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ORIGINAL RESEARCH

Chemical Composition and Antioxidant Activity of *Syzygium aromaticum* and *Monodora myristica* Essential Oils from Cameroon

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Abstract

The objective of this study was to evaluate the chemical composition and antioxidant activity of *Monodora myristica* and *Syzygium aromaticum* essential oils. The oils were extracted by hydrodistillation and their chemical composition determined by Gas-chromatography coupled to a mass spectrometer detector. The antioxidant activity of the oils was evaluated through the following tests: the 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity; the ferric reducing antioxidant power, the metal chelation and finally the hydroxyl radical scavenging activity. Results showed that alpha-phellandrene (52.2%) and (p)-cymene (13.1%) were the most represented compounds in the essence of *Monodora myristica* while Eugenol (59.5%) and (E)-Caryophyllene (23%) were the most abundant molecules in that of *Syzygium aromaticum.* The evaluation of the antioxidant activity showed that the oil of *Syzygium aromaticum* has good antioxidant activity compared to that of *Monodora myristica*.

Practical Applications

The essential oils of *Monodora myristica* and *Syzygium aromaticum* can be used in the formulation of medicines that can help to fight against the damages and diseases caused by oxidative stress. They can also be used as food additives such as flavouring agents, natural preservative or antioxidants in foods.

Keywords: *Monodora myristica*, *Syzygium aromaticum*, Essential oil, chemical composition, antioxidant activity.

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1. Introduction

The increasing interest of researchers in looking for natural sources of antioxidants has led to a deep screening of plants for medicinal or industrial use. This is due to the side effects on humans' health of synthetic medicines and chemicals used as food additives. Antioxidants, especially those from natural origin have been demonstrated as playing a protective role in the body against the damages caused by free radicals (Reactive oxygen species and Alkyl radicals) (Halliwell, 2006; Womeni *et al.*, 2016). These substances promote oxidative stress in the body as well as chemical alteration of oils, fats and lipid-based foods, and lead to the decrease of their nutritional and organoleptic properties (Kazuhisa, 2001). In humans, they are related to several degenerative disorders such as arterosclerosis, cancer, Alzheimer etc (Prior, 2004). Antioxidants, when present, have the ability to donate their hydrogen atom and stop their activity. Various natural sources of antioxidants have already been explored in the past for their antioxidant activity. Amongst these are spices (Nassar *et al.*, 2007; Bouba *et al.*, 2010; Womeni *et al*., 2013).

Spices have been used for thousands of Centuries to enhance the flavour and aroma of food and prolong their shelf-life (Srinivasans, 2005). They are consumed as whole spices or ground into powder; they are also used in soup preparation in various homes and represent the principal ingredient in the preparation of traditional dishes. Spices are good sources of nutrients such as proteins, carbohydrates, vitamins, lipids and mineral elements (Erukainure *et al.*, 2015). Apart from this, they possess phytochemicals such as phenolic acids, essential oils, flavonoid, carotenoid, terpenoid etc, which have been proven to have good medicinal properties (Shan *et al*., 2005; Kennedy *et al.*, 2011).

Syzygium aromaticum commonly known as clove is a dried aromatic unopened floral bud of an evergreen tree of 10-20 m height belonging to the family of Myrstacae. It is generally used as spice of flavouring agent in food preparation (Mashkor, 2015). It has been proven to have many therapeutic uses (antioxidants, anti-inflammatory, antifungal, anti cancer, antimicrobial etc.) (Omenebelle and Okpoghono, 2017; Chaieb *et al.*, 2007). Its high phenolic content has already been demonstrated by other authors (Womeni *et al.*, 2013; Omenebelle and Okpoghono, 2017). *Monodora myristica* also known as Calabash nutmeg or African nutmeg, is an edible plant which widely grows in Africa, Central and South America, Australia and Asia (Omobuwajo *et al.*, 2003). Its seeds are rich in aromatic compounds and generally used as spice in the preparation of food of flavouring agent (Ekeanyanwu *et al.*, 2010). The same seeds have been demonstrated to have several medicinal properties. They are used in the treatment of headache, stomachache, and hypertension (Uwakwe and Nwaoguikpe, 2008). Their antimicrobial and antioxidant properties have already been proven (Feyisayo and Oluokun, 2013; Enabulele *et al.*, 2014). These activities are attributed to the bioactive molecules present in these seeds as it has been demonstrated that their extracts contain alkaloids, steroids, tannins, flavonoids and other phenolic compounds, and essential oil components (Okwu, 2001).

