HiLL PUBLISHING

International Journal of Food Science and Agriculture, 2024, 8(4), 145-151
https://www.hillpublisher.com/journals/jsfa/
ISSN Online: 2578-3475
ISSN Print: 2578-3467

Optimization of the Extraction of Phytochemical Compounds of *Abrus Pulchellus* for the Production of "*Boumkaye*" Drink Made from Millet

Oumar Ibn Khatab Cissé[1,2,*], Bou Ndiaye[2], Alioune Sow[2,3], Khadim Niane[2], Papa Guedel Faye[2], Nicolas Ayessou[2], Mady Cissé[2]

[1]Ecole Nationale Supérieure d'Agriculture (ENSA), BP A296, Thies, Senegal.
[2]Laboratoire Eau, Energie, Environnement et Procédés Industriels (LE3PI), Ecole Supérieure Polytechnique, Dakar 10700, Senegal.
[3]UFR Sciences Agronomiques, Aquaculture et Technologies Alimentaires (S2ATA), Université Gaston Berger, BP 234, Saint-Louis, Senegal.

How to cite this paper: Oumar Ibn Khatab Cissé, Bou Ndiaye, Alioune Sow, Khadim Niane, Papa Guedel Faye, Nicolas Ayessou, Mady Cissé. (2024). Optimization of the Extraction of Phytochemical Compounds of *Abrus Pulchellus* for the Production of "*Boumkaye*" Drink Made from Millet. *International Journal of Food Science and Agriculture*, 8(4), 145-151.
DOI: 10.26855/ijfsa.2024.12.002

Received: October 29, 2024
Accepted: November 27, 2024
Published: December 25, 2024

Corresponding author: Oumar Ibn Khatab Cissé, Ecole Nationale Supérieure d'Agriculture (ENSA), BP A296, Thies, Senegal; Laboratoire Eau, Energie, Environnement et Procédés Industriels (LE3PI), Ecole Supérieure Polytechnique, Dakar 10700, Senegal.

Abstract

"*Boumkaye*" drink (3 to 5% ethanol) is prepared with millet and the incorporation of an aqueous extract of creepers of *Abrus pulchellus*. "*Boumkaye*" is still consumed for its anthelmintic properties. In the literature, such properties are correlated with tannins and polyphenols. The manufacture of "*Boumkaye*" is defined by steps that are not mastered and require a lot of handling. The objective of this work is to optimize the preparation of "*Boumkaye*" for possible industrial exploitation. Several conditions were tested to extract the tannins and polyphenols. The extracts were used to prepare "*Boumkaye*" optimized and followed during fermentation. The aqueous extracts of *A. pulchellus* depending on extraction temperature and grinding have shown that the optimum time is 12 hours. The concentrations of tannins and polyphenols are respectively 1.44 g/100 g and 0.79 g/100 g. "*Boumkaye*" formulas with these extracts have the same characteristics as "*Boumkaye*" of the traditional process characterized by a 4-day maceration. The mashing and baking steps have been reduced to one step. The trials made it possible to reduce the various unit operations while maintaining the nutritional and antioxidant qualities of "*Boumkaye*".

Keywords

Millet; drink; optimization; "*Boumkaye*"

1. Introduction

"*Boumkaye*" drink made from millet (*Pennisetum glaucum* L.) is prepared according to a traditional method by the indigenous populations of Casamance (Senegal). "*Boumkaye*" is mainly consumed for its therapeutic properties correlated with the creepers of *Abrus pulchellus* used during manufacturing processes [1]. *Abrus pulchellus* Wall is a medicinal plant belonging to *Fabaceae* family. The leaves and creepers of *Abrus pulchellus* are widely used in traditional medicine for their antioxidant, antibacterial, and anthelmintic properties [2, 3]. In the literature, such properties have been reported for tannin-rich phytotherapeutic remedies [4-9]. In the case of other local African beers such as "*Tchapalo*" and "*Dolo*", plant extracts (*Hibiscus esculentus* and okra bark) are used as adjuvants to flocculation [10, 11]. The manufacturing process of "*Boumkaye*" is based on a maceration of 4 days of the creepers of *Abrus pulchellus* and a trituration with mortar to extract the active compounds. Thus, obtaining the aqueous extract of the creepers of *Abrus pulchellus* is a difficult step and requires a lot of handling. This aqueous extract is then mixed with the millet porridge and stored at room temperature (25°C) for alcoholic and lactic fermentation [1]. The objective of this work is to optimize the manufacturing processes of the "*Boumkaye*" drink. In this sense, the extraction phase of the active ingredients of the creepers of *Abrus pulchellus* Wall will be reviewed but preserving at best the nutritional and therapeutic qualities of "*Boumkaye*".

