Antioxidant potential of medicinal plants used against liver diseases in Bengassou,Bocanda department (Central-Eastern, Côte d'Ivoire)

Abstract

Hepatitis, which causes acute liver infections, is a global health problem, especially viral hepatitis B and C, which are major causes of serious morbidity and death. In Côte d'Ivoire, viral hepatitis (78%) is the leading cause of chronic liver disease. Late diagnosis of this condition forces most patients, who are generally poor, to turn to medicinal plants, given the high cost of treatments offered by traditional medicine. Hence the need to evaluate their hepatoprotective potential. To contribute to this, this study focused on the phytochemical composition and antioxidant properties of several medicinal plants used to treat liver disease in Bengassou. Oxidative stress, a state of imbalance between the generation and elimination of free radicals in the body, is considered a major factor in the pathogenesis of liver disease. This study aims to identify the major groups of phytochemicals in hydroethanolic extracts from these plants via colorimetric tests, and to evaluate their antioxidant properties using DPPH radical scavenging and Folin-Ciocalteu assays. Polyphenols, flavonoids, sterols and polyterpenes were found in most of the species studied. Three of them, namely the leaves of *Uncariaafricana* (TPC = 1,99 ± 0,02 mg GAE/g DM; CR_{50} = 0,109 10^{-4} mg/ml), *Entandrophragmaangolense* (TPC = 2,58 ± 0,04 mg GAE/g DM; CR_{50} = 0,0026 mg/ml) and *Vismiaguineensis* (TPC = 1,79 ± 0,01 mg GAE/g DM; CR_{50} = 0,0334 mg/ml) exhibited the best antioxidant profiles. These species represent promising candidates for the development of Improved Traditional Medicines (ITM) against hepatitis.

Keywords: medicinal plants, liver diseases, phytochemicals, antioxidant properties, Bengassou

Introduction

Medicinal plants have been used since ancient times and long constituted the primary therapeutic resource, grounded in empirical knowledge **(Catier and Roux, 2007)**. Their use has expanded considerably worldwide **(Kouamé& Koné, 2017)**, particularly in developing countries where access to conventional medicine remains limited **(WHO, 2012)**. In West Africa, nearly 80% of the population relies on medicinal plants for primary healthcare **(WHO, 2002)**. This reliance persists, especially in rural communities, where traditional remedies are often perceived as more accessible and culturally appropriate **(Marshall, 1998)**.

In Côte d'Ivoire, disparities in access to primary, secondary, and specialized healthcare services continue to pose a significant public health challenge **(Goba, 2012)**. As highlighted by **WHO/UNICEF (2005)**, medicinal plants represent the backbone of primary healthcare for a large proportion of the population due to their geographical availability, affordability, and cultural acceptance. The first volume of the Ivorian Pharmacopoeia, published in 2018, consolidates extensive ethnobotanical knowledge documented by several authors **(Adjanohoun&AkéAssi, 1979, 2011; Bouquet &Debray, 1974; Vangah-N'Guessan, 1995; Téré, 2000; Zirihi, 2006; Malan, 2008; Tra Bi et *al.*, 2008; Koné et *al*., 2012; N'Guessan et *al.*, 2015; Orsot et *al.*, 2016)**. Among the recorded species, several are traditionally employed in the management of liver disorders.

The liver plays a central role in maintaining metabolic homeostasis through its involvement in carbohydrate and lipid metabolism, bile synthesis, and vitamin storage **(Ahsan et *al.*, 2009)**. Its dysfunction can therefore result in severe pathological conditions, making liver diseases a major global health concern **(Asha et *al*., 1998; Adewusi et *al*., 2010)**.

In Côte d'Ivoire, despite ongoing efforts to curb hepatitis through awareness and early screening initiatives, effective treatment remains constrained by the high costs associated with modern medical care. This economic barrier encourages patients to seek alternative therapies based on medicinal plants **(Pourette et *al.*, 2014; Anzouan et *al.*, 2022)**. Experimental evidence increasingly supports the hepatoprotective potential of several plant species **(Akharaiyi et *al.*, 2005; Sourabié et *al.*, 2012; Mallik et *al*., 2014; Jaiswal et al., 2015; Adesiyun, 2018)**. Bioactive compounds such as alkaloids, flavonoids, lignans, saponins, and terpenoids have attracted significant scientific interest for their hepatoprotective properties **(Domitrović&Potočnjak, 2016; Zhou et *al*., 2021)**. Through their antioxidant activity, these phytochemicals may enhance hepatic defense mechanisms and mitigate the progression of liver damage. This is particularly relevant as hepatitis is closely associated with oxidative stress resulting from an imbalance between pro-oxidant and antioxidant systems **(Rambaldi et *al*., 2005; Li et *al.*, 2015)**.

The present study aims to promote the rational use of medicinal plants in the management of liver diseases in Bengassou, a hamlet located in the Bocanda department (central-eastern Côte d'Ivoire), recognized for its rich ethnomedicinal heritage in treating hepatic disorders **(Siallou et *al.*, 2024)**. Specifically, this study seeks to identify major phytochemical groups using colorimetric screening and to assess their antioxidant potential through DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging activity and the Folin–Ciocalteu assay.

