Journal of Applied Pharmaceutical Science Vol. 4 (08), pp. 036-041, August, 2014
Available online at http://www.japsonline.com
DOI: 10.7324/JAPS.2014.40807
ISSN 2231-3354

Antioxidant activity and total phenolic content of nine plants from Côte d'Ivoire (West Africa)

Yao Konan, Koné Mamidou Witabouna, Bonfoh Bassirou, Kamanzi Kagoyire

Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire and Centre Suisse de Recherches Scientifiques en Côte d'Ivoire (CSRS), Côte d'Ivoire.

ARTICLE INFO

Article history:
Received on: 14/04/2014
Revised on: 07/05/2014
Accepted on: 18/05/2014
Available online: 27/08/2014

Key words:
Antioxidant; Côte d'Ivoire; Free radical; Polyphenols; Plants; West Africa

ABSTRACT

Plants are widely consumed in Africa and may contribute to improve the nutritional status and health of people. The aim of this study was to evaluate the antioxidant activity and total phenolic content of nine plants consumed in people's diet. Out of 20 extracts tested (10 dichloromethane and 10 methanolic 80%), 18 (90%) exhibited ability to scavenge free radicals. High correlation has been established between antioxidant activity and total phenolic content of *Psorospermum febrifugum, Myrianthus arboreus* and *Ceratotheca sesamoides*. These plants could be potential rich sources of natural antioxidants and developed into functional food for nutrition and prevention of oxidative stress-related diseases.

INTRODUCTION

An excess production of free radicals and a deficient cellular antioxidant defense system leads to oxidative stress in human (Morales-González, 2013). This condition generally imposed by reactive oxygen species, plays an important role in many chronic and degenerative diseases (Dichi *et al*., 2013). These diseases such as ischemic heart disease, cancer, diabetes mellitus and ageing are increasing in Sub-Saharan countries. According to Mayosi (2013), a projected tsunami of hypertension and diabetes will occur in this continent which records the lowest number of health professionals per capita, and the most fragile of health systems in the world. An 81% relative increase in diabetes in the world will occur in Africa, resulting in 49.7 million people with diabetes by 2030 (Federation, 2011). This increase is mainly the result of increasing urbanisation, lifestyle, stress, lack of physical activity, over-consumption of foods rich in saturated fat, sugar and starch. The treatment of these diseases is highly costly in West Africa and promotion of functional food may be an alternative medicine solution. Wild plants are still consumed as food and/or herb tea in many areas of West African countries such as Côte d'Ivoire. There is a compelling evidence that consumption of fruit and vegetable-rich diet inversely correlates with the risk of cardiovascular diseases and certain forms of cancer (Crowe *et al*., 2011; Marmot, 2011; Leenders, 2013).

Therefore, the development and utilization of more effective antioxidant of plants origin are desirable. These antioxidants of natural origin can scavenge free radicals and limit their effects on cell damage. According to Leja *et al.* (2013), high nutritional value of food is due to the presence of compounds exhibiting antioxidant activity, especially the suppression of active oxygen. This chemoprotective effect is, at least in part, related to the activities of polyphenolic compounds, carotenoids, tocopherols and ascorbic acid (Blomhoff *et al*., 2006; Moylan and Reid, 2007). There is growing evidence that an increase in dietary levels of such substances may be of long-term benefit to human health (Pandey and Rizvi, 2009). Among these phytocompounds, phenolic compounds are receiving considerable attention as potential agents for preventing and treating many oxidative stress-related diseases (Gan *et al*., 2010) or improving nutritional status of people. Côte d'Ivoire is endowed naturally with a very rich flora and the use of plant ingredients as food or medicinal sources is well documented (Ambé, 2001; Yao, 2010; Koné *et al*., 2012). But there are still few reports about the antioxidant activities of these plants (Aké *et al*., Soro *et al*., 2010, Ahoua *et al*., 2012) and polyphenols content.

* *Corresponding Author*
Email: yao83konan@yahoo.fr

The current study was initiated to explore the *in vitro* free radical scavenging potential and total phenolic content of some plant foods from Côte d'Ivoire.

