	8.83 ± 0.05^c	8.80 ± 0.20^c
Browning index	14.25 ± 0.02^a	12.23 ± 0.02^b	48.07 ± 0.03^c	51.36 ± 0.02^d	65.87 ± 0.45^e	59.65 ± 0.03^f
Yellow index	16.82 ± 0.01^a	14.59 ± 0.01^b	46.94 ± 0.01^c	49.03 ± 0.01^d	56.6 ± 0.54^e	54.87 ± 0.07^f
Reducing sugars (g/100 mL)	1.34 ± 0.00^a	1.44 ± 0.00^a	8.08 ± 0.22^b	13.31 ± 0.15^c	1.58 ± 0.20^a	1.15 ± 0.54^a
Antioxidant activity (% inhibition)	17.99 ± 1.07^a	31.23 ± 2.17^b	36.44 ± 0.35^c	43.76 ± 0.76^d	41.68 ± 1.09^d	29.98 ± 1.61^b
Polyphenols (mg gallic acid/100 mL)	38.08 ± 0.75^a	$46.67 \pm 15.29^{a,b}$	76.60 ± 7.48^c	$65.24 \pm 0.88^{b,c}$	103.71 ± 8.23^d	76.41 ± 0.84^c

MB1: mead "Bessoudioury" prepared with added wine *Borassus* palm, first production. MB2: mead "Bessoudioury" prepared with added wine *Borassus* palm, second production. MP1: mead "Bessoudioury" prepared with added wine palm, first production. MP2: mead "Bessoudioury" prepared with added wine palm, second production. ^{a,b,c}: values in columns labeled with different letters are significantly different ($p < 0.05$).

Bessoudioury. However, meads with the addition of *Borassus* palm wine (MB1 and MB2) have volatile acidity (0.03 - 0.08), much lower than those formulated with palm wine (0.18 - 0.19). "Bessoudioury" has an ethanol content of 8% (v/v), lower than that found in the traditional "Kuri" meads of Cameroon (15.4% according to [8]; Ethiopia (16.5% - 17.5% for "Ogol" [9]; 6.98% - 10.9% for "Tej" according to [17] and of South Africa (11.92 - 12.03 for "iQhilika" according to [2].

Traditionally fruits and herbal extracts are used to impart particular flavors and tastes, but in the case of mead it seems not masking the flavor of honey [6]. The incorporation of *Borassus* palm and palm wines is therefore essential for the sensory qualities sought in "Bessoudioury". In addition, researches on mead had already established different strains of *Saccharomyces cerevisiae* tested for their resistance to high concentrations of ethanol and the osmotic stress of honey [32] [33]. These strains, quite similar to those used in oenology, are responsible for the biotransformation of glucose and fructose, in ethanol and carbon dioxide [6]. The volatile acidities established in *Bessoudioury* beverages, lower than acceptable limits in oenology [32], corroborate the hypothesis of a single alcoholic fermentation. This further confirms its sanitary and organoleptic quality. The acid pH (pH = 3) of both wines and finished mead is incompatible with the growth of most microorganisms. To this is added the bactericidal and antifungal effect of ethanol.

The polyphenol concentrations of "Bessoudioury" (65.24 - 103.71 mg/100 g) prove their best nutritional benefits compared to wines (38.08 - 46.67 mg/100 g). The high antioxidant activities confirm it well (29.98% - 43.76%). Antioxidant capacity is the main physiological role attributed to polyphenols. The antioxidant action of a phenolic compound can result from a combination of chemical events, including enzymatic inhibition, metal chelation, hydrogen donation and oxidation to a stable radical. In the body, free radicals are at the root of much oxidative degradation of macromolecules such as DNA and lipids. Polyphenols can act as antioxidants in different ways. By inhibiting the potential for cell and lipid degradation generated by free radicals, polyphenols would play a role in the protection against degenerative diseases, certain cancers and cardiovascular diseases [34] [35] [36].

The factorial design of the principal component analysis confirmed the three classes of products studied (*Borassus* palm and palm wines, MB1/MB2, MP1/MP2). Positive correlations were established between "Bessoudioury" and polyphenols, antioxidant activity and color indices. However, the correlation is stronger for drinks made by adding palm wine. The meads MP1 and MP2 also have a closer dependence on the volatile acidity along the second dimension of the factorial plane (**Figure 3**).

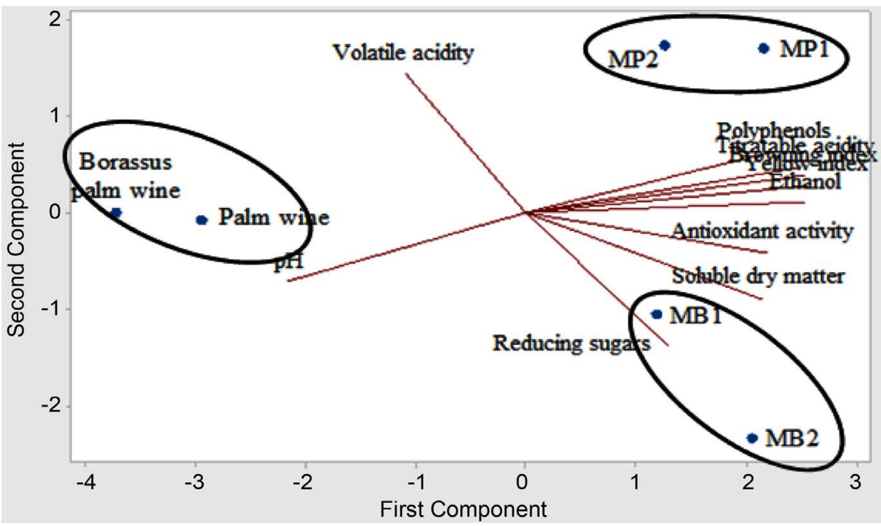

Figure 3. Correlation between the physicochemical parameters and the extracts analyzed according to the first two dimensions of the principal components analysis.

The two formulations of the *Bassari* mead of Kedougou (Senegal) follow the availability of raw materials (*Borassus* palm or palm wines). "Bessoudioury" was originally the main drink shared during religious ceremonies and rites of passage. Today, the production of this mead has become an income-generating activity for many local households. The information gathered from producers and consumers, however, indicates a preference for "Bessoudioury" prepared with *Borassus* palm wine.

4. Conclusion

This traditional drink has an alcohol content of 8% (v/v) and a high concentration of polyphenols (65 - 103 mg/100 mL). The manufacturing process of "Bessoudioury" has some differences compared to other African meads. The *Borassus* palm wine and palm wines added during fermentation bring particular flavors to the end product. This work has provided a better understanding of this honey-based drink and advice to investigate genomic aspect of its microbial flora.

Conflicts of Interest

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

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