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Physical, Biochemical, and Mineral Characterization of Wine Produced from Cashew Apple Enriched with *Hibiscus sabdariffa* Calyxes

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Abstract In Côte d'Ivoire, most cashew apples remain unprocessed due to their astringency and certain taboos. These taboos suggest that consuming cashew apples with milk is considered incompatible. This study aims to characterize cashew apple wine enriched with *Hibiscus sabdariffa* calyxes. Three formulations incorporating *Hibiscus* calyxes were assessed for their physical, biochemical, and mineral composition. Color intensity analysis using a spectrometer revealed that wine formulations 1 and 2 exhibited superior color intensity at 6.109 and 6.531 nm, with polyphenolic compound content ranging from 0.940 ± 0.086 to 1.06 ± 0.529 g EAG.L^{-1}. Antioxidant activity, as determined by ABTS inhibition rate, ranged from 31.86% to 38.42%. Inductively coupled plasma analysis indicated a variety of minerals, with potassium (2548.494 to 2962.914 mg/L), sodium (1153.265 to 1260.049 mg/L), and calcium (1649.299 to 1749.172 mg/L) being the most abundant. No heavy metals, such as lead or cadmium, were detected. The resulting cashew apple wine formulations exhibited a diverse nutritional profile.

Keywords: *Cashew apple wine, biochemical composition, Hibiscus sabdariffa, nutritional potential*

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1. Introduction

Wine is a fermented drink produced from fresh grapes or grape juice, where some or all of the sugar is converted into alcohol. Wine has had a significant impact on civilizations, influencing landscapes and trade development. Initially with a vital religious role, its perception evolved to symbolize high education and wealth [1].

In Côte d'Ivoire, various traditional fermented drinks are crafted from cereals like tchapalo or from oil palms, roasters, and raffia, like bandji. Crafting these beverages proves lucrative for producers due to the sustained market demand. Additionally, these drinks hold a central position in local culture, intertwined with traditional practices of hospitality and conviviality [2]. They are a fundamental aspect of most families' lifestyles, strengthening bonds between individuals.

Although the term "wine" traditionally refers to grape fermentation, which is a fruit, it might be beneficial to create wine from other fruits to mimic the grape's flavor, taste, and beneficial phenolic compounds composition. Fruit wines, a captivating yet often overlooked category in the realm of fermented drinks, present a diverse range of flavors beyond conventional grape wine. While grape wine remains dominant and iconic, wines derived from fruits like apples, cherries, berries, and others boast a rich historical background [3,4].

For instance, cashew apples, the fruit of the cashew tree, a profitable crop due to rising global nut prices [5] could be utilized for winemaking. Cashew apples are highly juicy (85 to 90% water), sweet (9 to 13% carbohydrates), slightly fragrant, and acidic [6] like grapes. However, one of the main avenues of valorization exploited in Côte d'Ivoire is the processing of apples into juice. There are numerous studies on the processing of cashew apples into juice, jam, flour, and other derivatives [7,8]. However, few studies exist on making wine from cashew apples. Moreover, since the most popular wine is red wine, how can red wine made from cashew apples be accepted by consumers? This study aims to incorporate *Hibiscus sabdariffa*, a plant rich in anthocyanins (compounds responsible for the red color of the leaves), into the various stages of cashew apple fermentation.

2. Material and Methods

2.1. Hardware

The materials used in this study include cashew apples (Figure 1) and Hibiscus sabdariffa calyces (Figure 2). The cashew apples were sourced from the fields surrounding Yamoussoukro, in the Bélier region of Côte d'Ivoire, while the Hibiscus sabdariffa calyces were obtained from the local market in Yamoussokro town. Subsequently, the *Hibiscus sabdariffa* apples and calyces were transported to the Institut National Polytechnique Félix Houphouët Boigny (INPHB) school factory for the fermentation process.

Figure 1. Cashew apple

Figure 2. Hibiscus sabdariffa chalices

2.2. Methods

2.2.1. Winemaking

Three types of wine were produced at the INP-HB factory-school, with a total volume of 75 L. The wines were produced from cashew apples, with the addition of *Hibiscus sabdariffa* calyxes using different processes. For wine 1, the calyxes were added during pasteurization. For wine 2, they were added during fermentation, and for wine 3, during stabilization. The ratio of cashew apple to hibiscus was [85,86,87,88,89,90] [10,11,12,13,14,15] (w/w).