2. Material and methods

2.1 Optimization of extraction of the active compounds of the creepers of *Abrus pulchellus*

Extraction optimization was based on the phytochemicals of the creepers of *Abrus pulchellus* (Figure 1). Several conditions were tested (temperature, particle size) to extract tannins and polyphenols, and compared to traditional extraction (Table 1). The creepers/water ratio was 0.2 g/100 mL corresponding to the proportions described in the manufacture of "*Boumkaye*" [1]. The tannins and polyphenols were then monitored during aqueous extraction every 2 hours for 4 days.

Figure 1. *Abrus pulchellus*: (a) whole creepers; (b) crushed creepers.

Table 1. Conditions for extracting tannins and polyphenols from the creepers of *Abrus pulchellus*

	Abrus pulchellus creepers	Temperature (°C)
Extract 1	whole	25
Extract 2	crushed	25
Extract 3	crushed	80

2.2 Production of "*Boumkaye*" drink

The aqueous extracts of the creepers of *Abrus pulchellus* were used to produce in the laboratory two types of "*Boumkaye*" according to the process established by Cissé et al. [1]. The second phase of the production of "*Boumkaye*" drink is characterized by mashing and cooking stages at high temperatures (90-100°C). The latter is the cause of various nutritional and antioxidant alterations. Thus, the optimization consisted of reducing these two stages into a single cooking based on optimized extracts of *Abrus pulchellus*. The drinks were stored at room temperature (25°C) and characterized physic chemically for 1 month at a frequency of 7 days.

2.3 Physicochemical methods

The determination of total tannins was done according to the method described by Joslyn [12]. The tannins are oxidized by the Folin Denis reagent in an alkaline medium to give a blue color whose intensity is measured at 760 nm. The tannin concentration is expressed in tannic acid equivalent. The total polyphenols were characterized using the George method, which involves UV/Visible spectrophotometry (Analytik Jena, Specord 200 plus, Germany) to measure the absorbance at specific wavelengths, indicating the presence and concentration of polyphenols. The parameters pH, titratable acidity, ethanol, dry matter, and reducing sugars were made using French standards [13]. Color indices [14] were evaluated by a laboratory colorimeter (Konika Minolta, CR C5, Japan). All analyses were done in triplicate.

2.4 Statistical methods

One-way ANOVA was used to compare the mean values of tannins and polyphenols between the optimized and traditional "*Boumkaye*" samples, with a significance level set at $P < 0.05$. To do this, the Minitab software version 17 was used.

3. Results and discussion

3.1 Tracking the extraction of tannins and polyphenols from the creepers of *Abrus pulchellus*

Monitoring of phytochemical compounds showed that extraction was optimal after 12 hours. The tannin concentrations are 1.6 and 1.3 mg/100 ml for the crushed liana extracts; 1.5 mg/100 ml for whole creepers extract (Figure 2). The maximum polyphenol contents are respectively 1.2; 1.51 and 1.57 mg/100 ml (Figure 3). The temperature of 80°C offers the highest concentrations of antioxidant molecules. However, crushing *Abrus pulchellus* Wall creepers has no significant

impact on extraction time and yield.

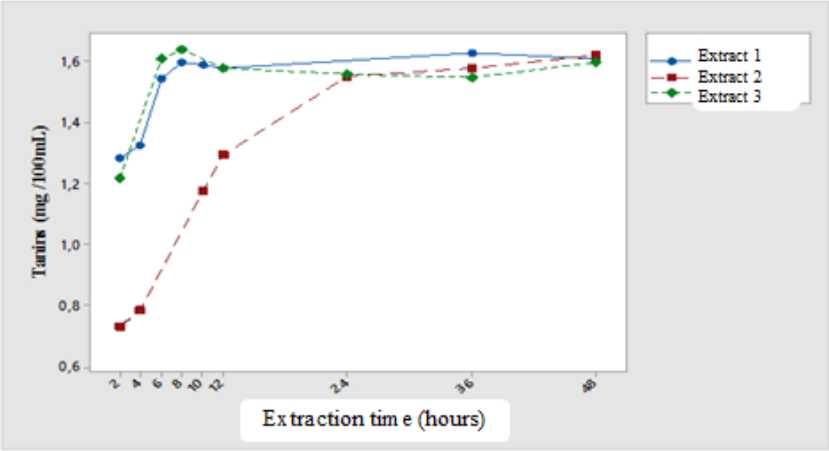

Figure 2. Monitoring the tannin concentration during the maceration of *Abrus pulchellus* creepers.