Previous reports in the literature showed that *Syzygium aromaticum* buds extract are rich in phenolic compounds and have very good

antioxidant activity. The chemical composition of its essential oil has also been significantly explored (Nassar *et al.*, 2007; Mashkor, 2015; Omenebelle and Okpoghono, 2017). In the same line, several studies have been conducted on the seeds of *Monodora myristica*, most of them centered only on the activity of their extracts (ethanolic, methanolic or aqueous). In one study, Omenebelle and Okpoghono (2017) (2017) and Feyisayo and Oluokun (2013) showed that the ethanolic, aqueous and diethyl-ether extracts of *Monodora myristica* seeds have good antioxidant properties. In the same line, Enabulele *et al.* (2014) showed that *Monodora myristica* seeds have good antimicrobial, good nutritional value and good phytochemical composition. The chemical composition and hypotensive effects of *Monodora myristica* essential oil has already been reported (Koudou *et al.*, 2007).

Though several studies have been conducted on these plants, relatively low data are available on the antioxidant activity and chemical composition of their essential oils.

The objective of this study is to determine the chemical composition and evaluate the antioxidant activity of *Syzygium aromaticum* buds and *Monodora myristica* seeds essential oils produced and commercialized in Cameroon.

2. Materials and methods

2.1. Material

Syzygium aromaticum Buds and *Monodora myristica* seeds were purchased from vendors in a local market located in Dschang, Menoua's Head Department. All chemicals and reagents used in this study were of analytical grade.

2.2. Methods

2.2.1. Extraction of essential oils

The essential oils of *Syzygium aromaticum* Buds and *Monodora myristica* seeds were extracted as described by Kamte *et al.* (2017). The plant materials were ground using a blender (Moulinex) and subjected to hydrodistillation using a Clevenger- type apparatus. The essential oil obtained was dried using Sodium sulfate (Na_2SO_4) crystals and stored as -20°C in vials; sealed with Teflon caps and protected from light before use. The oil yield was calculated following the formula:

$$Y = \frac{WE}{WP} \times 100$$

WE = weight of the essential oil

Wp= weight of plant material

2.2.2. Chemical composition of the essential oils

The chemical constituents of the essential oils were analyzed using a gas chromatograph coupled to a mass spectrometer as described by Kamte *et al.* (2017). The identification of essential oil components was achieved by co-injection with the authentic standards available, together with a comparison of the retention indices and the mass spectra of those appearing in the ADAMS, NIST 08, and FFNSC2 libraries.

2.3. Evaluation of the antioxidant activity

2.3.1. DPPH - Radical scavenging activity

The radical scavenging activity of the essential oils were determined using the 2,2-diphenyl-1-picryl hydrazyl (DPPH) method, as described by Womeni *et al.* (2016). 4.5 ml of 0.002% alcoholic solution of DPPH was added to 0.5

ml of different concentrations (125, 250, 500, 1000 and 2000 µg/ml) of samples and standard solutions separately, in order to have final concentrations of products of 25-200 µg/ml. The samples were kept at room temperature in the dark and after 30 min, the absorbance of the resulting solution was measured at 517 nm. The absorbance of the samples, control and blank were measured in comparison with methanol. Synthetic antioxidant, butylated hydroxyl toluene (BHT), which is a recognized powerful radical scavenger, was used as positive control. The following formula was used for the calculation of the radical scavenging activity:

