



Phytochemical assessment, antiradical and antifungal activity of a recipe composed of three plants: *Khaya senegalensis*, *Mangifera indica* and *Ocimum canum*.

Ablam Alognon^{1*}, Sossawè Poli¹, Minyo Ega Sossa Montant¹, Yao Hoinsou¹, Luckman Gbati¹, Efuli Holaly Gbekley^{1,2}, Akouétévi Gérard Toudji¹, Bouraïma Djeri¹

¹Microbiology and Food Quality Control Laboratory (LAMICODA), Higher School of Biological and Food Techniques (ESTBA), University of Lomé, Lomé, 01BP 1515, Togo

²Laboratory of Biomedical Sciences, Food and Environmental Health - Research Unit in Biomedical Sciences and Bioactive Substances (LaSBASE-UR-2SB), Higher School of Biological and Food Techniques (ESTBA), University of Lomé, 01BP 1515, Lomé, Togo.

*Correspondence: Ablam Alognon: gastonalognon92@gmail.com; Tel: 91081487.

Submission 18th July 2024. Published online at <https://www.m.elewa.org/Journals/> on 30th September 2024. <https://doi.org/10.35759/JABs.200.4>

ABSTRACT

Objectives: The present study assessed the pharmacological properties of plants and a recipe used in traditional medicine for the treatment of *Candida albicans* vaginitis in Togo.

Methodology and Results: Qualitative phytochemical analysis was studied using standard tests, Total phenol content, Condensed tannin levels, flavonoid content were determined respectively by the Folin-Ciocalteu method, Butanol-HCl method, and the aluminium chloride method, and free radical scavenging activity by phosphomolybdate reduction and the FRAP method. The microdilution method coupled with spreading on an agar medium was used for the antifungal tests. Phytochemical analysis revealed phenolic compounds, alkaloids, flavonoids, saponosides, tannins, triterpenes, and sterols. *Khaya senegalensis* contains more phenols (97.26±0.10 mg AGE/g) and recorded the best free radical scavenging activity with both methods (2.7±0.00 with the FRAP method and 0.08±0.00 mgAAE/g with the molybdate reduction method (0.08 ±0.00 mg AAE/g). *Mangifera indica* contains more proanthocyanidins (0.98%±0.00 mgCE/g) and more flavonoids (196.35±5.27 mgAGE/g). Antifungal tests showed that all of the plants and that of the recipe had antifungal activity on the germs tested. MICs and MFCs ranged from 3.125 to 50 mg/ml. The recipe extract was fungicidal on most germs tested.

Conclusion and application of results: The results obtained partly justify the traditional use of this recipe in the treatment of *Candida albicans* vaginitis in Togo.

Keywords: *Khaya senegalensis*, *Mangifera indica*, *Ocimum canum*, vaginitis, recipe, plants.

INTRODUCTION

Vaginitis is more common after the patient has a vaginal imbalance. Among the various forms of candidiasis, vulvovaginal candidiasis (VVC) is a frequent reason for consultation in gynaecology (Pihet et Marot, 2013, Bergogne-Bérézin, 2007). Seventy five percent (75%) of women were affected by VVC during their reproductive age. of (Dovnik *et al.*, 2015). Many cases of VVC have an effect on a sexual activity and mental health. (Blostein *et al.*, 2017). *Candida albicans* is usually the pathogen, which is implicated in VVC. Some complications can be observed in CVV including infertility, premature birth, miscarriage and other infectious diseases (Powell et Nyirjesy, 2014). The high cost of drugs and the phenomenon of antifungal resistance due to the repeated use of antifungals make treatment difficult (Garnaud C, Cornet, 2020). To find solutions

of these problems, new alternatives are needed. New molecules which could be used to fight bacteria could be found in medicinal plants (Mbaveng *et al.*, 2015). Indeed, a review by Alognon *et al.* (2023) on the antifungal activity of medicinal plants in West Africa identified 56 plants studied with 43% of the plants exhibiting good activity *in vitro* (Alognon *et al.*, 2023). Based on an ethnobotanical survey, we focused on *K. senegalensis*, *M. indica* and *O. canum*, three plants used to treat vulvovaginal candidiasis in Togo. However, the scientific knowledge available concerning the activity of these plants on microorganisms is insufficient. The overall aim of this study is to contribute to the evaluation of the pharmacological properties of a recipe made up of these three plants used in traditional medicine in Togo for the treatment of vulvovaginal candidiasis.