Materials and methods

Plant selection

The plants were selected following an ethnomedicinal survey conducted by **Siallou*et al*. (2024)** in Bengassou.The subsequent literature review, based on the lack of information relating to hepatoprotective properties, led to the selection of 13 medicinal plants**(Table I**).

The organs of these plants were harvested in July 2018, dried in a ventilated room at room temperature, then crushed in a mortar and blender to obtain fine powders. These powders were stored in Kraft paper at room temperature.

Table I. Medicinal plants used to treat liver diseases that have been identified and selected

Plant extracts	Family	Part used
***Albizia adianthifolia*(Schumach)W. Wight**	Fabaceae	Bark
***Aframamumalboviolaceum*(Ridl.) K.Schum.**	Zingiberaceae	Leaves
***Anthocleistanobilis*G. Don**	Gentianaceae	Leaves, Bark
***Bombax buonopozense*P.Beauv.**	Malvaceae	Leaves
***Diospyrosmonbuttensis*Gürke**	Ebenaceae	Leaves
***Entandrophragmaangolense*(Welw.) C.DC.**	Meliaceae	Leaves, Bark
***Ficus sur* Forssk.**	Moraceae	Leaves
***Griffoniasimplicifolia*(DC.) Baill.**	Fabaceae	Leaves
***Leonotis nepetefolia (*L.) R. Br.**	Lamiaceae	Leaves
***Oxyanthusunilocularis*Hiern**	Rubiaceae	Leaves, Bark
***Trichiliaprieureana*A. Juss.**	Meliaceae	Leaves
***Uncariaafricana*G. Don**	Rubiaceae	Leaves
***Vismiaguineensis (*L.) Choisy**	Hypericaceae	Leaves

Preparation of extracts

Fifteen (15) g of powder from each part of the plant were macerated in 100 ml of an ethanol-water mixture (80:20). This maceration was repeated three times, renewing the solvent every 24 hours. The hydroalcoholic macerates were combined, filtered and then evaporated under reduced pressure using a rotary evaporator until a dry hydroalcoholic residue was obtained. Aliquots of the selective extracts obtained were used to perform phytochemical screening and antioxidant profiling.

Phytochemical screening

Polyphenol detection

Polyphenols were detected using the ferric chloride reaction. A drop of 2% ferric chloride aqueous solution was added to 2 ml of each solution. The presence of polyphenols is

indicated by the appearance of a blue-black or green colouration of varying intensity **(N'Guessan et *al.*, 2009)**. If a positive reaction is obtained, coumarins, flavonoids and tannins are sought.

Detection of flavonoids

In a test tube, a few drops of concentrated hydrochloric acid and 2 to 3 magnesium chips were added to 2 ml of the extract. A pink-orange or purplish colour indicates the presence of flavonoids **(Auwal et *al.*, 2014)**.

Detection of coumarins

Coumarins were identified using the lactone ring test. Two (2) millilitres of each solution were examined under UV light at 366 nm. The appearance of blue fluorescence indicates the presence of coumarins. A confirmation test is performed with soda. To do this, 1 g of plant powder is placed in a test tube with a few drops of distilled water. The tube is covered with filter paper soaked in 10% soda (NaOH) and brought to the boil. The paper is removed and examined under UV light at 366 nm. Any yellow fluorescence indicates the presence of coumarins **(Auwal et *al.*, 2014)**.

Detection of tannins

Five (5 ml) of Stiasny's reagent (30% CH_2O in concentrated HCl 2/1(v/v)) was added to an aliquot of the extract taken in methanol and then evaporated. The formation of flakes after cooling indicates a positive reaction. The solution is then filtered and saturated with sodium nitrate ($NaNO_3$). A few drops of 2% $FeCl_3$ (m/v) are added to this mixture. The appearance of a blue, blue-black or black colour indicates the presence of gallic tannins, while a green or dark green colour indicates the presence of catechinic tannins **(Karumi et *al.*, 2004)**.

Detection of alkaloids

Alkaloids were detected using Dragendorff's reagent (iodine and bismuth). Six (6) ml of solution were evaporated and the residue was taken up with 6 ml of ethanol. Then, 3 drops of Dragendorff's reagent were added to the tube. The formation of an orange precipitate indicates the presence of alkaloids **(Auwal et *al.*, 2014)**.

Detection of sterols and polyterpenes

An aliquot amount of hydroethanolic crude extract from each plant sample is dissolved hot in 1 ml of acetic anhydride ($CH_3CO_3CH_3$) in a test tube. Next, 0.5 ml of concentrated

sulphuric acid (H_2SO_4) is slowly poured down the side of the test tube. The appearance of a purple colour turning blue and then green indicates a positive reaction **(Békro et *al.*, 2007)**.

Evaluation of antioxidant properties

Total Phenolic Content (TPC)

The total phenolic content (TPC) was determined using the Folin-Ciocalteu method, adapted from **Singleton & Rossi (1965)**. Briefly, 0,005 g of each hydroethanolic crude extract was dissolved in 10 mL of distilled water. 1 mL aliquot of this solution (diluted 1/10) was mixed with 1,5 mL of a Na_2CO_3 solution (17% w/v) and 0,5 mL of Folin-Ciocalteu reagent (0,5 N). The mixture was incubated at 37°C for 30 minutes. Absorbance was then measured at 760 nm against a blank (containing no extract).