$$AA\% = [(Abs_{control} - Abs_{sample}) \times 100/Abs_{control}]$$

2.3.2. Ferric reducing antioxidant power activity

The antioxidant potential of essential oils were also evaluated by its ability to reduce iron (III) to iron (II) following the method of Oyaizu (1986). An aliquot of 0.5 ml plant essential oil (125, 250, 500, 1000 and 2000 µg/ml) was mixed with 1 ml phosphate buffer (0.2 M, pH 6.6) and 1 ml of 1% aqueous $K_3Fe(CN)_6$ solution, well shaken and incubated at 50 °C for 30 min. After incubation, 1 ml of 10% TCA solution was added to stop the reaction and the mixture was centrifuged at 3000 rpm for 10 min. 1.5 ml of supernatant, 1.5 ml of distilled water and 0.1 ml of 0.1% $FeCl_3$ solution were mixed and incubated for 10 min and absorbance read at 700 nm on spectrophotometer. A sample blank, containing all the reagents but no essential oil was prepared under the same conditions. Catechin, a recognized powerful ferric reducer compound, was used as positive control to compare the reducing power of the essential oil. Higher absorbance indicates higher reducing power.

2.3.3. Hydroxyl radical scavenging activity

The hydroxyl radical scavenging capacity of the essential oils was evaluated by the method described by Olabinri *et al.* (2010). 60 µl of $FeSO_4.7H_2O$ (1 mm) was added to 90 µl of aqueous 1,10 phenanthroline(1 mm), 2.4 ml of 0.2 M phosphate buffer pH 7.8 was added to the above mixture, followed by addition of 150 µl of hydrogen peroxide (0.17 mm) and 1.5ml of different concentrations of sample in sequence. The mixture was incubated for 5 min at room temperature. The absorbance of the mixture was read at 560 nm against blank. All readings were taken in triplicate and Catechin was used as the standard. The % inhibition was calculated by following equation.

$$\% \text{ Hydroxyl radical scavenging capacity} = [(A_0 - A_1)/A_0] \times 100$$

Where A_0 was the absorbance of control and A_1 was the absorbance of the essential oil or standard.

2.3.4. Metal chelation activity

The antioxidant potential of the essential oils was also evaluated by its ferrous ion chelating activity (Benzie and Szeto, 1999). In test tubes containing 160 µl of sample solution (1000 µg/ml), 160 µl of aqueous solution of 1, 10-phenanthroline (0.25 %) and 400 µl of methanolic $FeCl_2$ (0.1 %) were added. After 10 min incubation at room temperature, 880 µl of distilled water was added and the absorbance was measured at 510 nm. The metal chelating efficiency of the oil was compared to that of Catechin (positive control). The inhibition

percentage (IP) of the formation of the complex Fe^{2+}-phenanthroline was calculated using the following formula:

$$IP\% = Abs_{sample} \times 100/Abs_{control}$$

2.4. Statistical analysis

Results obtained in the present study were subjected to one-way analysis of variance (ANOVA) with Dunnet tests using Graph pad-In Stat version 3.05, to evaluate the statistical significance of the data. A probability value at $p < 0.05$ was considered statistically significant.

3. Results and discussion

3.1. Results

3.1.1. Extraction

The extracted oil was yellow, and the extraction yield 4.12 and 2.14% respectively for *Syzygium aromaticum* and *Monodora myristica*.

3.1.2. Chemical composition of the essential oils

The table below (Table 1) shows the chemical composition of *Syzygium aromaticum* essential oil. Three families of volatile compounds were identified: Aromatics, sesquiterpene hydrocarbons and oxygenated monoterpenes. The most represented family was aromatics (66.7%), followed by sesquiterpenes hydrocarbons (32.8%) and oxygenated monoterpene (0.3%). In the family of aromatics, two main components were identified, Eugenol (59.5%) and Eugenol acetate (7.2%). The sesquiterpene hydrocarbons family was made-up of (E)-caryophyllene (23%), alpha-humulene (3%), alpha-copaene (1.8%), delta-cardinene (1.6%) and alpha-cubebene (1.5%).In the last family (Oxygenated monoterpenes), only one compound was detected, which is Caryophyllene oxide (0.3%).