2.1.2. Chromatic Characteristics

The spectrophotometric method [9] is employed to express chromatic characteristics in a conventional manner. By analyzing the absorption spectrum of red wine, various attributes such as hue, color intensity, and brightness can be inferred.

The intensity is conventionally given by:

$$I = A_{420} + A_{520} + A_{620} \quad (1)$$

Hue is conventionally given by:

$$N = A_{420} / A_{520} \quad (2)$$

2.1.3. Biochemical Methods

Ascorbic acid content was measured by the 2,6-dichlorophenolindophenol (2,6-DCPIP) titration method (AOAC, 1984). Total polyphenols were determined spectrophotometrically, using the colorimetric Folin Ciocalteu reagent (Wood *et al.* 2002). Antioxidants were determined by ABTS assay. This method is based on the compounds' ability to reduce the ABTS radical-cation$^{+\circ}$ (2,2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid). The test was carried out according to the method described by Choong *et al* (2007). Absorbance was 0.7±0.02 at 734 nm.

The inhibition rate (% I) of ABTS$^{\circ+}$ was expressed as follows:

$$\%I = [(A_0 - Abs_{extract}t)/ A_0] \times 100 \quad (3)$$

%I = ABTS inhibition rate $^{\circ+}$

$\mathbf{A_0}$ = diluted ABTS absorbance,

$Abs_{extract}$ = diluted ABTS absorbance + sample

2.1.4. Determination of Mineral Elements

Inductively coupled plasma mass spectrometry (ICP-MS) is used to determine the content of elements present in wine. Wine samples are prepared by diluting (1/10) with deionized water. Then, filtered before injection into the ICP-MS system. The presence of various mineral elements is determined at different wavelengths such as potassium (766 nm), calcium (422 nm), magnesium (279 nm), sodium (589 nm), Iron (238 nm), and Zinc (213 nm) (**OIV, 2017**).

2.1.5. Statistical Test

Statistical analysis of the results obtained during the study was carried out using STATISTICA version 7.1 software. A one-factor analysis of variance (ANOVA) was performed. Statistically significant differences were highlighted by Duncan's test at the 5% threshold.

3. Results and Discussion

3.1. Results

3.1.1. Chromatic Characteristics

Spectrometer analysis of the different wines showed a high color intensity for Wine 2, with a value of 6.537nm, while Wine 1 had an average color intensity of 6.109nm. Wine 3, on the other hand, had a low color intensity of 5.613 nm.

The shades of wines 1, 2, and 3 are 0.811, 0.803 and 1.098 respectively. In terms of brilliance, Wine 2 has a higher brilliance than Wine 1 and Wine 3 (3.219 > 3.001 > 2.193) (Figure 2 and Table 1).