MATERIALS AND METHODS

Plant material selection and extraction

Nine plants were selected after an ethnobotanical survey carried out in 2009 on food and medicinal plants consumed in three ecological areas in Southern- (Abidjan), Central- (Bouaké) and Northern- (Korhogo) Côte d'Ivoire (Yao, 2010). The selection was made on the basis of the frequency of consumption by people, abundance and availability during the course of the study. The tested species were collected on the market of Abidjan, Bouaké and Korhogo from October to December 2009 (Table 1). Voucher specimens of the recorded plants were collected by us, dried and processed according to standard practice, identified and then stored together with photos at the Herbarium of the Centre Suisse de Recherches Scientifiques.

Parts of the plants used for study were leaves or seeds. These leaves and seeds were dried under air conditioning (18 °C), and grounded to obtain powder. The crude extracts were successively prepared from 10 g of plant powder in 100 ml of dichloromethane (DCM) and methanol 80% (MeOH), under mechanical stirring for 24 h. After filtration, the solvents were evaporated in a rotary evaporator (rotavapor) at 40 °C. The extracts were frozen and lyophilized. The yield (r) was calculated for each extract using the following formula:

$$r = \frac{\text{Weight of extract}}{\text{Weight of plant powder}} \times 100$$

Radical scavenging assay

The antioxidant activity was performed using TLC qualitative detection of free radical scavengers (Takao et al., 1994) and quantitative estimation of percentage of the radical neutralization (Molyneux, 2004). TLC bioautography method was used to detect the presence of antioxidant substances in extracts, as this method provides rapid detection and localization of the active compounds in a plant extract (Geethaa, 2009). For *in vitro* assays, 10 µl of each extract (10 mg ml^{-1} in methanol) were deposited on aluminium back silicagel 60 F_{254}. The plates were then developed in a mobile phase; $CHCl_3$-MeOH-H_2O (65: 35: 5) for methanolic extracts and hexan-ethyl acetate (1:1) for dichloromethane extracts. After drying, plates were sprayed with a 1,1-diphenyl-2-picrylhydrazyl radical (DPPH) solution (2 mg ml^{-1} in methanol). The activity is characterized by the appearance of yellow or white spots on purple background.

The quantitative assessment of antioxidant activity was determined according to the method described by Molyneux (2004). The active extracts in TLC detection were serially diluted in methanol from 38.46 to 2.40 µg ml-1. The reaction mixture was prepared from 100 µl of each dilution and 2500 µl of DPPH (0.04% in methanol). After 30 mn post-incubation, the absorbance was immediately measured at 517 nm with a spectrophotometer (HACH DR. 2400). The radical scavenging activity (RSA) was measured as the decrease in absorbance of samples versus DPPH standard solution. Ascorbic acid, Trolox and Gallic acid were used as positive controls. The percent inhibition of DPPH after 30 min incubation was determined by the following formula:

% Inhibition (DPPH) = [(A0 - Ai)/A0)] × 100 (with A0: absorbance of blank, Ai: absorbance of extract).

We considered as IC_{50} the minimum concentration at which 50% of DPPH were inhibited. The IC_{50} was graphically determined using Trolox (800-25 µM) as the reference compound for calibration. A low IC_{50} value indicates strong antioxidant activity in a sample (Geethaa, 2009).

Finally the antioxidant ability was expressed as mg Trolox equivalent g^{-1} of dry matter (mg TE g^{-1} of dry weight).

Determination of total phenolic content

Total phenolic content (TPC) was determined with spectrophotometer using Folin-Ciocalteu phenol reagent (Singleton, and Rossi, 1965). Twenty milliliters of methanolic extract 80% were concentrated in a rotavapor (40 °C). Two thousand five hundred microliters of Folin-Ciocalteu reagent (1/10) were added to 500 µl of concentrated extract and incubated for 2 min at room temperature. Two thousand microliters of Na_2CO_3 solution (75 g l^{-1}) were added to the reaction mixture which was immediately incubated at 50 °C for 15 min. After fast cooling in ice-cold water, the absorbance was measured at 760 nm using spectrophotometer (HARCH DR. 2400). Gallic acid (0 - 50 µg ml^{-1}) was used as the reference compound for calibration. The total phenolic content (TPC) was reported as mg gallic acid equivalent per gram of dry weight (mg GAE 100 g^{-1} of dry weight)

Calculation and Statistical analysis

The values of DPPH and TPC (mg standard equivalent per gram of dry weight) were calculated using the equations below (Wiwat and Wallaya, 2007):

$$\text{Values of DPPH (mg standard equivalent } g^{-1} \text{ of dry weight)} = \frac{[(SA-BA)/(Slope)][1/U)]}{[2][1000]} \times r$$

$$\text{Values of TPC (mg standard equivalent } g^{-1} \text{ of dry weight)} = \frac{[(SA-BA)/(Slope)][50/U)]}{[2][1000]}$$

where: SA = Sample absorbance for TPC or absorbance decrease of sample for DPPH values; BA = Blank (no extract) absorbance for TPC or absorbance decrease of blank for DPPH values (extract was substituted by distilled water for blank); Slope = Slope of standard curve [1 / U] or [50 / U] = Total volume of extract (ml) / Used volume of extract (ml) [2] = Weight of used sample (g), [1000] = Factor for changing µg to mg.