The chemical composition of *Monodora myristica* essential oil is shown in Table 2. Five classes of volatile compounds were detected in this plant essence. They were monoterpene hydrocarbons, oxygenated monoterpenes, sesquiterpene hydrocarbons, oxygenated sesquiterpenes and aromatics. Among these classes, monoterpene hydrocarbons are the most represented, with a total percentage of 69.5. In this class, the following compounds were the most abundant: alpha-phellandrene (52.2%), alpha-pinene (6.3%), myrcene (4.4%), Limonene (3.7%) and alpha-thujene (2.9%). This class is followed by aromatics, which represent 13.1% of the oil composition, p-cymene being the only compound detected in this family. Oxygenated monoterpenes and sesquiterpene hydrocarbons were present at the same levels (4.1% each). Linalool (3.3%) and alpha-terpineol (0.8%) were the most represented oxygenated monoterpenes, while delta-cadinene (2.6%) and gamma-cadinene (1.5%) were the major sesquiterpene hydrocarbons. The lowest represented class was the oxygenated sesquiterpenes (2.8%).

3.1.3. Evaluation of the Antioxidant activity

3.1.3.1. DPPH Radical Scavenging Activity

The radical scavenging activity of *Syzygium aromaticum* and *Monodora myristica* essential oils are presented in Figure 1. It can be observed that, the activity of *Syzygium aromaticum* essential oil was similar ($p>0.05$) to that of the synthetic antioxidant used (BHT) at all concentrations. However, the radical

Table 1: Chemical composition of *Syzygium aromaticum* fruits essential oils.

Name	Class	RI	RI Lit.	%	ID
Alpha-pinene	MH	922	932	0.0	Std
Sabinene	MH	960	969	0.0	RI,MS
Beta-pinene	MH	963	974	0.0	Std
Limonene	MH	1021	1024	0.0	Std
Linalool	MO	1097	1095	0.0	Std
Terpinen-4-ol	MO	1169	1174	0.0	Std
Methyl salicylate	ARO	1188	1190	0.0	RI,MS
Alpha-cubebene	SH	1338	1345	1.5	RI,MS
Eugenol	ARO	1355	1356	59.5	Std
Alpha-copaene	SH	1363	1374	1.8	RI,MS
(E)-caryophyllene	SH	1405	1417	23.0	Std
Alpha-humulene	SH	1437	1452	3.0	Std
Allo-aromadendrene	SH	1445	1458	0.1	RI,MS
Cis-murola-4(14),5-diene	SH	1448	1465	0.1	RI,MS
Cis-cadina-1(6),4-diene	SH	1460	1461	0.3	RI,MS
Gamma-cadinene	SH	1464	1478	0.2	RI,MS
Germacrene-D	SH	1466	1484	0.3	RI,MS
Ar-curcumene	SH	1473	1479	0.0	RI,MS
Gamma-murolene	SH	1481	1478	0.1	RI,MS
Alpha-zingiberene	SH	1486	1493	0.1	RI,MS
Alpha-muurolene	SH	1487	1500	0.1	RI,MS
Trans-muurola-4(14),5-diene	SH	1499	1495	0.1	RI,MS
(E,E)-alpha-farnesene	SH	1501	1505	0.2	RI,MS
Delta-cadinene	SH	1511	1522	1.6	RI,MS
trans-cadina-1,4-diene	SH	1518	1533	0.3	RI,MS
Eugenol acetate	ARO	1522	1521	7.2	RI,MS
Caryophyllene-oxide	SO	1565	1582	0.3	Std
1-epi-cubenol	SO	1612	1627	0.0	RI,MS
			Total	**99.8**	