MATERIALS AND METHODS

Solvents and reagents: methanol, magnesium chloride, iron trichloride, Dragendorff reagent, concentrated sulfuric acid, aluminium chloride, rutin, Folin-Ciocalteu reagent (FCR), gallic acid, potassium bicarbonate, butanol, HCl, 0.6M sulfuric acid, 0.1% sodium phosphate, ascorbic acid, distilled water, ferric chloride, quercetin, chloroform, 95% ethanol, distilled water were purchased from Fisher (USA).

Plant material and extraction: The plant material used consisted of the trunk barks of *K. senegalensis* and *M. indica*, and the whole plant of *O. canum*. Plant samples were collected in Anfoin (Lakes prefecture) and in Vogan (VO prefecture) in the Maritime Region. The plants were shade-dried for two weeks at the laboratory temperature ($28 \pm 2^\circ\text{C}$)

before being ground into powder. To prepare the hydroethanol extract, 250 g of powder was stirred for 48 h in 3000 ml of 70% dilute ethanol. It was then filtered through Whatman N° 1 filter paper. A rotary evaporator was used to evaporate the solvent. The extracts were then frozen and freeze-dried.

Fungal strains: Two reference strains of *C. albicans* (*C. albicans* ATCC 10231 and *C. albicans* ATCC 35659) and 6 strains of *C. albicans* were used as biological material. Strains were provided by the Institut National d'Hygiène.

Qualitative phytochemical testing of extracts: A summary qualitative phytochemical analysis was studied using standard tests. Extracts were analysed for

phenolic compounds, alkaloids, flavonoids, tannins, triterpenes/sterols, and saponosides (Odeja *et al.*, 2014).

Testing for phenolic compounds: A few drops of iron trichloride (FeCl₃) were added to 2 ml of extract. The presence of a blackish-brown coloration showed the presence of phenolic compounds.

Flavonoid detection: Add a few drops of magnesium turnings to 2 ml of extract. When a few drops of concentrated HCl are added, a yellow-orange or purple-red coloration appears, confirming the presence of flavonoids.

Testing for alkaloids: To 2 ml of extract, one drop of Dragendorff's reagent was added. The presence of alkaloids was confirmed by formation of a precipitate

Test for saponosides: 2 ml of extract in two separate tubes was shaken vigorously for 1 minute. The presence of persistent foam in the extract proves the presence of saponosides. The second tube served as a control.

Triterpenes and sterols: The appearance of a red-brown ring between two phases, one clear at the bottom and the other green (not so much) at the top, after addition of a few drops of chloroform and concentrated sulfuric acid to 2ml of extract indicates the presence of triterpenes and sterols.

Quantitative phytochemical testing of extracts

Polyphenol assay: Total phenol content was assessed using the method described by Singleton *et al.* (1999) taken over by Ouadja *et al.* (2018). Values were determined by extrapolation on a standard curve, obtained from a series of dilutions of gallic acid (200 mg/l) with distilled water, ranging from 0.1 to 0.25 mg/ml. A mixture of 0.2 ml extract (the sample to be assayed) at 1mg/ml and 0.5 ml FCR diluted 1/2 in distilled water is added to the test tubes. After 5 minutes incubation at room temperature, 0.5 ml sodium carbonate (20 g/l) was added to the mixture. The

volume in each tube was made up to 4ml. After shaking, the different solutions are left to stand, protected from light, for 30min. Optical density was read at 760 nm against a negative blank consisting of a mixture of 0.5ml FCR, 0.5ml sodium carbonate and distilled water, and a positive blank consisting of the extract to be determined and distilled water. Three readings are taken per sample.

Proanthocyanidin assay: Proanthocyanidin content was assessed using the Butanol-HCl method, developed by Porter *et al.*, (1986) taken over by Ouadja *et al.* (2018). The test consisted in adding to 50 mg of each extract, 0.2ml of ammoniacal iron sulfate (20g/l) and 7ml of a butanol/HCl solution (95/5 ml) in tubes. After 45 min incubation in a water bath at 95°C, absorbances were read at 550 nm. Optical densities were read three times for each extract.

$$X = (OD \times 1CE/g) / 0.280$$

OD = 280 g equivalent to 1% catechin; OD = optical density measured at 540nm; X = equivalent catechin concentration per gram (%CE /g).