Quantification was performed using a linear calibration curve (y = ax + b) generated from gallic acid standards at various concentrations under identical conditions. The TPC expressed in micrograms of gallic acid equivalent per gram of dry matter (µg GAE/g DM), was calculated using the following formula:

$$Q(\text{ µg GAE/g DM}) = \frac{V \times C \times d}{m}$$

Q: Total phenolic content (µg GAE/g DM);
V: Total volume of the extraction solvent (mL);
C: Concentration of gallic acid established from the calibration curve (µg/mL)
d: Dilution factor;
m: Mass of the extract used (g).

DPPH radical reduction assay

The radical scavenging activity was determined using the DPPH (2,2-diphenyl-1-picrylhydrazyl) assay, following the method described by **Blois (1958)** with slight modification. Briefly, 0.03 g of each crude hydroethanolic extract was dissolved in 10 mL of rectified ethanol (96%). A series of extract solutions was prepared at various concentrations (1; 0,5; 0,25; 0,125, 0,061, 0,042; 0,031; 0,016; 0,008; 0,004 mg/mL). A 0,03 mg/mL DPPH radical solution was also prepared in the same solvent.

For the assay, 1 mL of each extract dilution was mixed with 2 mL of the DPPH solution. The mixtures were incubated at 37°C for 30 minutes in the dark. Absorbance was measured at 517 nm using a spectrophotometer.

The following controls were used:

Reaction mixture: 1 mL of extract solution + 2 mL of DPPH solution;

Control: 1 mL of ethanol (96%) + 2 mL of DPPH solution;

Blank: 3 mL of ethanol (96%).

The following equation was used to calculate the DPPH radical reduction percentage induced by the extracts (RP):

$$RP\ (\%) = \left(1 - \frac{A_{extract}}{A_{control}}\right) \times 100$$

$A_{extract}$and $A_{control}$ are the absorbance values of the sample and the control, respectively.

The CR_{50} value, defined as the extract concentration required to reduce 50% of DPPH radicals, was determined from the linear regression curve of RP(%) versus extract concentration. When the 50% reduction level was not experimentally achieved, the CR_{50} was estimated by interpolation of the values surrounding the 50% reduction threshold. Antioxidantcapacityisinverselyproportional to the CR_{50} value. Thus, a higher CR_{50}indicateslowerantioxidantcapacity, and vice versa **(Tanoh et *al.*, 2019)**.

Statistical analyses

The averages of the amounts of the different compounds were calculated using Excel software and were subjected to a one-way analysis of variance (ANOVA) using GraphPad Prism 5 software. When a difference is observed for each characteristic ($p < 0.05$), the variance is completed by comparing the means using Tukey's multiple comparison test at a threshold of 0.05.

Results

Phytochemicalsdetected

Phytochemical screening of the 16 hydroethanolic extracts obtained from the leaves and bark of the 13 plants showed that all these extracts have total polyphenols, flavonoids, sterols, and polyterpenes in common, except the bark of *Anthocleista nobili*s. Coumarins were present in the hydroethanolic extracts of the leaves and bark of *Entandrophragmaangolense*, the leaves of *Trichiliaprieureana*, *Uncariaafricana*, *Vismiaguineensis*, *Bombax buonopozense*, and *Diospyros monbuttensis*. Condensed tannins were present in virtually all hydroethanolic extracts, except for the leaves of *Entandrophragmaangolense* and *Ficus sur*, which contain

hydrolyzable tannins, and *Albizia adianthifolia*, which contains neither. Alkaloids, on the other hand, were not present in any of the extracts **(Table II)**. These results show a diversity of chemical compound groups in the hydroethanolic extracts of the leaves and bark of the plants studied.

Table II. Chemical compounds in hydroethanolicextractsfrom the leaves and bark of plants used to treathepatitis in Bengassou

Plant extracts	Organs	Poly	Flav	Cou	Ster/ Polyt	TC	TH	Alc
Albizia adianthifolia	Bark	+	+	-	+	-	-	-
Aframamumalboviolaceum	Leaves	+	+	-	+	+	-	-
Anthocleistanobilis	Bark	+	+	-	-	+	-	-
	Leaves	+	+	-	+	+	-	-
Bombax buonopozense	Leaves	+	+	+	+	+	-	-
Diospyrosmonbuttensis	Leaves	+	+	+	+	+	-	-
Entandrophragmaangolense	Bark	+	+	+	+	+	-	-
	Leaves	+	+	+	+	-	+	-
Ficus sur	Leaves	+	+	-	+	-	+	-
Griffoniasimplicifolia	Leaves	+	+	-	+	+	-	-
Leonotisnepetefolia	Leaves	+	+	-	+	+	-	-
Oxyanthusunilocularis	Leaves	+	+	-	+	+	-	-
	Bark	+	+	-	+	+	-	-
Trichiliaprieureana	Leaves	+	+	++	+	+	-	-
Uncariaafricana	Leaves	+	+	+	+	+	-	-
Vismiaguineensis	Leaves	+	+	+	+	+	-	-

Poly. Polyphenols;Flav. Flavonoids; Cou. Coumarins; TC. Condensed tannins; TH. Hydrolyzabletannins;Alc. Alkaloids;Ster/Polyt. Sterols and polyterpenes

Total phenolic compound content

The results obtained are shown in **Table III**. These results show that the phenolic compound content (TPC) variedamong the organs of the same plant. The highest TPC was found in hydroethanolic extracts of bark (2.58±0.04 mgEAG/g DM) and leaves (2.42±0.08 mgEAG/g DM) of *Entandrophragmaangolense*, followed respectively by the leaves of *Trichiliaprieureana* (2.01±0.06 mgEAG/g DM), *Uncariaafricana* (1.99±0.02 mgEAG/g DM) and *Vismiaguineensis* (1.79±0.01 mgEAG/g DM.