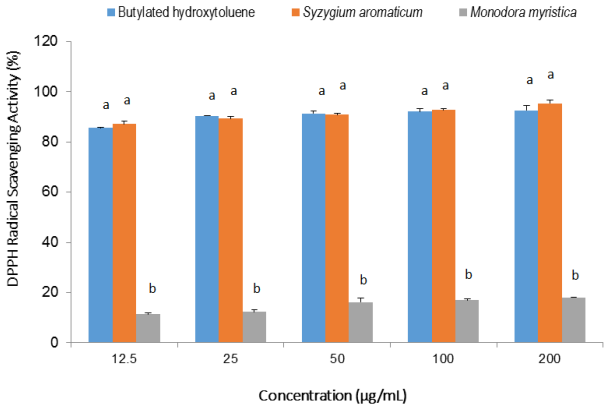
Legend :
MH: Monoterpene hydrocarbons
MO: Oxygenated monoterpenes
SH: Sesquiterpene hydrocarbons
SO: Oxygenated sesquiterpenes
ARO: Aromatics
RI: Retention index
MS: Mass spectrum
Std:Co-injection with authentic compounds
RI Lit: Ris taken from ADAMS

Table 2: Chemical composition of *Monodora myristica* seeds essential oils.

Name	Class	RT_MS	RI	RI_LIT	AREA	%
Alpha-thujene	MH	3.64	917	924	10767610	2.9
Alpha-pinene	MH	3.75	922	932	23628411	6.3
Sabinene	MH	4.65	961	969	264733	0.1
Beta-pinene	MH	4.70	963	974	1157414	0.3
Myrcene	MH	5.17	983	988	16637724	4.4
Delta-2-carene	MH	5.40	993	1001	2980814	0.8
Alpha-phellandrene	MH	5.57	1000	1002	196834211	52.2
Delta-3-carene	MH	5.74	1005	1008	184446	0.0
Alpha-terpinene	MH	5.90	1010	1014	1083480	0.3
p-cymene	ARO	6.16	1018	1020	49394607	13.1
Limonene	MH	6.27	1021	1024	14132808	3.7
1,8-cineole	MO	6.36	1023	1026	149070	0.0
(Z)-beta-ocimene	MH	6.69	1033	1032	1657709	0.4
(E)-beta-ocimene	MH	7.03	1043	1044	681262	0.2
Gamma-terpinene	MH	7.31	1051	1054	869529	0.2
Terpinolene	MH	8.33	1084	1086	224291	0.1
Linalool	MO	8.85	1096	1095	12381690	3.3
Cis-p-menth-2-en-1-ol	MO	9.50	1114	1118	874855	0.2
Trans-p-menth-2-en-1-ol	MO	10.17	1132	1136	586326	0.2
Terpinen-4-ol	MO	11.50	1169	1174	169231	0.0
p-cymen-8-ol	ARO	11.90	1180	1179	159488	0.0
Alpha-terpineol	MO	12.00	1182	1186	3181081	0.8
Trans-piperitol	MO	12.64	1200	1207	577666	0.2
Carvacrol	ARO	16.10	1299	1298	1919166	0.5
Alpha-cubebene	SH	17.39	1338	1345	307228	0.1
Alpha-copaene	SH	18.17	1362	1374	760579	0.2
(E)-carophyllene	SO	19.51	1403	1419	1353938	0.4
Alpha-santalene	SH	19.64	1408	1416	2582801	0.7
Alpha-humulene	SH	20.54	1437	1452	440905	0.1
Gamma-murolene	SH	21.35	1463	1478	641892	0.2
Germacrene-D	SH	21.72	1475	1484	314087	0.1
Epi-cubebol	SO	21.88	1481	1493	1094489	0.3
Alpha-murolene	SH	22.09	1487	1500	1602929	0.4
Gamma-cadinene	SH	22.45	1499	1513	5544810	1.5
Delta-cadinene	SH	22.78	1511	1522	9789501	2.6
Germacrene-D-4-ol	SO	24.21	1560	1574	7029731	1.9
Epi-alpha-cadinol	SO	26.08	1626	1637	3289913	0.9
Epi-alpha-murolol	SO	26.44	1639	1640	2049429	0.5
						99.1