Determination of flavonoid content: Flavonoid content was assessed using the method described by Andzi-Barhé *et al.* (2015). The operation-involved vortexing 1ml of the 1mg/ml extract solution or 1ml of each quercetin concentration with 1ml of 2% aluminium chloride (AlCl₃). After 10 min incubation, absorbance will be measured directly with a UV-visible spectrophotometer (METASH UV-5200PC UV/VIS Spectrophotometer) at 415 nm against a blank. Quercetin will be used as a standard. Three tests will be carried out for each extract.

Evaluation of the free radical scavenging activity of the extracts by the phosphomolybdate reduction method: The

protocol used is that described by Prieto *et al.* (1999). The phosphomolybdate reagent was prepared (100 ml reagent) from a mixture of 90ml 0.6M sulfuric acid, 5 ml 0.1% sodium phosphate and 5 ml 1% ammonium molybdate. For the test, 1ml of each extract was added to 9ml of the above reagent. The mixture was heated to 95°C in a water bath for 90 minutes, after which it was cooled to room temperature. Optical densities were measured at 695 nm against a blank consisting of reagent and distilled water. The standard antioxidant used is ascorbic acid, and results were expressed as milligrams of ascorbic acid equivalent per gram of extract noise (mg AAE/g). Tests were carried out in three trials.

Evaluation of antioxidant activity using the FRAP (Ferric Reducing Antioxidant Power) method: The protocol used is that described by Benzie *et Strain* (1996). For test extract samples, to 3 ml of freshly prepared FRAP assay reagent in a test tube with a mixture of three solutions (acid buffer pH = 3.5 (50 ml), 2,4,6- tripyridyl-s-triazine (TPTZ) solution (5 ml) and iron III chloride solution (5 ml) reagent (3ml), test extract solution (100 µl) of titre 1mg/ml were mixed in the same proportions as for standard curve plotting. Optical density was read after 5 minutes at 593 nm. The antioxidant capacity of the extracts was measured using the calibration curve by the colour change linked to the formation of the complex (Fe²⁺ TPTZ) and expressed in µmol Eq FeSO₄/mg dry extract. Trials were repeated 3 times.

Assessment of antifungal activity: In a 96-well plate, three successive series of gradient 2 dilutions were made from the extract stock solutions and MH broth. A series of concentrations of: 100 mg/ml, 50mg/l, 25mg/ml, 12.5 mg/ml. The volume of extract per well is 100 µl. Each well then receives 100 µl of microbial suspension. The test was performed in an aseptic environment under a

laminar flow hood (BIO KLONE 2) and repeated three times for each extract *C. albicans* strain. Nystatin Injection 10mg/ml was used as the standard antibiotic. The wells were read after 18-24h incubation in an oven at 37°C. Turbidity and haze deposit in each well were assessed by eye. The Minimum Inhibitory Concentration (MIC) was read, corresponding to the concentration of the well containing the lowest concentration of extract with no visible culture. The Minimum Fungicidal concentration (MFC), which by definition is the lowest concentration that kills 99.99% of the starting inoculum, was determined by spreading a 100 µl aliquot of wells with concentrations are greater than or equal to the MIC on sabouraud chloramphenicol. Tests were performed three times. Antifungal activity is considered fungicidal if MFC/MIC= 1; fungistatic if MFC/MIC= 2 (Ouada *et al.*, 2018) .

Study of the synergistic, antagonistic and additive effects of extracts: The effect of combining different extracts was assessed using the method described by Toudji *et al.*, 2018 (Toudji *et al.*, 2018) . Dilutions are always of order 2 for each extract. In each well, 50µl of each dilution of the two extracts to be combined is added to 100µl of bacterial inoculum. The different combinations are assessed by calculating the fractional inhibitory concentration index (FICI). FICI = FICIA + FICIB, where A, B and C are the different extracts. If FICI<1, there is Synergy; 1<FICI<2, No interaction; FICI>2, Antagonism; FICI= 1, Additivity

Statistical analysis: The statistical study was carried out using Graph Pad Prism 5 statistical software and Excel 2016 spreadsheet software. The standard error of the mean accompanied. The difference between means is considered statistically significant at the 5% level (p<0.05). Mean values.