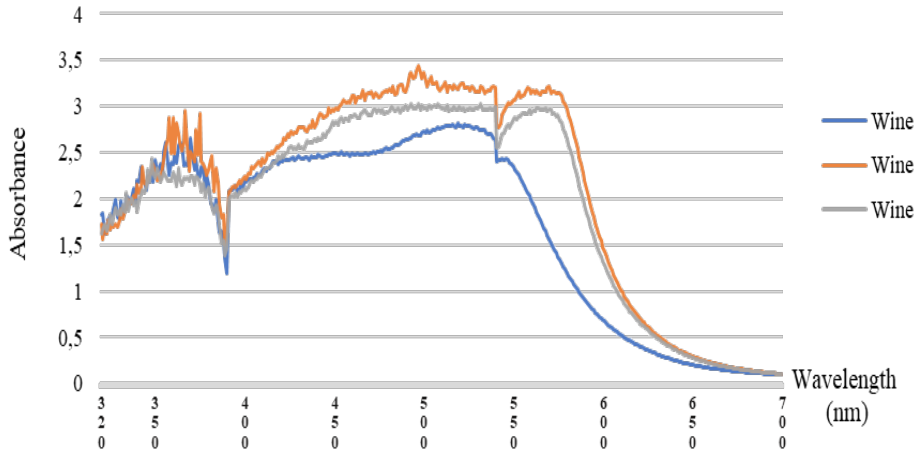


Figure 3. Absorption spectrum of the different cashew apple wines obtained

Table 1. Results of the chromatic characteristics of the wines obtained

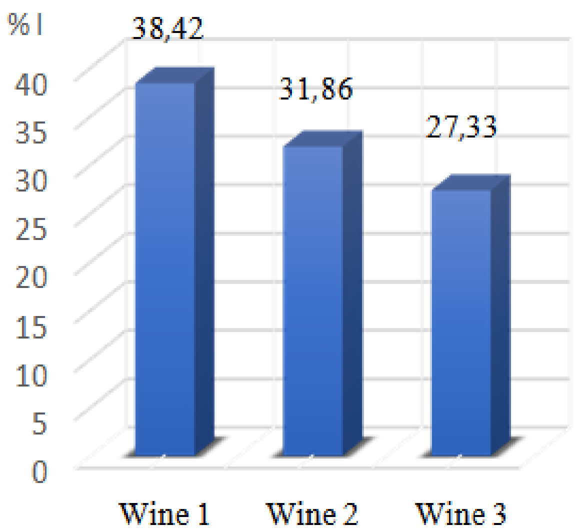
Parameters	Wine 1	Wine 2	Wine 3
Grade (N= 420 / 520)	0.811	0.803	1.098
Color intensity (nm) (IC= $A_{420} + A_{520} + A_{620}$)	6.109	6.531	5.613
Radiance (Max. at 520 nm)	3.001	3.219	2.193

The data presented here represents the mean of three independent trials.

3.1.2. Biochemical Characteristics

The results for vitamin C, polyphenols, and antioxidant activity of cashew apple red wine is shown in Table 2.

These results show a significant difference between Wine 1, Wine 2, and Wine 3. With a vitamin C content ranging from 111.6 to 315.54 mg/100mL, Wine 2 has a high vitamin C content, followed by Wine 1 and Wine 3. Polyphenol results expressed in grams per liter gallic acid equivalent (g EAG.L^{-1}) are 1.06 ± 0.529 for Wine 1, 0.940 ± 0.086 for Wine 2 and 0.883 ± 0.083 for Wine 3. Antioxidant activity, characterized by the calculated inhibition rate, was 38.42% for Wine 1, 31.86% for Wine 2 and 27.33% for Wine 3 (Figure 3).



The data presented here represents the mean of three independent trials.

Figure 4. Percentage of ABTS inhibition in wines obtained

Table 2. Results of the vitamin C, polyphenol, and antioxidant content of the wine obtained

Parameters	Wine 1	Wine 2	Wine 3
Vitamin C (mg/100 mL)	232.8 ± 1.45[a]	315.54 ± 1.53[b]	111.65 ± 0.54[c]
Polyphenols (g EAG.L^{-1})	1.06 ± 0.529[b]	0.940 ± 0.086[ab]	0.883 ± 0.083[a]
Antioxidants (µmol TE/L)	0.43662 ± 0.0003[a]	0.4827 ± 0.0003[b]	0.5140 ± 0.0005[c]

Mean and standard deviation were obtained over three repetitions. No significant difference at p-value 0.05 between means with the same letter.

3.1.3. Mineral Characteristics

ICP analysis was used to identify the various minerals present in different types of wine. The results revealed the presence of calcium (1749.172; 1649.299 and 1659.897), magnesium (719.693; 714.534 and 683.599), potassium (2901.421; 2962.914 and 2548.494), sodium (1194.447; 1153.265 and 1260.049), iron (11.547; 8.181 and 7.360), and zinc (2.896; 0.490 and 4.501) in wines 1, 2, and 3, respectively, expressed in mg. L-1. Furthermore, the heavy metals cadmium and lead were not detected. These analyses indicated that potassium, sodium, and calcium were more abundant in the various types of wine compared to other minerals present (Table 3).