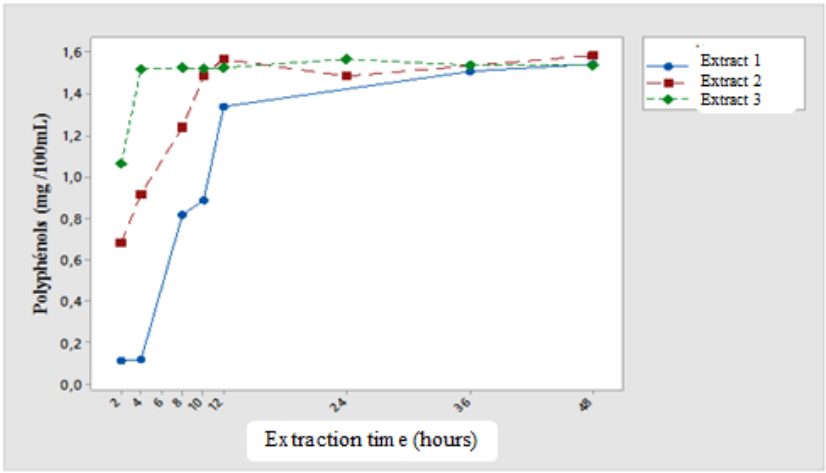

Figure 3. Monitoring the polyphenol content during the maceration of *Abrus pulchellus* creepers.

Tannins and polyphenols have a greater affinity with organic solvents: acetone, ethyl acetate [15, 16]; alcohols: ethanol, methanol [16] or water in the presence of acid (HCl) or bases (NaOH, Na_2CO_3, $NaHCO_3$) [17-19]. Extraction yields vary considerably depending on the solvent, time and extraction method (maceration or microwave). However, extraction tests of tannins and polyphenols on the bark of *Acacia mollissima* and the bark of *Lathyrus maritimus* L. show a better yield for alcohols compared to water and organic solvents [9, 15, 16]. The contents of tannins and polyphenols found in *Abrus pulchellus* creepers are then compared to those found in other plants (Table 2). Extracts from *Abrus pulchellus* creepers have higher tannin contents than the barks of *Acacia mollissima* and *Lathyrus maritimus*, which are known to be rich in tannin compounds [15, 16].

Table 2. Comparison of the concentrations of polyphenols and tannins obtained by aqueous extraction [15, 16]

Extracts	Tannins (g/100g) [a]	Polyphenols (g/100g) [b]
Whole creepers *Abrus pulchellus*	1.44	0.67
Crushed creepers *Abrus pulchellus*	1.33	0.79
Barks *Acacia mollissima*	0.35	43.79
Barks *Lathyrus maritimus*	0.015	-

Notes. a: Tannins in g tannic acid equivalent/100 g. b: Polyphenols in g gallic acid equivalent/100 g.

In summary, the optimal extraction conditions involved crushing the creepers and extracting at 80 °C for 12 hours, yielding the highest concentrations of tannins and polyphenols. The macerate of crushed creepers could make it possible to simplify the second manufacturing phase based on the incorporation of the aqueous extract into raw "*Boumkaye*".

3.2 Physico-chemical characteristics of optimized drinks

The optimizations proposed in "*Boumkaye*" manufacturing process made it possible to produce two types of drinks ("*Boumkaye*" optimized 1 and "*Boumkaye*" optimized 2) based respectively on the aqueous extracts of crushed lianas macerated at 25 and 80 °C. Their different physicochemical characteristics were evaluated and compared to those of a control "*Boumkaye*" (Table 3).