RESULTS

Qualitative phytochemical tests: The results of qualitative phytochemical tests are reported in Table 1. They show that the extracts tested contain all the compounds tested, with the exception of *K. Senegalensis*, which contains no alkaloids

Table 1: Results of qualitative phytochemical tests

	phenolic compound	Alkaloids	Flavonoids	Saponosides	Tannins	Triterpenes and sterols
<i>M. indica</i>	+	+	+	+	+	+
<i>K. senegalensis</i>	+	-	+	+	+	+
<i>O. canum</i>	+	+	+	+	+	+
<i>Recipes</i>	+	+	+	+	+	+

(+: presence; -: absence).

Total phenol, proanthocyanidin and flavonoid contents. Results summarized in table 2 shows that *K. senegalensis* extract is richest in total polyphenols (4.15±0.11 mg GAE/g extract), followed by *M. indica* extract (97.26±0.10 mg GAE/g extract). *O. canum* extract has the lowest total polyphenol value (39.5±0.06 mg GAE/g extract), while *M. indica* extract is richer in proanthocyanidins or condensed tannins (0.98 mg CE/g), while the recipe is richer in flavonoids.

Table 2: Results of quantitative phytochemical tests

Compounds Extracts	Total polyphenols (mg AAE/g)	Proanthocyanidins (mg CE/g)	Flavonoids (mg QE/g)
<i>K. senegalensis</i>	97.26±0.10	0.59%±0.01	177.02±19.39
<i>M. indica</i>	95.68±0.34	0.98%±0.00	196.35±5.27
<i>O. canum</i>	39.5 ± 0.06	0.58%±0.00	93.07±4.80
Recipe	95.25 ± 5.25	0.94%±0.00	213.64±6.14

Anti-free radical activity: The results are summarized in table 3. : Anti-free radical activity showed that *Khaya senegalensis* recorded the best free radical scavenging activity with both methods (2.7±0.00 with the FRAP method and 0.08±0.00 mgAAE/g with the molybdate reduction method. The highest value was obtained with *K. senegalensis* extract (0.08 mg AAE/g of extract).

Table 3: Anti-free radical activity results

Compounds Extracts	Anti-free radical activity FRAP (mg AAE/g)	Anti-free radical activity Phosphomolybdate (mg AAE/g)
<i>K. senegalensis</i>	2.7±0.00	0.08±0.00
<i>M. indica</i>	2.6±0.00	0.06±0.00
<i>O. canum</i>	2.4±0.04	0.06±0.00
Recipe	2.6±0.00	0.07±0.00

Antifungal activity: The antifungal activity results (Table 4) show that, overall, the four hydroethanolic extracts tested (*K. senegalensis*, *M. indica*, *O. canum* and the Three-Plant Recipe) showed antifungal activity on all *Candida* strains tested at concentrations ranging from 3.125 to 50 mg/ml.

Table 4: Antifungal activity of extracts

Germs	Concentrations (mg/ml)	Extracts			Recipe
		<i>K. senegalensis</i>	<i>M. indica</i>	<i>O. canum</i>	
	MIC	12.5	12.5	6.25	3.125
<i>C. albicans</i>	MFC	25	25	12.5	6.25
ATCC (36591)	MFC/MIC	2	2	2	2
	MIC	12.5	12.5	12.5	12.5
<i>C. albicans</i>	MFC	25	25	25	25
ATCC(10231)	MFC/MIC	2	2	2	2
	MIC	6.25	12.5	6.25	3.125
<i>C. albicans 1</i>	MFC	12.5	25	12.5	3.125
	MFC/MIC	2	2	2	1
	MIC	12.5	12.5	12.5	6.25
<i>C. albicans</i>	MFC	25	12.5	25	6.25
2	MFC/MIC	2	1	2	1
	MIC	12.5	12.5	6.25	3.125
<i>C. albicans 3</i>	MFC	25	12.5	6.25	3.125
	MFC/MIC	2	1	1	1
	MIC	25	12.5	6.25	12.5
<i>C. albicans 4</i>	MFC	25	12.5	12.5	12.5
	MFC/MIC	1	1	2	1
	MIC	6.25	6.25	6.25	3.125
<i>C. albicans 5</i>	MFC	6.25	6.25	6.25	3.125
	MFC/MIC	1	1	1	1
	MIC	12.5	25	12.5	6.25
<i>C. albicans 6</i>	MFC	25	50	12.5	12.5
	MFC/MIC	2	2	1	2