Table 3. Results of the mineral composition of the wines obtained

Minerals	Wine 1	Wine 2	Wine 3
Ca (mg. L^{-1})	1749.172	1649.299	1659.897
Mg (mg. L^{-1})	719.693	714.534	683.599
K (mg. L^{-1})	2901.421	2962.914	2548.494
Na (mg. L^{-1})	1194.447	1153.265	1260.049
Fe (mg. L^{1})	11.547	8.181	7.360
Zn (mg. L^{-1})	2.896	0.490	4.501
Cd (mg. L^{-1})	ND	ND	ND
Pb (mg. L^{-1})	ND	ND	ND

Detection limit of Cadmiun and lead : 0.001 ppm

3.2. Discussion

Spectroscopic analysis revealed that the cashew apple wines obtained exhibited a red coloration, specifically a vermilion-red hue. Despite cashew apples not containing anthocyanic compounds, the red color of cashew apple wine could be attributed to the presence of *Hibiscus sabdariffa* calyxes. These calyxes are known for their richness in polyphenols and anthocyanins[10]. Anthocyanins, with their high coloring power and solubility in aqueous media, serve as natural food colorants that could potentially replace synthetic ones in the agri-food industry. The antioxidant properties of anthocyanins suggest that incorporating them into the diet could have beneficial effects on human health, particularly in combating cardiovascular risks, cellular aging, and fortifying blood vessels in the epidermis[10,11].

Both polyphenols and vitamin C have a significant impact on antioxidants. Table 2 indicates a trend where the vitamin C and polyphenol content of the wine varies based on the timing of adding *Hibiscus sabdariffa* calyxes. Aside from polyphenols, vitamin C plays a crucial role in various biological functions of the body, acting as an antioxidant to safeguard cells from free radical damage, aid in collagen synthesis, support the immune system, and reduce the risk of chronic diseases. [12,13,14,15,16].

The antioxidant activity is assessed through the inhibition rate of ABTS. Since ABTS serves as a free radical analogue, the ability of different cashew apple wine formulations to inhibit free radicals in the body is significant. Specifically, the results demonstrate that formulation 1 wine can inhibit 38.42% of free radicals, whereas formulations 2 and 3 wines can inhibit 31.86% and 27.33%, respectively. Furthermore, according to [17] free radicals lead to chain reactions that can damage cells in the body.

In the wine context, various minerals play a vital role in composition and quality. Mineral analysis indicates the presence of potassium, calcium, and magnesium in the wine, which may contribute to acidity and protein stability. Additionally, mineral elements like iron and zinc can enhance color stability, influence enzymatic reactions during fermentation, and impact the sensory attributes of the wine. Beyond its taste qualities and potential as a food complement, wine offers nutritional value due to its essential mineral content. Minerals are inorganic elements essential to the proper functioning of the human organism [19].

4. Conclusion

The cashew apple wine enriched with *Hibiscus sabdariffa* calyxes demonstrated a number of distinctive characteristics at the conclusion of the study. The antioxidant activity of the wines, designated as Wine 1 and Wine 2, was notably high, and the addition of the Hibiscus calyxes imparted a vibrant red hue to Wine 2. These wines offer a compelling mineralogical profile. Nevertheless, although the wine sector is not a primary focus of our research (cocoa, coffee, and cotton), this innovation could facilitate optimization of the cashew nut sector by various players. Furthermore, the resulting wine 1 could be an ideal complement to a variety of spicy dishes.

References

[1] C. Martin, “La spectroscopie Raman pour la lutte contre la contrefaçon et pour la sécurisation de la filière vin,” UNIVERSITÉ DE BORDEAUX, 2015.

[2] D. Nkwe, J. Taylor, and A. Siame, “Fungi, Aflatoxins, Fumonisin Bl and Zearalenone Contaminating Sorghum-based Traditional Malt, Wort and Beer in Botswana,” *Mycopathologia*, vol. 160, pp. 177–86.

[3] S. E. Katz, *The Art of Fermentation: An In-depth Exploration of Essential Concepts and Processes from Around the World*. Chelsea Green Publishing, 2012.

[4] A. Lea, *Craft Cider Making: Third Edition*. Crowood, 2015.

[5] J.-B. Djaha, A. N’daadopo, E. Koffi, C. Ballo, and M. Coulibaly, “Croissance et aptitude au greffage de deux génotypes d’anacardier (*Anacardium occidentale L.*) élites utilisées comme porte–greffe en Côte d’Ivoire,” *Int. J. Bio. Chem. Sci*, vol. 6, no. 4, pp. 1453–1466.