Each experiment was performed in triplicate on samples and means were calculated. The analysis of variance (one way ANOVA) was used to compare percent inhibition of DPPH and TPC of active extracts using the software STATISTICA 8.0 (Statistica, 2007). When comparison showed significant difference

between the extracts tested, the complementary test of the multiple comparisons of means (Turkey test) was applied to determine the level of relationship between extracts (Westlake, 1971). If $P < 0.05$ the test was significant. The correlations (R^2) between concentrations and percent inhibition of DPPH of extracts were estimated by dose-response curves, $R^2 \geq 0.90$ was considered as strongly correlated (Prabhjit *et al*., 2008).

RESULTS

The highest yield of 30.8% was obtained from methanolic extract of *Psorospermum febrifugum* and the lowest yield (0.8%) from dichloromethane extract of *Myrianthus arboreus* (Table 1). Out of 20 crude extracts, 18 (90%) exhibited antioxidant ability. Radical scavenging assay varied considerably among extracts. In general, the activity was relatively low for DCM extracts and only seven extracts exceeded 10 % of free radical neutralization. These plants were *P. febrifugum*, *M. arboreus Ceratotheca sesamoides*, *Ficus dicranostyla*, *Cleome gynandra* and *Justicia galeopsis* (Table 2). A significant difference ($F = 45.8$; $P < 0.001$) was observed between DPPH inhibition percentages. High RSA (about 50 % of DPPH scavenging) was observed for extracts of *P. febrifugum* (75.7±7.8%), *M. arboreus* (73.7±8.4%) and *C. sesamoides* (57±14.4%). Low percentage of the radical neutralization was recorded with the dichloromethane extracts of *F. dicranostyla* (24.7±6.2%), *C. gynandra* (17.5±4.3%) and *J. galeopsis* (12.2±1.7%). The methanolic extract of *P. febrifugum* leaves (50±5.2 mg TE g^{-1}) exhibited the highest RAS, followed by *M. arboreus* (13.3±1.5 mg TE g^{-1}) and *C. sesamoides* (12.6±3.2 mg TE g^{-1}) (Table 2). The remaining extracts showed low activity (values of DPPH = 0.5±0.1-2.1±0.5 mg TE g^{-1}). To the best of our knowledge, this present study is the first report on the antioxidant capacity of most of the studied plants especially *J. galeopsis*, *F. dicranostyla* and *Rhynchosia buettneri*. The quality of the antioxidants in the extracts was determined by the IC_{50} values shown in Table 2. The methanolic extract of *P. febrifugum* (IC_{50} = 2.3 µg ml^{-1}) gave a value lower than ascorbic acid (IC_{50} = 2.9 µg ml^{-1}) but greater than gallic acid (IC_{50} = 1.5 µg ml^{-1}). *M. arboreus* and ascorbic acid exhibited similar activity, with IC_{50} value of 2.9 µg ml^{-1}. The DPPH radical scavenging abilities of the remaining extracts such as *C. Sesamoides* (IC_{50} = 7.5 µg ml^{-1}) were significantly lower than those of ascorbic acid and gallic acid. High correlation coefficients were estimated between extract concentrations used and free radical scavenging activity of active extracts from *P. febrifugum* (R^2 = 0.98), *M. arboreus* (R^2 = 0.96) and *C. sesamoides* (R^2 = 0.96), proven a dose-response effect. Total phenolic contents ranged from 291.9±6.9 to 178.5±5.8 mg GAE 100 g^{-1} (Table 3). A significant difference ($F = 47.7$; $P < 0.001$) was observed between the extracts. All active methanolic extracts showed greater amounts of Total phenolic contents. *P. febrifugum* (291.9±6.9 mg GAE 100 g^{-1}) and *M. arboreus* (263.9±1.7 mg GAE 100 g^{-1}) were the most rich in phenolics, followed by *R. buettneri* (224.5±5.9 mg GAE 100 g^{-1}). In the current study, linear correlation ($y = -0.0031x^2 + 0.2148x$; R^2 = 0.95) were found between TPC and antioxidant activity of methanolic extracts of *P. febrifugum*, *M. arboreus* and *C. sesamoides*.