Table III. Total phenolic compound content of hydroethanolicextracts

Plant species	Organs	Polyphenols ±ET (mg EAG/g DM)
Aframamumalboviolaceum	Leaves	0,39±0,02^{ef}
Albizia adianthifolia	Bark	0,43±0,06^{e}
Anthocleistanobilis	Bark	0,72±0,05^{d}
	Leaves	0,22±0,01^{efg}
Bombax buonopozense	Leaves	1,25±0,05^{c}
Diospyrosmonbuttensis	Leaves	0,36±0,02^{ef}
Entandrophragmaangolense	Bark	2,58±0,04^{a}
	Leaves	2,42±0,08^{a}
Ficus sur	Leaves	0,03±0,01^{g}
Griffoniasimplicifolia	Leaves	0,36±0,01^{ef}
Leonotisnepetifolia	Leaves	0,30±0,01^{ef}
Oxyanthusunilocularis	Leaves	0,23±0,03^{efg}
	Bark	0,08±0,01^{g}
Trichiliaprieureana	Leaves	2,01±0,06^{b}
Uncariaafricana	Leaves	1,99±0,02^{b}
Vismiaguineensis	Leaves	1,79±0,01^{b}
Statisticalparameters	Dl	15
	F	485,335
	P	<0,001

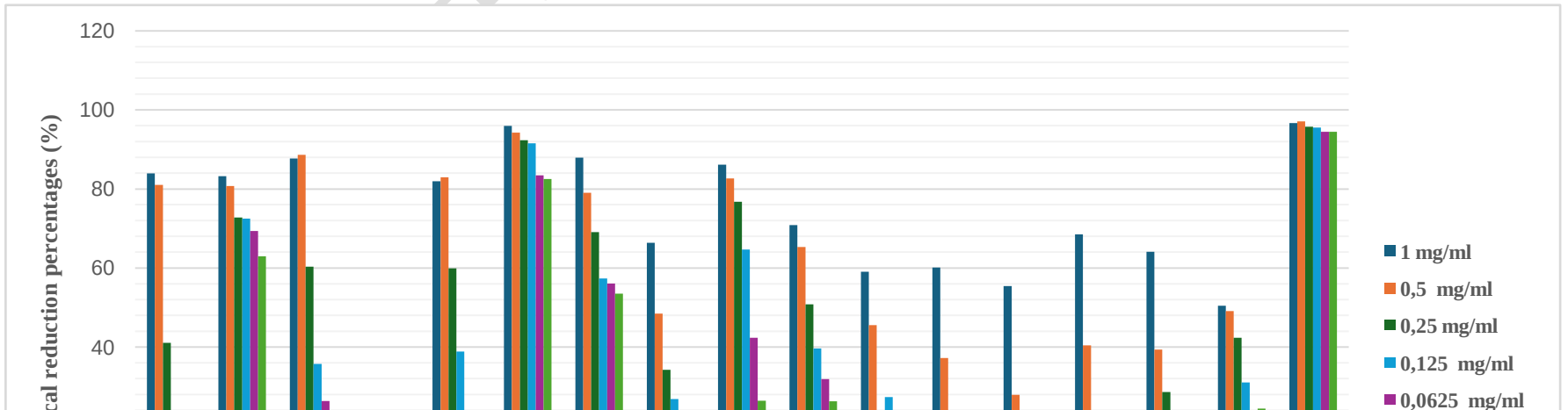
SD. Standard deviation;**GAE**. Gallicacidequivalent;**df.**Degrees of freedom;**F.**Statistical test value; **P.**Probability; **DM.** Dry matter. Values with the sameletters are not significantlydifferent.

Radical scavenging activity

For each extract, the RPs are shown in **Figure 1**. These results show that RPs increased with the concentration of the plant extract. In addition, the hydroethanolic extracts of the leaves of *Vismiaguineensis*, *Uncariaafricana* and *Entandrophragmaangolense*, with RPs between 50 and 95%, appear to have the highest anti-radical properties of all the plant extracts studied. The EC_{50}areshown in **Table IV.** The hydroethanolic extract of *U. africana* leaves (EC_{50} = 0.109 10^{-4} mg/ml) had the greatest DPPH radical reduction capacity. It is followed by the hydroethanolic extracts of the leaves of *E. angolense* (EC_{50} = 0.0026 mg/ml) and *V. guineensis* (EC_{50} = 0.0334 mg/ml).

(0,0026 mg/mL), which shows an activity nearly identical to Vitamin C, and *V. guineensis* (0,0334mg/mL). These findings confirm that among all studied samples, the leaves of *U. africana*, *E. angolense*, and *V. guineensis* possess the most potent antioxidant properties.