The lowest MIC (3.125 mg/ml) was obtained with Recipe extracts on *C. albicans* ATCC 36591, *C. albicans* 1, *C. albicans* 3 and *C. albicans* 5. The lowest FMC was obtained with recipe extracts (3.125 mg/ml). *K. senegalensis* bark extract was fungicidal on *C. albicans* 4; *C. albicans* 5; and fungistatic

on all other strains tested. *M. indica* bark extract was fungicidal on *C. albicans* 2; *C. albicans* 3, *C. albicans* 4; *C. albicans* 5, and fungistatic on all other strains. Whole plant extract of *O. canum* was fungicidal against *C. albicans* 3; *C. albicans* 5; *C. albicans* 6, and fungistatic on other strains.

Table 5: Study of synergistic, antagonistic and additive effects of extracts

Combination Strains	<i>Ks/Mi MIC</i>	<i>FIC_{Ks}</i>	<i>FIC_{Mi}</i>	<i>FICI</i>	<i>Action</i>	<i>Ks/Oc MIC</i>	<i>FICKs</i>	<i>FICOc</i>	<i>FICI</i>	<i>Action</i>
ATCC 36591	6.25	0.5	0.5	1	Ad	6.25	0.5	1	1.5	-
ATCC 10231	6.25	0.5	0.5	1	Ad	6.25	0.5	0.5	1	Ad
Ca1	3.125	0.5	0.25	0.75	S	6.25	0.5	0.5	1	Ad
Ca2	12.5	1	1	2	-	6.25	0.5	0.5	1	Ad
Ca3	6.25	0.5	0.5	1	Ad	6.25	0.5	0.5	1	Ad
Ca4	12.5	0.5	1	1.5	-	25	1	0.5	1	Ad
Ca5	6.25	0.5	1	1.5	-	50	0.5	0.5	1	Ad
Ca6	12.5	0.5	0.5	1	Ad	12.5	0.5	0.5	1	Ad

Ad= additivity; S= synergy; - = no interaction

Table 5 (continued)

Combination Strains	<i>Mi/Oc MIC</i>	<i>FICMi</i>	<i>FICOc</i>	<i>FICI</i>	<i>Action</i>
ATCC 36591	3.125	0.25	0.5	0.75	S
ATCC 10231	6.25	0.5	0.5	1	Ad
Ca1	6.25	0.5	1	1.5	-
Ca2	6.25	0.5	0.5	1	Ad
Ca3	6.25	0.5	1	1.5	-
Ca4	12.5	1	2	3	An
Ca5	3.125	0.5	0.5	1	Ad
Ca6	6.25	0.25	0.5	0.75	S

Ad= additivity; S= synergy; - = no interaction, Ca = *C. albicans*. The study of the effect of combining extracts showed that 62.5% (10/16) of combinations showed additivity, 12.5% showed synergy and 18.75% showed no interaction and 6.25% showed antagonism.

DISCUSSION

The results show us that the extracts tested all contain flavonoids, triterpenes and sterols, results confirmed by other authors (Pritesh et Zara, 2015 ; Fagbohoun, 2014 ; Takin *et al.*, 2014 ; Atto *et al.*, 2016 ; Ononamadu *et al.*, 2019) . Alkaloids are present in all extracts tested except in *K. senegalensis* extracts. Fagbohoun confirmed the absence of alkaloids in *K. senegalensis* in 2014, while Fagbohoun (2014) and Harbone *et al.* (2000) proved the presence of alkaloids in *M. indica* and *O. canum*. Several studies have been carried out on *K. senegalensis*, *M. indica* and *O. canum*. However, quantitative phytochemical studies of phenolic compounds in extracts from these plants are limited. In the present study, *M. indica* recorded a proanthocyanidin content of