Table 3. Physicochemical characteristics of "*Boumkaye*" drinks

Parameters	Control	Optimized 1	Optimized 2
pH	6.65 ± 0.01^{a}	6.54 ± 0.00^{b}	2.23 ± 0.06^{a}
Titratable Acidity (mEq/100g)	2.17 ± 0.11^{a}	2.39 ± 0.11^{a}	10.24 ± 0.32^{a}
Dry matter (g/100g)	10.41 ± 0.24^{a}	10.64 ± 0.52^{a}	0.57 ± 0.01^{a}
Reducing sugars (g/100g)	0.30 ± 0.01^{a}	0.37 ± 0.01^{a}	97.05 ± 2.35^{a}
Polyphenols (mg gallic acid /100g)	107.43 ± 2.43^{a}	107.61 ± 1.77^{a}	45.04 ± 3.68^{b}
Tannins (mg tannic acid /100g)	52.42 ± 1.12^{a}	55.80 ± 1.75^{a}	32.12 ± 0.03^{b}
Browning index	29.74 ± 0.15^{a}	32.24 ± 0.02^{b}	33.44 ± 0.01^{b}
Yellow index	29.63 ± 0.11^{a}	31.24 ± 0.00^{b}	2.23 ± 0.06^{a}

"*Boumkaye*" control and "*Boumkaye*" optimized drinks 1 and 2 are quite similar from a physicochemical and biochemical point of view. These polyphenol characteristics are respectively 107.43; 107.61 and 97.05 mg/100 g and those in tannins: 52.42; 55.80 and 45.04 mg/100g. These values for tannins and polyphenols do not show significant differences. This demonstrates the effectiveness of optimizing the extraction of the principles of *Abrus pulchellus* creepers.

3.3 Study of the maturation of the optimized "*Boumkaye*"

"*Boumkaye*" drinks were stored at room temperature (25 °C) and monitored for one month. The evolution of the pH (Figure 4), titratable acidity (Figure 5), and ethanol content (Figure 6) of the optimized and control drinks follow the trends described during the diagnostic and characterization work of "*Boumkaye*". The concentrations of tannins (Figure 7) and polyphenols (Figure 8) were also monitored during maturation.

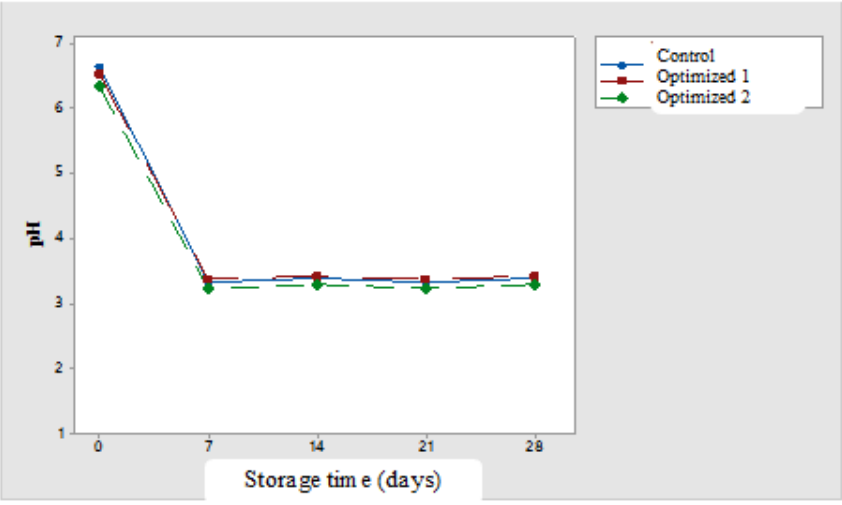

Figure 4. Evolution of the pH depending on the storage duration of "*Boumkaye*".

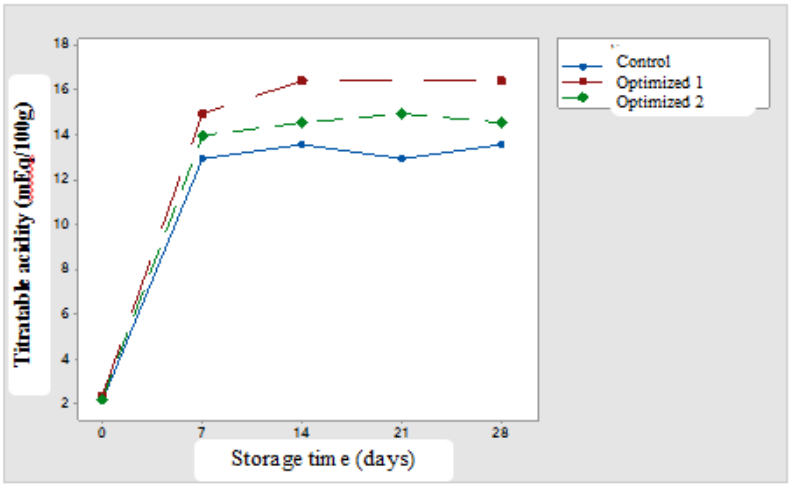

Figure 5. Evolution of the titratable acidity to the storage duration of "*Boumkaye*".