Figure 1. Histogram of the DPPH radical reduction percentages (RP) of the hydroethanolic extracts at different concentrations



Entanec. *Entandrophragma angolense* écorces ;**Entanfe.** *E. angolense* feuilles ;**Antnobec.** *Anthocleista nobilis* écorces ;**Antnofe.** *A. nobilis* feuilles ;**Trichprife.** *Trichilia prieureana* feuilles ;**Unafrife.***Uncaria africana* ;**Visgui.** *Vismia guineensis ;***Oxyunif.** *Oxyanthus unilocularis* feuilles ;**Bombuo.***Bombax buonopozense ;* **Grisim.** *Griffonia simplicifolia **;*** **Leonep.***Leonotis nepetifolia* ;**Afralb.** *Aframamum alboviolaceum* ;**Oxyuniec.** *O.*

Table IV. Reducing concentrations (EC_{50}) of crudehydroethanolicextracts

Plant extracts	Organs	EC_{50}(mg/ml)
Vitamine C		0,002456
Aframamumalboviolaceum	Leaves	0,805
Albizia adianthifolia	Leaves	0,716
Anthocleistanobilis	Bark	0,159
	Leaves	>1
Bombax buonopozense	Leaves	0,0842
Diospyrosmonbuttensis	Leaves	0,717
Entandrophragmaangolense	Bark	0,287
	Leaves	0,0026
Ficus sur	Leaves	0,683
Griffoniasimplicifolia	Leaves	0,212
Leonotisnepetifolia	Leaves	0,582
Oxyanthusunilocularis	Leaves	0,495
	Bark	0,854
Trichiliaprieureana	Leaves	0,175
Uncariaafricana	Leaves	$0{,}109\ 10^{-4}$
Vismiaguineensis	Leaves	0,0334

Discussion

Phytochemical screening revealed a diversity of chemical compound groups in the 16 hydroethanolic extracts studied. Polyphenols and flavonoids, tannins (except the bark of *Albizia adiantifolia*), sterols, and polyterpenes (except in the bark of *Anthocleista nobilis*) are present in all extracts.

Coumarins were present in the hydroethanolic extracts of the leaves and bark of *Entandrophragmaangolense*, the leaves of *Trichiliaprieureana*, *Uncariaafricana*, *Vismiaguineensis*, *Bombax buonopozense* and *Diospyros monbuttensis*. Alkaloids are absent in all the extracts studied. The presence of this group of secondary metabolites was reported by several authors. This is the case of **Sieniawska*et al.* (2022)** and **Akoto *et al*. (2020)**, who detected alkaloids in the methanolic extracts of *Ficus sur* bark and *Griffoniasimplicifolia* leaves, respectively.

Similarly, **Sima Obiang *et al*. (2015)** reported the presence of the above-mentioned compounds in the hydroethanolic extract of *A. nobilis* bark, while **Kangbéto*et al.* (2022)** found these phytochemicals in the ethanolic extract of *T.prieureana* leaves. However, alkaloids absent in all the extracts studied were identified by **Kangbéto*et al*. (2022)** in the ethanolic extract of *T. prieureana* leaves, by **Iroka*et al.* (2014)** in the aqueous and ethanolic

extracts of *B.Buonopozense* bark, and by **Lagou*et al.*(2016)** in the ethanolicextract of *E. angolense*bark. These contradictory results could be explained, on the one hand, by the solubility of any alkaloids in aqueous or organic solvents and, on the other hand, by the polarity of the extraction solvents. Indeed, due to their extremely complex and varied chemical structures, the solubility of alkaloids and their respective salts can vary considerably depending on the polarity of the extraction solvents **(Kumar, 2014)** and the pH of the reaction medium. Furthermore, a positive test for alkaloids may be due to the presence of other nitrogenous constituents in the plant, such as purines, proteins, betaines, and ammonium salts **(Kumar, 2014)**. Conversely, the presence of flavonoids in all hydroethanolic extracts compared to other secondary metabolites is evidence of the widespread distribution of flavonoids in the plant kingdom, as reported by **Macheix*et al*. (2005)**. In addition to flavonoids and tannins, coumarins observed in hydroethanolic extracts from the bark and leaves of *E. angolense*, and the leaves of *T. prieureana*, *U. africana*, *V. guineensis*, and *B. buonopozense* are reported to be responsible for the high total phenol content of these extracts compared to other plant extracts. Phenolic compounds are the most important group of phytochemicals in plants. They are divided into ten chemical classes characterized by the presence of a benzoic nucleus to which one or more hydroxyl groups are directly linked **(Macheix*et al*., 2005; Stalikas, 2007)**.

The evaluation of antioxidant properties showed that, of all the extracts studied, the leaves of *U. africana*, *E. angolense*,and *V. guineensis*exhibited the best antioxidant properties (higher RP with low EC_{50}).