Legend:
MH: Monoterpene hydrocarbons
MO: Oxygenated monoterpenes
SH: Sesquiterpene hydrocarbons
SO: Oxygenated sesquiterpenes
ARO: Aromatics
RI: Retention index
MS: Mass spectrum
Std: Co-injection with authentic compounds
RI Lit: Ris taken from ADAMS

scavenging activity of *Monodora myristica* essential oil was significantly lower ($p<0.001$) compared to that of *Syzygium aromaticum* and Butylated hydroxytoluene. Globally, the antioxidant activity of *Monodora myristica* was increasing with the concentration while that of Butylated hydroxytoluene and *Syzygium aromaticum* was constant.

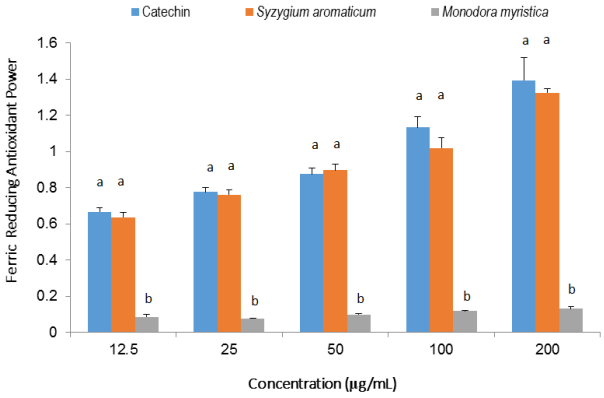


a-b Values are Mean± Standard deviation. Values of the same concentration with different superscripts are significantly different ($p<0.05$)

Figure 1. DPPH Radical scavenging activity of the essential oils and the synthetic antioxidant

3.1.3.2. Ferric Reducing Antioxidant Power

Figure 2 shows the ferric reducing antioxidant power of *Syzygium aromaticum* and *Monodora myristica* essential oils in comparison with the synthetic antioxidant (Catechin). As previously observed, no significant difference was registered between the activity of *Syzygium aromaticum* essential oil and that of Catechin. However, the lowest activity was registered with *Monodora myristica* essential oil at all concentrations. Globally, the activity of the essences and synthetic antioxidant was increasing with concentration.

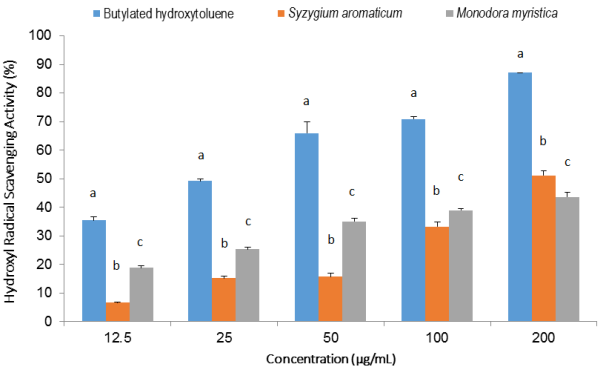


a-b Values are Mean± Standard deviation. Values of the same concentration with different superscripts are significantly different ($p<0.05$)

Figure 2. Ferric reducing antioxidant power of the essential oils and the synthetic antioxidant

3.1.3.3. Hydroxyl Radical Scavenging Activity

The capacity of *Monodora myristica* and *Syzygium aromaticum* essential oils to scavenge the hydroxyl radical is presented in Figure 3. A relative increase ($p<0.05$) in activity with the concentration was registered in all the samples. The highest activity ($p<0.001$) was recorded with Butylated hydroxytoluene at all concentrations, followed by the essential oil of *Monodora myristica* (at concentration 12.5-100 µg/mL). However, at concentration 200 µg/mL, the activity of *Syzygium aromaticum* essential oil was significantly higher ($p<0.05$) than that of *Monodora myristica*.