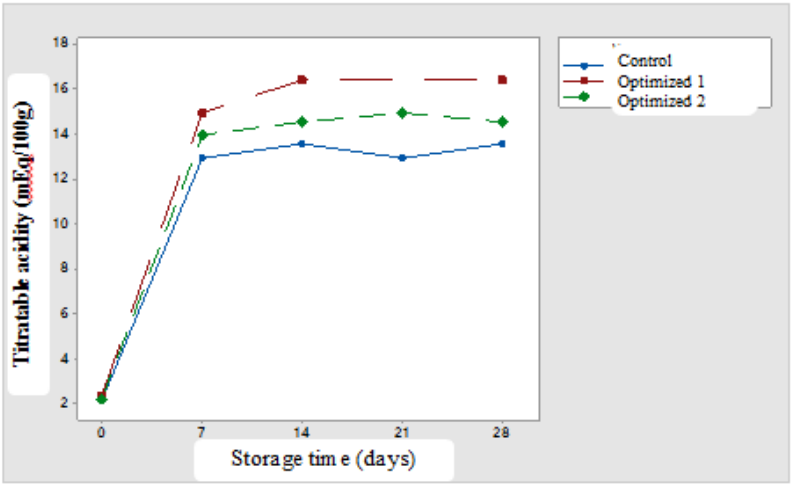

Figure 6. Evolution of the ethanol content depending on the storage duration of "*Boumkaye*"

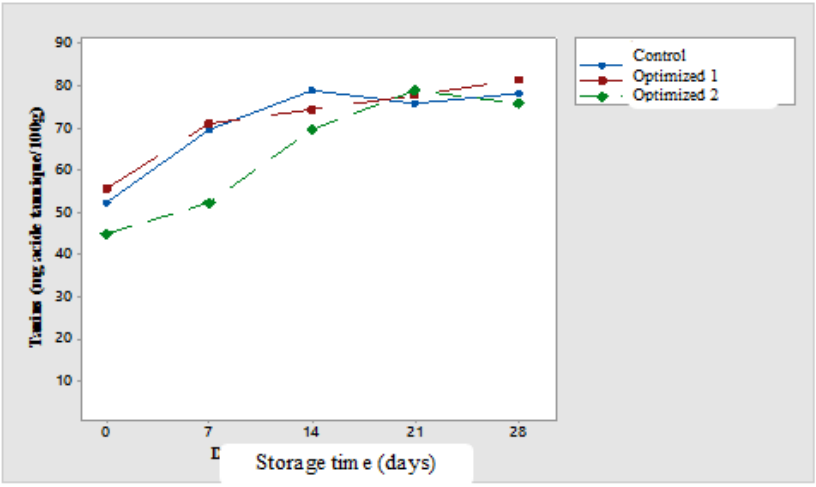

Figure 7. Evolution of the tannin concentration depending on the storage duration of "*Boumkaye*"

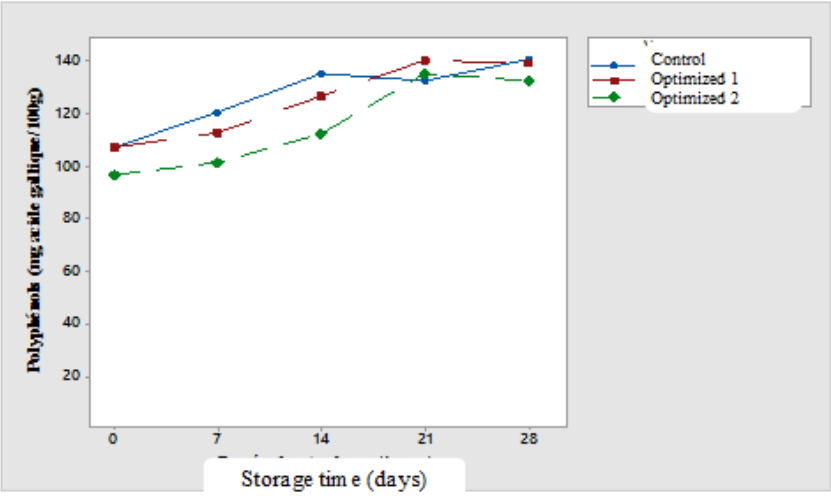

Figure 8. Evolution of the polyphenol concentration depending on the storage duration of "*Boumkaye*".