The strong antioxidant activity attributed to the hydroethanolic extracts of the leaves of U. *africana*, *E. angolense* and *V. guineensis* can be explained by the high quantity of phenolic compounds contained in these plant organs. The presence of sterols and polyterpenes detected in these plants could also explain this activity. Terpenoids (monoterpenes and carotenoids) have strong antioxidant properties **(Gutiérrez-Del-Río *et al*., 2021)**. The antioxidant activity of certain plants, notably *B. buonopozense*, *G. simplicifolia*, *A. nobilis*, *A. adianthifolia* and *E. angolense*, has been reported in the literature **(Ngwoke*et al*., 2015; Sonibare*et al*., 2017; Akoto *et al*., 2020; Tilaoui*et al*., 2021; Oyawaluja*et al*., 2019)**. However, the difference in EC_{50} values can be explained by the influence of the extraction solvent **(Xie &Schaich., 2014; Sharma & Bhat, 2009)**. In this study, a hydroethanolic solvent was used, whereas most previous studies used methanol or ethanol (100%) as the extraction solvent.

Conclusion

This study highlighted the antioxidant potential of 16 plant extracts studied and their major groups of phytochemicals. Three of them stood out for their remarkable antioxidant activities and significant phenolic compound content. These are the leaves of *E. angolense,U. africana* and *V. guineensis*. These results open up promising prospects for the promotion of the pharmacopoeia used in Côte d'Ivoire. The next step in this work will be to evaluate the safety of these extracts (acute and subacute toxicity) in order to guarantee their safe use. Furthermore, confirmation of their hepatoprotective properties *in vivo* would be a crucial step towards the development of improved traditional medicines (ITMs) for the treatment of liver diseases.

REFERENCES

Adesiyun A. E., Oghenesuvwe E. E. &Nwoke E. E. (2018). Hepatoprotective Effect of *Capsicum frutescens* Supplemented Diet against Acetaminophen Induced Liver Damage in Laboratory Animals. *Proceedings for Annual Meeting of The Japanese Pharmacological Society WCP2018 (The 18th World Congress of Basic and Clinical Pharmacology)* (pp. PO3-13). Japanese Pharmacological Society.

Adewusi E. A. &Afolayan A. J. (2010). A review of natural products with hepatoprotective activity. *Journal of Medicinal Plants Research,4*(13), 1318-1334.

Adjanohoun E. &AkéAssi L., 1979. *Contribution au recensement des plantes médicinales de la Côte d'Ivoire*. Centre National de Floristique. Abidjan (Côte d'Ivoire) ; 359 pp.

Ahsan R., Islam K. M., Musaddik A. & Haque E. (2009). Hepatoprotective activity of methanol extract of some medicinal plants against carbon tetrachloride induced hepatotoxicity in albino rats. *Global Journal of pharmacology*, *3*(3), 116-122.

Akharaiyi F. C., Boboye B., &Adetuyi F. C. (2012). "Hepatoprotective effect of ethanol leaf extract of *Cnestisferruginea* on Swiss albino mice induced with paracetamol.

Akoto C. O., Acheampong A., Tagbor P. D. &Bortey K. (2020). Determination of the antimicrobial and antioxidant activities of the leaf extracts of *Griffoniasimplicifolia*.*Journal of Pharmacognosy and Phytochemistry*, *9*(2), 537-545.

Anzouan-Kacou H. Y. K., Dehinsala M., Bangoura A. D., Kouamé D. H., Stanislas A., ... &Doffou A. K. M. (2022). Aspects socio-économiques de la prise en charge des hépatites virales chroniques en Côte-d'Ivoire Socio-economic aspects of the management of chronic viral hepatitis in Côte-d'Ivoire. *Annales africaine de médecine*, **15**(4), e4770.

Auwal M. S., Saka S., Mairiga I. A., Sanda K. A., Shuaibu A., & Ibrahim A. (2014). Preliminaryphytochemical and elemental analysis of aqueous and fractionated pod extracts of *Acacia nilotica*(Thorn mimosa). *Veterinary Research Forum: an International Quarterly Journal*, *5*(2), 95-100.

Békro Y.A., Mamyrbekova J. A., Boua B. B., Tra Bi F. H. &Ehilé E. E. (2007). Etude ethnobotanique et screening phytochimique de *Caesalpiniabenthamiana* (Baill.) Herend. etZarucchi (Caesalpiniaceae). *Sciences & nature*, *4*(2), 217-225.

Bi F. T., Irié G. M., N'gaman K., & Mahou C. H. B. (2008). Études de quelques plantes thérapeutiques utilisées dans le traitement de l\'hypertension artérielle et du diabète : deux maladies émergentes en Côte d'Ivoire. *Sciences & Nature*,*5*(1), 39-48.

Blois M. S. (1958). Antioxidantdeterminations by the use of a stable free radical. *Nature, 181*(4617), 1199-1200.

Bouquet A. and Debray M. (1974):Medicinal plants in the Ivory Coast.232-pp.

Catier O. & Roux D. (2007). Botanique, pharmacognosie, phytothérapie (3ème éd.). *Rueil-Malmaison: Wolters Kluwer France.*

D'abrosca D., Pacifico S., Cefarelli G., Mastellone C., Fiorentino A.(2007). 'Limoncella' apple, an Italian apple cultivar: Phenolic and flavonid contents and antioxidant activity; *Food Chemistry*; 104: 1333-1337 pp.

Domitrović R. &Potočnjak I. (2016). A comprehensive overview of hepatoprotective natural compounds: mechanism of action and clinical perspectives. *Archives of toxicology*, *90*, 39-79.