Table. 1 : Studied plants and their TLC free radical scavenging activity.

Plant species	Family	Traditional usage	Parts tested	Extraction solvent	Yield (%)	Rf of active spots	Activity
Beilschmiedia mannii (Meisn.) Benth. & Hook. f.	Lauraceae	Food (sauce)	Seeds	DCM	1.7	-	-
				MeOH	12.1	0.05	+
			Seeds with pericarp	DCM	1.1	-	-
				MeOH	14.1	0.07	+
Ceratotheca sesamoides Endl.	Pedaliaceae	Food (sauce)	Leaves	DCM	2.2	0.74	++
				MeOH	10.3	0.05	+++
						0.16	++
						0.27	+++
Ficus dicranostyla Mildbr.	Moraceae	Food (sauce)/herb tea (malaria)	Leaves	DCM	3.9	0.74	+++
				MeOH	15.5	0.05	+
						0.16	++
Cleome gynandra (L.) Briq.	Capparidaceae	Food (sauce)	Leaves	DCM	2.7	0.74	+++
				MeOH	20.6	0.5	+
						0.19	+
Justicia galeopsis T. Anderson ex C. B. Clarke	Acanthaceae	Food (sauce)	Leaves	DCM	1.8	0.73	+++
				MeOH	15.5	0.05	++
						0.19	++
						0.33	++
Myrianthus arboreus P. Beauv.	Cecropiaceae	Food (sauce)	Leaves	DCM	0.8	0.72	++
				MeOH	8.4	0.07	+++
						0.19	+
Psorospermum febrifugum	Hypericaceae	Herb tea (malaria)	Leaves	DCM	1.3	0.72	++
				MeOH	30.8	0.05	+++
						0.27	+++
						0. 45	+
Rhynchosia buettneri Harms	Fabaceae	Herb tea (malaria)	Leaves	DCM	1.7	0.72	+
				MeOH	11.1	0.02	++
						0.21	+
Solanum macrocarpum L.	Solanaceae	Food (sauce)	Leaves	DCM	2.2	0.72	+
				MeOH	14.5	0.06	+

DCM = dichloromethane; MeOH = methanol. ; Rf : retention factor; +++ : strong activity ; ++ : activity ; + : weak activity ; - : no activity ;

Table. 2 : Free radical scavenging activity of active plants.

Plant species and standards	Parts tested	Extraction solvent	Antioxidant potential			
			Mean of % Inhibition ± SD	Ability (mg TE g^{-1} ± SD)	IC_{50} (µg ml^{-1})	R^2 with concentrations
Psorospermum febrifugum	Leaves	MeOH	75. 7 ± 7.8^{ab}	50.0 ± 5.2^{f}	2.3±0.1	0.98
		DCM			15.2±0.4	0.98
Myrianthus arboreus	Leaves	MeOH	73.7± 8.4^{ab}	13.3 ± 1.5^{g}	2.9±0.2	0.96
Ceratotheca sesamoides	Leaves	MeOH	57.0± 14.4^{bc}	12.6 ± 3.2^{g}	7.5±0.3	0.96
Rhynchosia buettneri	Leaves	DCM	39.9± 10.9^{cd}	1.1 ± 0.3^{h}	>38.4	0.91
Justicia galeopsis	Leaves	DCM	12.2 ±1.7^{e}	0.5 ± 0.1^{h}	> 38.4	0.93
Cleome gynandra	Leaves	DCM	17.5 ± 4.3^{e}	1.0 ± 0.2^{h}	> 38.4	0.99
Ficus dicranostyla	Leaves	DCM	24.7 ± 6.2^{de}	2.0 ± 0.5^{h}	> 38.4	0.98
Gallic acid			88.9 ± 3.1^{a}	nd	1.5±0.1	0.98
Ascorbic acid			76 ± 8.9^{ab}	nd	2.9±0.2	0.94
Statistical parameters		ddl	8	6		
		F	45.8	56.1		
		P	< 0.001	< 0.001		

DCM : dichloromethane ; MeOH : methanol ; R = Correlation coefficient; Means followed by the same letter in each column do not differ significantly ($p < 0.05$)

Table. 3 : Total phenolic content and correlation coefficient of methanol extracts of active plant species (mg GAE 100 g^{-1}).