During the fermentation process, the pH of the optimized "*Boumkaye*" samples showed a significant decrease compared to the control, indicating a faster rate of lactic acid production due to the optimized extraction process. The acid pH is related to the maturation of "*Boumkaye*" drinks with ethanol and lactic acid production. High acidity has the advantage of ensuring microbiological stability by inhibiting the growth of pathogens [20-22]. Yeasts and lactic acid bacteria of "*Boumkaye*", however, are likely to initiate alcoholic and lactic fermentations. In addition, the optimized "*Boumkaye*" drink provides the same nutritional quality as the control sample. This is an asset for a future industrial exploitation.

In traditional processes, the use of plant extracts is a delicate step that strongly influences the quality of finished beers. The aqueous extract of *Hibiscus esculentus* used as a clarifier in the manufacture of "*Tchapalo*" leads to an increase in dry matter and turbidity [9, 23]. In the case of "*Dolo*", okra barks are incorporated to facilitate the separation of the first quality must [11]. The preparation of "*Boumkaye*" drink has the particularity of integrating a medicinal plant called *Abrus pulchellus*, known for its anthelmintic properties [2, 3, 8]. The aqueous extract of the creepers of *Abrus pulchellus* is also involved in the production of amylolytic enzymes essential for brewing [1]. Some manufacturing methods of "*Dolo*" use extracts of *Abelmochus esculentus* bulbs, *Curculigo pilosa*, *Gladiolus klattianus*; or leaves of *Adansonia digitata* and *Boscia senegalensis*, to increase the intake of amylolytic enzymes [24-26].

4. Conclusion

"*Boumkaye*" is prepared according to a traditional method marked by a phase of aqueous extraction of the active ingredients of the creepers of *Abrus pulchellus*. Optimization trials have shown that extraction is maximal after 12 hours with reference to the tannins and polyphenols contained in the creepers of *Abrus pulchellus*. The optimized extraction process not only simplified the production of "*Boumkaye*" but also preserved its nutritional and therapeutic qualities, making it a viable option for industrial-scale production while maintaining the traditional drink's benefits.

References

[1] Cissé OIK, Ayessou NC, Faye PG, Cissé M, Camara AC, Bodian A, Ndiaye C, Sakho M, Diop CM. Process Diagnosis and Aging Effects on a Traditional Millet-Based Drink: Boumkaye. Food and Nutrition Sciences. 2018;09(05):464-473.

[2] Machana S, Weerapreeyakul N, Thitimetharoch T, Sripanidkulchai B. Anticancer activity screening of Thai medicinal plants in human leukemic cell line MOLT-4. EJC Supplments. 2010;8(5):83-154.

[3] Vinayaka KS, Swarnalatha SP, Preethi HR, Surabhi KS, Kekuda TRP, Sudharshan SJ. Studies on In vitro Antioxidant, Antibacterial and Insecticidal Activity of Methanolic Extract of Abrus pulchellus Wall (Fabaceae). African Journal of Basic & Applied Sciences. 2009;1(5-6):110-116.

[4] Chung KT, Wei CI, Johnson MG. Are tannins a double-edged sword in biology and health? Trends in Food Science & Technology. 1998;9(4):168-175.

[5] Hatano T, Kusuda M, Inada K, Ogawa TO, Shiota S, Tsuchiya T, Yoshida T. Effects of tannins and related polyphenols on methicillin-resistant Staphylococcus aureus. Phytochemistry. 2005;66(17):2047-2055.

[6] Song JH, Kim SK, Chang KW, Han SK, Yi HK, Jeon JG. In vitro inhibitory effects of Polygonum cuspidatum on bacterial

viability and virulence factors of Streptococcus mutans and Streptococcus sobrinus. Archives of Oral Biology. 2006;51(12):1131-1140.

[7] Song JM, Lee KH, Seong BL. Antiviral effect of catechins in green tea on influenza virus. Antiviral Research. 2005;68(2):66-74.