Goba Z. B. (2012). L'impact des politiques de santé publique en côte d'ivoire 1980-2010 : état des lieux, conséquences et perspectives. *Rev hist archéolafr (GodoGodo)*, 22, 142-157.

Gutiérrez-del-Río I., López-Ibáñez S., Magadán-Corpas P., Fernández-Calleja L., Pérez-Valero Á., Tuñón-Granda M., ... &Lombó F. (2021). Terpenoids and polyphenols as natural antioxidant agents in food preservation.*Antioxidants*, *10*(8), 1264

Harborne, A. J. (1998). *Phytochemicalmethods a guide to modern techniques of plant analysis*. springer science & business media.

Iroka F. C., Okereke C. N. & Okeke C. U. (2014). "Comparative phytochemical and proximate analyses on *Ceiba pentandra* (L) Gaertn. and *Bombax buonopozense* (P) Beauv."): 162-167.

Jaiswal S. K., Gupta V. K., Siddiqi N. J., Pandey R. S., & Sharma B. (2015). Hepatoprotective effect of *Citruslimon* fruit extract against carbofuran induced toxicity in Wistar rats. *Chinese Journal of Biology*, *2015*(1), 686071.

Kangbéto R. E. B., Attakpa S. E., Guinnin F., Sènou M. &Lagnika L (2022). Toxicological assessment of ethanolic extracts of *Annona senegalensis* and *Trichiliaprieureana* in the treatment of type 2 diabetes in Benin.*Journal of Physiology and Pathophysiology*,*13*(2), 27-35.

Karumi Y., OnyeyiliP. A. &OgugbuajaV. O. (2004. "Identification of active principles of Momordicabalsamina (balsamapple) leafextract. 179-182.

Koné W. M., Atindehou K. K., Terreaux C., Hostettmann K. U. R. T., Traore D. & Dosso M. (2004). Traditionalmedicine in North Côte-d'Ivoire : screening of 50 medicinal plants for antibacterialactivity. *Journal of ethnopharmacology*,*93*(1), 43-49.

Kouamé K. K. B. & Koné M. W. (2017). Évaluation des conditions de traitement et de stockage des plantes médicinales sur les marchés du district d'Abidjan. *European Scientific Journal*, 13(3), 396–412.

Kumar S. (2014). Alkaloidal drugs-A review.*Asian Journal of Pharmaceutical Science & Technology*,*4*(3), 107-119.

Lagou S. M., Lebri M., Tilaoui M., Achibat H., Kone W. M., Tra Bi H. F., Ait Mousse H., Ouchetto H., Hafid A., Zyad A. &Khouili M. (2016). Phytochemical analysis and in vitro antioxidant activity of extracts of *Entandrophragmaangolense* (Welw.) C.DC. (Meliaceae) a medicinal plant used in the treatment of obstetric fistula in Ivory Coast. *Der Pharma Chemica*; *8*(10): 192-197.

Li S., Tan H. Y., Wang N., Zhang Z. J., Lao L., Wong C. W. & Feng Y. (2015). The role of oxidative stress and antioxidants in liver diseases. *International journal of molecular sciences*, *16*(11), 26087-26124.

Macheix J.-J., Fleuriet A. & Christian J. A. (2005).Les composésphénoliques des végétaux : un exemple de métabolites secondaires d 'importance économique . *Presses polytechniques et universitaires romandes*, 181 p.

Malan, D. F. (2008). *Plantes médicinales et pratiques médicales traditionnelles en Côte d'Ivoire : cas de la région des montagnes* (Thèse de doctorat). Université de Abidjan

Mallik D., Bhattacharjee C. & Gouda T. S. (2014). Pharmacological intervention of the fruit of plant Ananas comosus acting as hepatoprotective activity in animal models. *Indian Journal of Research in Pharmacy and Biotechnology*, *2*(3), 1167.

Marshall, N. T. (1998). *Searching for a cure: Conservation of medicinalwildliferesources in East and SouthernAfrica*(pp. vi+-112). Cambridge: TRAFFIC International.

N'Guessan K.,Kadja B., Zirihi G., Traoré D. & Aké-Assi, L. (2009). Screening phytochimique de quelques plantes médicinales ivoiriennes utilisées en pays Krobou (Agboville, Côte-d'Ivoire). *Sciences & Nature*, *6*(1).

Ngwoke K. G., Anusi I. A., Eze P. M., Okezie U. M., Abba C. C. &Abonyi D. O. (2015). "Phytochemical and antioxidantproperties of stem barkextracts of Anthocleistanobilis." *European Journal of Medicinal Plants, 8*(2): 107-111.

OMS/UNICEF (2005). Rapport Mondial sur le paludisme Génève-New York, Mai 2005, 120p.

Oyawaluja B. O., Oyawaluja A. A., Babasanmi J. S., &Soneye O. (2019). Phytochemistry and antioxidant assays of *Entandrophragmaangolense* (Welw.) C. DC. (Meliaceae) using DPPH and nitric oxide free radical scavenging methods.*Nigerian Journal of Pharmaceutical Research*, *15*(2), 229-235.

Pourette D. & Enel C. (2014). Représentations et vécu de l'hépatite B de patients subsahariens en Côte d'Ivoire et en France. *Santé publique*, (6), 869-878.