0.98%±0.00 mgCE/g. This result is at odds with the work carried out by Dweck (2005), who showed that mango bark contains 16-20% condensed tannins. These differences could be explained by the variation of methodology, pedological and climatic differences. The phenolic compound content found would explain the antifungal activity of the extract of (*K. senegalensis*, *M. indica* and *O. canum*), as would the recipe. As phenols have the ability to inhibit the germination of pathogenic plant spores, they are excellent candidates for combating pathogenic fungi in humans (Cushnie et Lamb, 2005). Other experimentations demonstrated that phenolic compounds have antioxidant properties (Koudoro *et al.*, 2014) . In addition, the free radical scavenging activity of these plant

extracts and the recipe was determined by the phosphomolybdate reduction and by the FRAP method. These directly measure the total reducing capacity of the antioxidant present in the samples (Phatak et Hendre, 2013). The free radical scavenging activity of reducing compounds measured in this way is quantified in milligram ascorbic acid equivalent per gram (mg EAA/g) of extract. A good correlation was observed between the proanthocyanidin content of the extracts and the results of free radical scavenging activity ($r^2 = 0.94$). Studies by Ouadja *et al.* (2018) found the same correlation (Ouadja *et al.*, 2018). The highest value was obtained with *K. senegalensis* extract (0.08 mg EAA/g extract). These results corroborate the work of Martinez, *et al.* (2009) and Androulakis *et al.* (2006) and the lowest value was obtained with *M. indica* and *O. canum* extracts (0.06 mg ascorbic acid equivalent per gram extract). These results confirm those obtained by Martinez, *et al.* (2009) and Makut *et al.* (2008) who demonstrated the antiradical activity of *K. senegalensis* trunk bark extracts. These results confirm that *K. senegalensis* is a potential source of antioxidants. These results confirm use of this recipe in medicine. The antifungal power of *K. senegalensis* extract was studied against 8 strains of *Candida*. Our results confirm those of Makut *et al.* (2008) who found in 2008 that

K. senegalensis bark extract has a fungicidal effect against *C. albicans*. Earlier work demonstrated the antifungal efficacy of *K. senegalensis* bark extract *in vitro* on three vegetable fungal pathogens in the Sokoto metropolis at different concentrations 1mg/ml; 3 mg/ml; 6 mg/ml; 9 mg/ml and 12mg/ml. These extracts were found to be effective in reducing the growth of these pathogenic fungi to a percentage inhibition of (83.05±0.53%) (Shehu *et al.*, 2016.) The antifungal activity of *M. indica* extract was evaluated on 8 *Candida* strains. Results show the inhibitory properties of *M. indica* extract on *Candida* strains, with MICs ranging from 6.25 to 50 mg /ml. These results concur with those of Disegha GC, Akani (2017) who found that the ethanolic extract of *M. indica* proved sufficiently active against *C. albicans* with a MIC of 20 mg/ml. The antifungal activity of *O. canum* extract was studied against 8 *Candida* strains. Our results concur with those obtained by Thaweboon S, Thaweboon (2009) who demonstrated the antifungal activity of *O. canum in vitro* against *C. albicans*. The extract of the recipe composed of the three plants: *K. senegalensis*; *M. indica* and *O. canum* were fungicidal on germs tested. This fungicidal power is due to the additive effect of the three plants in the recipe on the germs.

CONCLUSIONS AND APPLICATIONS

This work is part of the evaluation of the activity of three plants and a traditional recipe based on three plants, *K. senegalensis*, *M. indica* and *O. canum* used in the treatment of vulvovaginal candidiasis in Togo. The results confirm that the recipe has antifungal activity. Its action was fungicidal on most of the *Candida* strains tested; with a Minimum Fungicidal Concentration ranging from 3.125 to 50mg/ml. Phytochemical analysis reveals

the presence of several chemical groups. Determination of total polyphenols showed their presence in large quantities in the hydroethanolic extracts of *K. senegalensis*, *M. indica* and the recipe exerts antiradical activity. The results obtained partly justify the traditional use of this recipe in the treatment of vulvo-vaginal candidiasis, and merit further research.

AUTHOR CONTRIBUTIONS

Conceptualization, A.A. and B.D.; methodology, A.A., S.P., A.G.T. software, S.P., A.A.; formal analysis, A.A., S.P.; resources, M.E.S.M., B.D.; data curation, S.P., A.A.; writing—original draft preparation, A.A, S.P., M.E.S.M., Y.H., L.G.; writing—review and editing, A.A., S.P., E.H.G., Y.H.; visualization, S.P., L.G., Y.H., M.E.S.M. B.D., All authors have read and

agreed to the published version of the manuscript.

Conflicts of Interest: The authors declare that they have no competing interests.