[6] D. Soro, C. Moctar, Y. K. Kone, E. N. Assidjo, B. K. Yao, and M. Dornier, “Valorization of cashew apple (Anacardium occidentale) and impact of vacuum evaporation at different temperatures in the juice quality,” *International Journal of Innovation and Applied Studies*, vol. 19, no. 1, Art. no. 1, Jan. 2017.

[7] J. Dossou, “Développement de paquet technologique innovant pour la valorisation de la pomme de cajou et l’amélioration du bien-être humain et des revenus des producteurs d’anacarde,” Université d’Abomey-Calavi (UAC) ; Bénin, 2012.

[8] D. Soro, “COUPLAGE DE PROCÉDÉS MEMBRANAIRES POUR LA CLARIFICATION ET LA CONCENTRATION DU JUS DE POMME DE CAJOU : PERFORMANCES ET IMPACTS SUR LA QUALITE DES PRODUITS,” Montpellier SupAgro, France, 2012.

[9] OIV, “RECUEIL DES METHODES INTERNATIONALES D’ANALYSE DES VINS ET DES MOUTS.” Accessed: Dec. 28, 2023. [Online]. Available: https://www.coleparmer.com/tech-article/measuring-ph-in-wine-making?tlg=fr-FR

[10] M. Cisse, M. Dornier, M. Sakho, A. Ndiaye, M. Reynes, and O. Sock, “Le bissap (*Hibiscus sabdariffa* L.) : composition et principales utilisations,” *Fruits*, vol. 64, no. 3, pp. 179–193.

[11] A. M. Sinela, “Etude des mécanismes réactionnels et des cinétiques de dégradation des anthocyanes dans un extrait d’Hibiscus sabdariffa L.,” MONTPELLIER SUPAGRO, Montpellier, 2016.

[12] A. Carr and S. Maggini, “Vitamin C and Immune Function,” *Nutrients*, vol. 9, no. 11, p. 1211, Nov. 2017.

[13] O. Carvajal-Zarrabal, Barradas-Dermitz, D. M., Orta-Flores, Z., Hayward-Jones, P. M., Nolasco-Hipolito Cirilo, Aguilar-Uscanga Ma. Guadalupe, & Miranda-Medina Anilú, Hibiscus sabdariffa L., roselle calyx, from ethnobotany to pharmacology.,” *JEP*, p. 25.

[14] H. Hemilä, “Vitamin C and Infections,” *Nutrients*, vol. 9, no. 4, Art. no. 4.

[15] S-K. Myung, Ju, W., Cho, B., Oh, S.-W., Park, S. M., Koo, B.-K., Park, B.-J., & for the Korean Meta-Analysis (KORMA) Study Group, Efficacy of vitamin and antioxidant supplements in prevention of cardiovascular disease: Systematic review and meta-analysis of randomised controlled trials,” *BMJ*, vol. 346, no. jan18 1.

[16] S. J. Padayatty, Katz, A., Wang, Y., Eck, P., Kwon, O., Lee, J.-H., Chen, S., Corpe, C., Dutta, A., Dutta, S. K., & Levine, M, Vitamin C as an Antioxidant: Evaluation of Its Role in Disease Prevention,” *Journal of the American College of Nutrition*, vol. 22, no. 1, pp. 18–35.

[17] G. Pizzino, Irrera, N., Cucinotta, M., Pallio, G., Mannino, F., Arcoraci, V., Squadrito, F., Altavilla, D., & Bitto, A, Oxidative Stress: Harms and Benefits for Human Health,” *Oxidative Medicine and Cellular Longevity*, vol. 2017, pp. 1–13, 2017.

[18] A. L. Waterhouse, G. L. Sacks, and D. W. Jeffery, *Understanding Wine Chemistry*. John Wiley & Sons, 2016.

[19] U. C. Okafor, J. I. Edeh, and S. O. Umeh, “Table Wine Production From Mixed Fruits Of Soursop (AnnonaMuricata) AndPineapple (AnanasComosus) Using Yeast From Palm Wine.,” *Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, vol. 12, pp. 52–56.