Rambaldi A., Jacobs B. P., Iaquinto G. &Gluud C. (2005). Milk thistle for alcoholic and/or hepatitis B or C liver diseases—a systematic cochrane hepato-biliary group review with meta-analyses of randomized clinical trials. *Official journal of the American College of Gastroenterology| ACG*, *100*(11), 2583-2591.

Sharma O. P. & Bhat T. K. (2009). DPPH antioxidant assay revisited.*Food chemistry*,*113*(4), 1202-1205.

SiallouA. P. A., kouakoubahR. K. D., n'guessanG. B., koném. W. &bi F. H. T. (2024). Étudeethnomédicinale des plantes utilisées dans le traitement de quelques maladies du foie dans la sous-préfecture de Bengassou (Centre-Est de la Côte d'Ivoire). *European Scientific Journal*, *20*(18), p. 195-215.

Sieniawska E., Świątek Ł., Sinan K. I., Zengin G., Boguszewska, A., Polz-Dacewicz, M., ... &Mahomoodally M. F. (2022). Phytochemical insights into *Ficus sur* extracts and their biological activity. *Molecules*, *27*(6), 1863.

Sima O. C., Obame E. L.-C., Ondo J.-P., O., Zongo C., Nsi E. E. & Traore S. A. (2015). Ethnotherapy study, phytochemical screening and antioxidant activity of *Antrocaryonklaineanum* Pierre and *Anthocleista nobilis* G. Don, Medicinal plants from Gabon.*International Journal of Advanced Research*, *3*(5), 812-9.

Singleton, V. L., & Rossi Jr, J. A. (1965). Colorimetry of total phenolicswithphosphomolybdic-phosphotungsticacidreagents. *American journal of Enology and Viticulture*, *16*(3), 144-158.

Sonibare M. A., Ayoola I. O. &Elufioye, T. O. (2017). Antioxidant and acetylcholinesterase inhibitory activities of leaf extract and fractions of *Albizia adianthifolia* (Schumach) WF Wright. *Journal of basic and clinical physiology and pharmacology*, *28*(2), 143-148.

Sourabié T. S., Ouedraogo N., Sawadogo W. R., Yougbare N., Nikiema J. B., Guissou I. P. &Nacoulma O. G. (2012). Evaluation of the anti-icterus effect of crude powdered leaf of *Argemone mexicana* L. (Papaveraceae) against CCl4-induced liver injury in ratst.*International Journal of Pharma Sciences and Research* (IJPSR), *3*(10), 491–496.

Stalikas C. D. (2007). Extraction, separation, and detection methods for phenolic acids and flavonoids.*Journal of SeparationScience*,*30*(18), 3268-3295

Tanoh S. K., N'Gaman-Kouassi C., Boa D., Mamyrbekova-Békro J. A., &Békro Y. A. (2019). Activité antioxydante des extraits bruts hydroéthanoliques et hydroacétoniques des organes de quatre plantes de Côte d'Ivoire médicinales. *Nature &Technology*, (21), 28-34

Téré, H. (2000). *Contribution à l'étude ethnobotanique des plantes médicinales utilisées dans le district d'Abidjan* (Mémoire de DEA). Université de Abidjan.

Tilaoui M., Achibat H., Lébri M., Lagou S., Ait Mouse, H., Zazouli, S., ... &Khouili M. (2021). Phytochemical screening, antioxidant and in vitro anticancer activities of *Bombax buonopozense* stem bark extracts. *Biotechnology & Biotechnological Equipment*, *35*(1), 1662-1668.

Torel J., Cillard J. &Cillard P. 1986*;* Antioxidants activities of flavonoids and reactivity with peroxy radical.*Phytochemistry*, 25: 383-385 pp.

Tra Bi F. H., Irié G. M., N'Gaman K. C. C. &Mohou C. H. B. (2008). Etude des plantes thérapeutiques utilisées dans le traitement de l'hypertension artérielle deux maladies émergentes en Côte d'Ivoire. *Sciences & Nature*, **5** (1) : 39-48.

Vangah-N'Guessan, R. (1995). *Contribution à l'étude des plantes médicinales utilisées en médecine traditionnelle en Côte d'Ivoire : cas de la région forestière* (Thèse de doctorat). Université Félix Houphouët-Boigny, Abidjan.

World HealthOrganization (WHO). (2013). *WHO TraditionalMedicineStrategy 2014–2023*. Geneva: WHO.

World HealthOrganization. (2002). *The world health report 2002: reducingrisks, promotinghealthy life*. World HealthOrganization.

Xie J. &Schaich K. M. (2014). Re-evaluation of the 2, 2-diphenyl-1-picrylhydrazyl free radical (DPPH) assay for antioxidant activity.*Journal of Agricultural and Food Chemistry*, *62*(19), 4251-4260.

Zhou Y., Wang J., Zhang D., Liu J., Wu Q., Chen J., ... & Pei J. (2021). Mechanism of drug-induced liver injury and hepatoprotective effects of natural drugs. *Chinese medicine*, *16*(1), 135.

Zirihi, G. N. (2006). *Études de quelques plantes médicinales utilisées en médecine traditionnelle en Côte d'Ivoire : activités pharmacologiques et analyse phytochimique* (Thèse de doctorat). Université de Abidjan.