ACKNOWLEDGMENTS

We would like to thank all those who have contributed directly or indirectly to the development of this assessment.

REFERENCES

- Alognon A, Poli S, Montant MES, Hoinsou Y, Gbati L, Gbekley EH, Djeri B, 2023. Antifungal activity of African medicinal plants: a review. *OAJ* 6(1):80-4.
- Androulakis XM, Muga SJ, Chen F, Koita Y, Toure B, Wargovich MJ, 2006. Chemopreventive effects of *Khaya senegalensis* bark extract on human colorectal cancer. *Anticancer Res* 26(3B):2397-405.
- Andzi Barhé T, 2015. Phytochemical studies, total phenolic and flavonoids content and evaluation of antiradical activity of the extracts of the leaves from *Dischistocalyx* sp. (Acanthacées). *Journal of Pharmacognosy and Phytochemistry* 3(6):174-8. 16.
- Attoh V, Pierre KD, Francois MG, Franck AM. 2016. Phytochemical Screening of *Sclerocarya birrea* (Anacardiaceae) and *Khaya senegalensis* (Meliaceae), antidiabetic plants. *International Journal of Pharmacy and Chemistry* 2(1):1.
- Benzie IF, Strain JJ, 1996. The ferric reducing ability of plasma (FRAP) as a measure of « antioxidant power »: the FRAP assay. *Anal Biochem* 239(1):70-6.
- Bergogne-Bérézin E, 2007. Flores vaginales normales, vaginites et vaginoses bactériennes: diagnostic et thérapeutique. *Antibiotiques* 9(2):139-44.
- Blostein F, Levin-Sparenberg E, Wagner J, Foxman B, 2017. Recurrent vulvovaginal candidiasis. *Annals of Epidemiology* 27(9):575-582.e3.
- Cushnie TPT, Lamb AJ, 2005. Antimicrobial activity of flavonoids. *International Journal of Antimicrobial Agents* 26(5): 343-356.
- Disegha GC, Akani N, 2007. Antifungal activity of *Mangifera indica* leaf extracts on selected fungi. *Science and Technology* 4(2):136-48.
- Dovnik A, Golle A, Novak D, Arko D, Takač I, 2015. Treatment of vulvovaginal candidiasis: a review of the literature. *Acta Dermatovenerologica Alpina Pannonica et Adriatica* 24(1).
- dweck AC, 2001. Article for cosmetics and toiletries magazine ethnobotanical plants from Africa. Black Medicare Ltd, Itshire, UK - Recherche Google [Internet]. [cité 11 nov 2020]. Disponible sur: <https://www.google.com/search?client=firefox-b-d&ei=MU-sX8j7AoCDhblP9KOdoA4&q=dweck%2C++A.C.+++%282001%29%3A++Article++for+++cosmetics+and+toiletries+magazine+ethnobotanical+++plants+++from+++Africa>.
- Fagbohoun L, 2014. Étude chimique de colorants naturels et matériaux