[8] Johansen PG, Owusu-Kwarteng J, Parkouda C, Padonou SW, Jespersen L. Occurrence and Importance of Yeasts in Indigenous Fermented Food and Beverages Produced in Sub-Saharan Africa. Frontiers in Microbiology. 2019;10:1-22.

[9] Ashaolu TJ, Adeyeye SAO. African Functional Foods and Beverages: A Review. Journal of Culinary Science & Technology. 2024;22(1):142-177.

[10] Amane ND, Assidjo NE, Gbongue MA, Bohoussou K, Cardot P. Caractérisation physico-chimique d'une bière traditionnelle ouest africaine: le Tchapalo. Agronomie Africaine. 2005;17(2):143-152.

[11] Hébert JP. La bière et le dolo au pays Dogon : Origine, savoir-faire et phénomène social. Agropolis Museum, Montpellier, France; 2003. p. 9.

[12] Georgé S, Brat P, Alter P, Amiot MJ. Rapid determination of polyphenols and vitamin C in plant-derived products. Journal of Agricultural and food chemistry. 2005;53(5):1370-1373.

[13] AFNOR. Produits dérivés des fruits et légumes jus de fruits, 1ère. in Recueil des normes. Paris, France: AFNOR; 1982. p. 327.

[14] AFNOR. Colorimétrie - Partie 4 : espace chromatique L*a*b* CIE 1976, 1re éd. Paris, France; 2011. p. 8.

[15] Chavan UD, Shahidi F, Naczk M. Extraction of condensed tannins from beach pea (Lathyrus maritimus L.) as affected by different solvents. Food Chemestry. 2001;75(4):509-512.

[16] Rhazi N, Hannache H, Oumam M, Sesbou A, Charrier B, Pizzi A, Charrier-El Bouhtoury F. Green extraction process of tannins obtained from Moroccan Acacia mollissima barks by microwave: Modeling and optimization of the process using the response surface methodology RSM. Arabian Journal of Chemistry. 2019;12(8):2668-2684.

[17] Brahim M, Gambier F, Brosse N. Optimization of polyphenols extraction from grape residues in water medium. Industrial Crops and Products. 2014;52:18-22.

[18] Ping L, Pizzi A, Guo ZD, Brosse N. Condensed tannins extraction from grape pomace: Characterization and utilization as wood adhesives for wood particleboard. Industrial Crops and Products. 2011;34(1):907-914.

[19] Sealy-Fisher VJ, Pizzi A. Increased pine tannins extraction and wood adhesives development by phlobaphenes minimization. Holz als Roh-und Werkstoff. 1992;50(5):212-220.

[20] Thomas KC, Hynes SH, Ingledew WM. Influence of medium buffering capacity on inhibition of Saccharomyces cerevisiae growth by acetic and lactic acids. Applied and Environmental Microbiology. 2002;68(4):1616-1623.

[21] Torija MJ, Beltran G, Novo M, Poblet M, Rozès N, Mas A, Guillamón JM. Effect of Organic Acids and Nitrogen Source on Alcoholic Fermentation: Study of Their Buffering Capacity. Journal of Agricultural and Food Chemistry. 2003;51(4):916-922.

[22] Simatende P, Gadaga TH, Jabulani Nkambule S, Siwela M. Methods of preparation of Swazi traditional fermented foods. Journal of Ethnic Foods. 2015;2(3):119-125.

[23] Amane ND, Assidjo NE, Gbongue MA, Bohoussou K, Cardot P. Caractérisation physico-chimique d'une bière traditionnelle ouest africaine: le Tchapalo. Agronomie Africaine. 2009;17(2):143-152.

[24] Adenuga W, Olaleye ON, Adepoju PA. Utilization of bitter vegetable leaves(Gongronema latifolium, Vernonia amygdalina) and Garcinia kola extracts as substitutes for hops in sorghum beer production. African Journal of Biotechnology. 2010;9(51):8819-8823.

[25] Sade FO. Proximate, antinutritional factors and functional properties of processed pearl millet (Pennisetum glaucum). Journal of Food Technology. 2009;7(3):92-97.

[26] Ezekiel CN, Ayeni KI, Misihairabgwi JM, Somorin YM, Chibuzor-Onyema IE, Oyedele OA, Abia WA, Sulyok M, Shephard GS, Krska R. Traditionally Processed Beverages in Africa: A Review of the Mycotoxin Occurrence Patterns and Exposure Assessment. Comprehensive Reviews in Food Science and Food Safety. 2018;17(2):334-351.