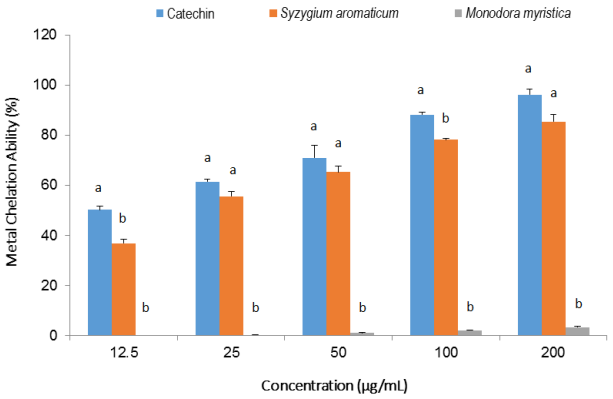


a-c Values are Mean± Standard deviation. Values of the same concentration with different superscripts are significantly different ($p<0.05$)

Figure 3. Hydroxyl Radical scavenging activity of the essential oils and the synthetic antioxidant

3.1.3.4. Metal Chelation Ability

Figure 4 shows the metal chelation ability of *Syzygium aromaticum* and *Monodora myristica* essential oils in comparison with Catechin. The essential oil of *Monodora myristica* has exhibited the lowest activity ($p<0.001$) compared to Catechin and the essential oil of *Syzygium aromaticum*. At concentration 25, 50 and 200 µg/mL, there was no significant difference ($p>0.05$) between the activity of *Monodora myristica* essential oil and that of Catechin. However, at concentration 12.5 and 100 µg/mL, the activity of Catechin was significantly higher ($p<0.05$) compared to that of *Syzygium aromaticum*. Generally, the metal chelation activity of the tested samples was proportional to their concentrations.



a-b Values are Mean± Standard deviation. Values of the same concentration with different superscripts are significantly different ($p<0.05$)

Figure 4. Metal chelation ability of the essential oils and the synthetic antioxidant

3.2. Discussion

The extraction yields obtained in this study were 14.01 and 2.74% respectively for *Syzygium aromaticum* and *Monodora myristica* essential oils. Both oils had a yellowish color. The value of the yield obtained in this study for *Syzygium aromaticum* essential oil was close to 12% , which is the value reported by Taroq *et al*. (2018) with the buds of this same plant. However the value of the yield obtained in this study for *Monodora myristica* essential oil was significantly higher than that reported by Koudou *et al.* (2007) who obtained an extraction yield of 1.2% with the same part of the plant harvested in the Lobaye Forest in Central Africa.

The chemical composition of *Syzygium aromaticum* essential oil showed that Eugenol (59.9%), (E)-Caryophyllene (23%), Eugenol acetate (7.2%), Alpha-humulene (3%) are the most represented molecules. These compounds have been previously reported in the buds of the same plant by other authors. Jimoh *et al.* (2017) showed that the essential oil of *Syzygium aromaticum* contains 75.10% of Eugenol and 13.57% of Eugenol acetate. However (E)-Caryophyllene was absent in their essence while beta-Caryophyllene was present (5.2%). Alpha-humulene was also absent in their oil. In the same line Taroq *et al.* (2018) demonstrated that the essential oil of *Syzygium aromaticum* contain 87.03% of Eugenol, 11.25% of Eugenol acetate and less than 1% of Caryophyllene. Globally the amount of Eugenol and Eugenol acetate obtained in this study was significantly lower compared to those reported by these authors.

Results of the evaluation of the chemical composition of *Monodora myristica* essential oil showed that Alpha-phellandrene (52.2%), p-cymene (13.1%), Alpha-pinene (6.3%), Myrcene (4.4%), Limonene (3.7%), Linalool (3.3%), Alpha-thujene (2.9%) and Delta-cadinene (2.6%). These results are in agreement with those reported by Koudou *et al.* (2007) who detected similar compounds in *Monodora myristica* fruits essential oil. Their report showed similar amounts of Alpha-

pinene (6.3%), Limonene (4%), Linalool (3.3%) and Myrcene (4.9%). However, the amount of Alpha-thujene, Alpha-phellandrene and delta-cadinene obtained in their study was significantly lower than that obtained in this study. This author showed that, the essential oil of *Monodora myristica* contains 1.8% of Alpha-thujene, 34.4% of Alpha-phellandrene and 0.3% of Delta-cadinene. In the same line, the amount of p-cymene detected in this study was significantly lower than those reported by those authors. It is important to note that, some compounds were present in the oil composition of African nutmeg used in this study and absent in that reported by Koudou *et al.* (2007) and vice-versa.