- résineux traditionnels au Bénin dans le domaine artisanal. In Avignon.
- Garnaud C, Cornet M, 2020. Membrane et paroi fongiques : des rôles clés dans la résistance aux antifongiques. *Revue Francophone des Laboratoires* 2020(519):50-8.
- Harborne JB, Williams CA, 2000. The phytochemical richness of the Iridaceae and its systematic significance. *Annali di botanica* 58.
- Koudoro Y, Agbangnan D. CP, Yèhouénu B, Tchobo FP, Alitonou G, Avlessi F, Sohounhloué DCK, 2014. Phytochemistry, antimicrobial and antiradical activities evaluation of essential oils, ethanolic and hydroethanolic extracts of the leaves of *Eucalyptus citriodora* hook from Benin. *Scientific Study & Research* 15:059-73.
- Makut MD, Gyar SD, Pennap GRI, Anthony P, 2008. Phytochemical screening and antimicrobial activity of the ethanolic and methanolic extracts of the leaf and bark of *Khaya senegalensis*. *African Journal of Biotechnology* 7(9).
- Martínez EP, Hío JC, Osorio JA, Torres MF, 2009. Identification of *Colletotrichum* species causing anthracnose on Tahiti lime, tree tomato and mango. *Agronomía Colombiana*. 27(2):211-8.
- Mbaveng AT, Sandjo LP, Tankeo SB, Ndifor AR, Pantaleon A, Nagdjuj BT, Kuete V, 2015. Antibacterial activity of nineteen selected natural products against multi-drug resistant Gram-negative phenotypes. *SpringerPlus* 4(1):823.
- Odeja O, Obi G, Ogwuche C, Elemike E, Oderinlo O, 2014. Phytochemical screening, Antioxidant and Antimicrobial activities of *Senna occidentalis* (L.) leaves. *International Journal of Herbal Medicine* 2(4):26-30.
- Ononamadu CJ, Alhassan AJ, Imam AA, Ibrahim A, Ihegboro GO, Owolarafe AT, Sule M, 2019. In vitro and in vivo anti-diabetic and anti-oxidant activities of methanolic leaf extracts of *Ocimum canum*. *Caspian J Intern Med* 10(2):162-75.
- Ouadja B, Anani K, Djeri B, Ameyaoh YO, Karou DS, 2018. Evaluation of the phytochemical composition, antimicrobial and anti-radical activities of *Mitracarpus scaber* (Rubiaceae). *JMPR*. 12(28):493-9. 10.5897/JMPR2018.6631. <https://academicjournals.org/journal/JMPR/article-abstract/902A6BD59084>.
- Pappas PG, Lionakis MS, Arendrup MC, Ostrosky-Zeichner L, Kullberg BJ, 2018. Invasive candidiasis. *Nat Rev Dis Primers* 4(1):1-20.
- Phatak RS, Hendre AS, 2013. Total antioxidant capacity (TAC) of fresh leaves of *Kalanchoe pinnata*. *Journal of pharmacognosy and phytochemistry* 2(5): 32-35.
- Pihet M, Marot A, 1986. Diagnostic biologique des candidoses. *Revue Francophone des Laboratoires* 2013(450):47-61.
- Porter L, Hritsch L, Chan B, 1986. The conversion of procyanidins and prodelphinidins to cyanidin and celphinidin. *Phytochemistry* 25:223-230.
- Powell AM, Nyirjesy P, 2014. Recurrent vulvovaginitis. *Best Pract Res Clin Obstet Gynaecol*. 28(7):967-76.
- Prieto P, Pineda M, Aguilar, 1999. Spectrophotometric Quantitation of Antioxidant Capacity through the Formation of a Phosphomolybdenum Complex: Specific Application to the Determination of Vitamin E. *Analytical biochemistry* 269:337-41.

- Pritesh et Zara, 2015. Phytochimie de *Mangifera indica* - Recherche Google [Internet]. [Cité 11 nov 2020]. Disponible sur: https://www.google.com/search?client=firefox-b-d&ei=Q0isX--5A_yHhbIPtcON-AE&q=Pritesh+et+Zara.
- Shehu H, Aziri AF, Musa AR, 2016. Ethnomedicinal potential of *Khaya senegalensis* (desr) a. Juss (mahogany) on pathogenic fungi of vegetables in sokoto metropolis. International Journal of Applied Chemistry and Pharmaceutical Sciences 1(1): 15- 24.
- Singleton V, Orthofer R, Lamuela-Raventos RM, 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. Methods in Enzymology 299:152-78. [https://doi.org/10.1016/S0076-6879\(99\)99017-1](https://doi.org/10.1016/S0076-6879(99)99017-1).
- Sobel JD, 2014. Vulvovaginal candidosis. The Lancet. 2007;369(9577):1961-71.
- Takin M, Ahokpè M, Zohoun L, Assou E, Aïvodji N, Agossou E, et al. Effect of total *Khaya senegalensis* (Meliaceae) barks extracts on hepatic liberation of glucose. National Journal of Physiology, Pharmacy and Pharmacology 4(2):112.
- Thaweboon S, Thaweboon B, 2009. In vitro antimicrobial activity of *Ocimum americanum* L. essential oil against oral microorganisms. The Southeast Asian journal of tropical medicine and public health 40(5).
- Toudji G, Thiombiano AME, Karou SD, Anani K, Yao A, Gbekley E, Kiendrebeogo M, Ameyapoh Y, Jacques Simporé J, 2018. Antibacterial and anti-inflammatory activities of crude extracts of three Togolese medicinal plants against esbl *Klebsiella pneumoniae* strains. African Journal of Traditional, Complementary and Alternative medicines 15:42-58.