Plant species	Parts tested	Content	Correlation (R^2) with antioxidant activity
Psorospermum febrifugum	Leaves	291.8±6.9^{a}	0.95
Myrianthus arboreus	Leaves	263.9±1.7^{b}	0.95
Rhynchosia buettneri	Leaves	224.5±5.9^{c}	nd
Beilschmiedia mannii	Seeds with pericarp	206.4±6.8^{d}	nd
Beilschmiedia mannii	Seeds	196.9±3.6^{de}	nd
Solanum macrocarpum	Leaves	183.1±6.4^{ef}	nd
Ceratotheca sesamoides	Leaves	186.2±7.3^{ef}	0.95
Cleome gynandra	Leaves	188.2±3.1^{ef}	nd
Justicia galeopsis	Leaves	189.8±4.7^{ef}	nd
Ficus dicranostyla	Leaves	178.5±5.8^{f}	nd
Statistical parameters	ddl	9	
	F	47.7	
	P	< 0.001	

SD: Standard deviation; nd: non determined; Values followed by the same letter in each column do not differ significantly ($p < 0.05$)

DISCUSSION

In the present study, free radical scavenging potential and total phenolic content of nine plant consumed in Côte d'Ivoire were evaluated. All the studied extracts showed some free radical neutralization. According to Geethaa *et al*. (2009), it is evident that low RSA also indicates some proton-donating ability. So these extracts could serve as free radical inhibitors or scavengers, acting possibly as primary antioxidants. However the most active extracts were obtained from the leaves of *P. febrifugum* and *M. arboreus*. In this study, high correlation coefficients were observed between extract concentrations used and free radical scavenging activity of active extracts such as *P. febrifugum*, *M. arboreus* and *C. sesamoides*. Previous studies reported high correlation (Prabhjit et al, 2008; Mauphiswana *et al*., 2010) while some observed no correlations (Yu *et al*., 2002). All methanolic extracts from *P. febrifugum*, and *M. arboreus* showed significant amounts of TPC. Antiradical activity depends on the content of phenolic compounds that behave like antioxidants, due to the reactivity of phenols (Rice-Evans *et al*., 1995; Leja *et al*., 2013). These phytochemicals contribute significantly to antioxidant property of plant extracts, which is often demonstrated by high correlation between the level of phenolics and antiradical activity of the extract (Blasa *et al*., 2010). The leaves of *P. febrifugum* are consumed as herb tea against malaria and antioxidants could provide protection against the oxidative stress induced by malaria infection (Metzger *et al*., 2001). Interestingly, the leaves extract showed high free radical scavenging activity that was strongly correlated with total phenolic content. This current antioxidant property supports the consumption of *P. febrifugum* by people in Côte d'Ivoire against malaria. The stem bark of this plant species from Cameroon also has shown antitumor (Kupchan *et al*., 1980), anticancer and antioxidant activities (Tamokou *et al*., 2013). This is a supplementary advantage of *P. febrifugum* that could strengthen its use for food, nutrition and medicinal purpose in West African countries like Côte d'Ivoire.

M. arboreus and *C. sesamoides* were good free radical scavengers. These two plants are eaten as vegetable sauces and recognized to be sources of nutritive compounds (Yao, 2010). Some phenolic compounds such as flavonoids and anthocyanes are known to be nutritive agents (Yao et al., 2004; Leja *et al*., 2013). In Cameroon, the barks and roots of this plant species are used in traditional medicine and possess antioxidant activity and contain polyphenols (Biapa *et al*., 2007). The present findings which complete the previous study show that all parts of *M. arboreus* are of interest in the control of oxidative stress. Also, leaves of *C. sesamoides* are consumed as food in human diet in Côte d'Ivoire whilst in Nigeria, this plant is a medicinal herb (Mukhtar *et al*., 2009).

There was weak correlation between RSA and TPC of methanolic extracts in *F. dicranostyla*, *R. buttneri*, *J. galopsis* and *C. gynandra*. These plant species exhibited weak antioxidant

activity but high amount of total phenolics. In the current study, their dichloromethane extracts were more active than methanolic extracts. In general, hydrophilic extracts have much higher antioxidant capacity than hydrophobic ones (Mukhtar *et al*., 2009). Lack of hydrogen donor bioactive constituents in the extract, slow rate of the reaction between DPPH and the substrate molecules (Geethaa *et al*., 2009) probably might explain the low DPPH antioxidant activity of the dichloromethane extracts.

CONCLUSION

Our findings show that plants consumed in West Africa for food and medicinal purpose are of benefit to nutrition and health. These plants can be sources for development of functional food. We plan to investigate other antioxidant phytochemicals (carotenoids and vitamins) and study the correlation between the antioxidant activity and seasons or collecting areas in order to develop functional food from the most active plants.

ACKNOWLEDGMENTS

The authors sincerely thank the Centre Suisse de Recherches Scientifiques en Côte d'Ivoire (CSRS) and Programme d'Appui Stratégique pour la Recherche Scientifique (PASRES) for financial support and technical assistance. Thanks are also due to Professor Aké Assi Laurent for botanical assistance and Dr Lydia Mosi for english editing.

REFERENCES

Ahoua ARC, Koné MW, Konan AG, Tra Bi FH, Bonfoh B. Antioxidant activity of eight plants consumed by great apes in Côte d'Ivoire. Afr J Biotechnol, 2012; 11: 11732-11740.

Aké CB, Koné MW, Kamanzi Atindehou K, Aké M. Evaluation de quelques propriétés biologiques de produits de cueillette non ligneux vendus sur les marches d'Abidjan et ses environs. Pharm Méd Trad Afr, 2006 ; 12 : 1-17.

Ambé GA. Les fruits sauvages comestibles des savanes guinéennes de Côte d'Ivoire : état de la connaissance par une population locale, les Malinké. Biotechnol Agron Soc Environ, 2001 ; 5 : 43-58.

Biapa P-CN, Agbor GA, Oben JE, Ngogang JY. Phytochemical studies and antioxidant properties of four medicinal plants used in Cameroon. Afr J Tradit Complement Altern Med, 2007; 4: 495-500.

Blasa M, Gennari L, Angelino D, Ninfali P. 2010. Fruit and vegetable antioxidants in health. In: Watson RR, Preedy VR (eds) Bioactive foods in promoting health. Fruits and vegetables, 1st edn. Elsevier Inc 37-58.

Blomhoff R, Carlsen MH, Andersen LF, Jacobs DR Jr. Health benefits of nuts: potential role of antioxidants. Br J Nutr, 2006; 96**:** S52-S60.

Crowe FL, Roddam AW, Key TJ et al. Fruit and vegetable intake and mortality from ischaemic heart disease: results from the European Prospective Investigation into Cancer and Nutrition (EPIC)-Heart study. Eur Heart J, 2011; doi: 10.1093/eurheartj/ehq465.

Dichi I, Breganó JW, Simão ANC, Cecchini R. 2013. Role of Oxidative Stress in Chronic Diseases. CRC Press.

Federation ID. 2011. *IDF Diabetes Atlas*, 5th edn. Brussels, Belgium : International Diabetes Federation.

Gan RY, Xu X-R, Song F-L, Kuang L, Li H-B. Antioxidant activity and total phenolic content of medicinal plants associated with prevention and treatment of cardiovascular and cerebrovascular diseases. J Med Plants Res, 2010 ; 4 : 2438-2444.

Geethaa S, Surash, R, Sreenivasan S, Mohd NM, Sabariah I, Sharif MM. In Vitro Antioxidant and Xanthine Oxidase Inhibitory Activities of Methanolic *Swietenia mahagoni* Seed Extracts. Molecules, 2009; 14: 4476-4485.

Koné WM, Koffi AG, Bomisso EL, Tra Bi FH. Ethnomedical study and iron content of some medicinal herbs used in traditional medicine in Cote d'Ivoire for the treatment of anaemia. Afr J Tradit Complement. Altern. Med, 2012 ; 9 : 81-87.

Kupchan SM, Streelman DR, Sneden AT. Psorospermin, a new antileukemic xanthone from *Psorospermum febrifugum*. J Nat Prod, 1980; 43: 296-301.

Leenders M, Sluijs I, Ros MM *et al*. Fruit and Vegetable Consumption and Mortality. Am J Epidemiol, 2013; doi: 10.1093/aje/kwt006.

Leja M, Kamińska I, Kramer M, Maksylewicz-Kaul A, Kammerer D, Carle R, Baranski R. The Content of Phenolic Compounds and Radical Scavenging Activity Varies with Carrot Origin and Root Color. Plant Foods Hum Nutr, 2013; 68:163-170.

Mamphiswana ND, Mashela PW, Mdee LK. Distribution of total phenolics and antioxidant activity in fruit, leaf, stem and root of *Monsonia burkeana*. Afr J Agric Res, 2010; 5: 2570-2575.

Marmot M. Fruit and vegetable intake reduces risk of fatal coronary heart disease. Eur. Heart J, 2011; 32: 1182-1183.

Mayosi BM. The 10'Best Buys' to combat heart disease, diabetes and stroke in Africa. Heart, 2013; 99: 973-974.

Metzger A, Mukasa G, Shankar AH, Ndeezi G, Melikian G, Semba RD. Antioxidant status and acute Malaria in children in Kampala, Uganda. Am J Trop Med Hyg, 2001; 65: 115-119.

Molyneux P. The use of the stable free radical diphenylpicrylhydrazyl (DPPH) for estimating antioxidant activity. Songklanakarin J Sci Technol, 2004; 26: 211-219.

Morales-González JA. 2013. Oxidative Stress and Chronic Degenerative Diseases - A Role for Antioxidants. In: Agricultural and Biological Sciences, InTec Edn.

Moylan JS, Reid MB. Oxidative stress, chronic disease, and muscle wasting. Muscle Nerve, 2007; 35: 411-29.

Mukhtar MD, Audu AA, Adoum OA, et al. Screening of some savannah plants for antiretroviral (ANTI-HIV) activity. Retrovirol, 2009; 6: 25.

Pandey KB, Rizvi SI. Plant polyphenols as dietary antioxidants in human health and disease. Oxid Med Cell Long, 2009; 2: 270-278.

Prabhjit K, Bikram S, Subodh K, Satwinderjeet K. In vitro evaluation of free radical scavenging activity of *Rubia cordifolia* L. J Chin Clin Med, 2008; 5: 278-284.

Rice-Evans AC, Miller JN, Paganga G. Structure-antioxidant activity relationships of flavonoids and phenolic acids. Free Rad Biol Med, 1995; 7: 933-956.

Singleton VL, Rossi JA. Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. Am J Enol Vitic, 1965; 16: 144-158.

Soro D, Koné MW, Kamanzi K. Evaluation des activités antimicrobiennes et anti-radicaux libres de quelques taxons bioactifs de Côte d'Ivoire, 2010; 40: 307-317.

Statistica. 2007. Statistica pour Windows, release 8.0 Statoft Inc, France.

Takao T, Kitatani F, Watanabe N, Yagi A, Sakata KA. simple screening method for antioxidants and isolation of several antioxidants produced bay marine bacteria from fish and shellfish. Biosci Biotechnol Biochem,1994; 58: 1780-1783.

Tamokou JD, Chouna JR, Fischer-Fodor E et al. Anticancer and Antimicrobial Activities of Some Antioxidant-Rich Cameroonian Medicinal Plants. PLoS One, 2013; 8: e55880.

Westlake WJ. A one-sided version of the Tukey-Duckworth Test. Technometrics, 1971; 13: 901-903.

Wiwat W, Wallaya M. Antioxidant capacity and phenolic content of some Thai culinary plants. Maejo Inter J Sci Technol, 2007; 01: 100-106.

Yao K. 2010. Plantes médicinales et alimentaires les plus utilisées en Cote d'Ivoire : Enquêtes ethnobotaniques, recherche des activités antioxydantes. Mémoire de DEA, Université de Cocody-Abidjan, Côte d'Ivoire.

Yao LH, Jiang YM, Shi J, Tomás-barberán FA, Datta N, Singanusong R, Chen SS. Flavonoids in Food and Their Health Benefits. Plant Foods Hum Nutr, 2004; 59: 113-122.

Yu L, Haley S, Perret J et al. Free radical scavenging properties of wheat extracts. J Agric Food Chem, 2002; 50: 1619-1624.

How to cite this article:

Yao Konan, Koné Mamidou Witabouna, Bonfoh Bassirou, Kamanzi Kagoyire. Antioxidant activity and total phenolic content of nine plants from Côte d'Ivoire (West Africa). J App Pharm Sci, 2014; 4 (08): 036-041.