Globally, the differences observed in the chemical composition of the tested essential oils compared to the literature can be attributed to climatic factors, location, harvesting period, part of the plant used and extraction technics (Kim and Choe 2004; Shan *et al.* 2005).

Result of the evaluation of the antioxidant activity showed that, the essential oil of *Syzygium aromaticum* is a powerful DPPH Radiacl Scavenger, Ferric reducer and Metal chelator compared to the essential oil of Monodora myristica. No significant difference was registered between the activity of its essence and that of the synthetic antioxidant used, at almost all concentrations. However, the best hydroxyl radical scavenging activity was recorded with the essential oil of *Monodora myristica* despite the fact that its activity was significantly lower compared to that of the synthetic antioxidant. The fact that the antioxidant activity of *Syzygium aromaticum* essential oil is significantly higher compared to that of *Monodora myristica* can be attributed to the presence of Eugenol and Eugenol acetate in high concentration in this essential oil. In fact, Eugenol is a phenolic antioxidant and this family of secondary metabolites in plants has been proven to be responsible of their antioxidant activity. (Bouba *et al.*, 2010; Womeni *et al.*, 2016; Djikeng *et al.*, 2017). The fact that Syzygium aromaticum is a good natural antioxidant has already been reported (Nassar *et al.*, 2007). The best hydroxyl radical scavenging activity of *Monodora myristica* essential oil compared to that of *Syzygium aromaticum* can be due to the nature of the antioxidants present, mostly Linalool which has also been proven as having good antioxidant activity. The lowest DPPH radical scavenging activity, Ferric reducing power and Metal chelation ability of Monodora myristica essential oil can be the consequence of its poor composition in Phenolic antioxidants as observed in its chemical composition. These results are in accordance with those of Ogunmoyole *et al.* (2013) and Feyisayo and Oluokun (2013), who showed that the extracts of Monodora myristica have very low DPPH radical scavenging activity and Ferric reducing power. However, the fact that this essential oil has a good hydroxyl radical scavenging activity is in agreement with the report of Feyisayo and Oluokun (2013).

The increase of the antioxidant activity with the concentration of phenolic antioxidants available has already been proven (Womeni *et al.*, 2016; Djikeng *et al.*, 2017). Phenolic antioxidants have the ability to donate their hydrogen atoms to free radicals in order to stabilize their structure and reduce the damages that they can cause in the human body. In the same line, they can reduce or chelate transition metals that catalyze the formation of free radicals and reactive oxygen species (Womeni

et al., 2016). In living organisms such molecules help in the prevention of several diseases such as cancer and cardiovascular disorders (Hidalgo *et al.*, 2010).

4. Conclusion

The objective of this study was to determine the chemical composition and antioxidant activity of *Syzygium aromaticum* and *Monodora myristica* essential oils. Results showed that the major components of *Syzygium aromaticum* essential oil are Eugenol, Eugenol acetate, (E)-Caryophyllene and Alpha-humulene. Those of the essence of *Monodora myristica* are: Alpha-phellandrene (52.2%), P-cymene (13.1%), Alpha-pinene (6.3%), Myrcene (4.4%), Limonene (3.7%), Linalool (3.3%), Alpha-thujene (2.9%) and Delta-cadinene (2.6%). Generally, the essential oil of *Syzygium aromaticum* was found to be a powerful DPPH Radical scavenger, Ferric reducer and Metal chelator while that of *Monodora myristica* was found to be a good hydroxyl radical scavenger. These extracts can be used to reduce the damages caused by free radicals in the body and therefore contribute to the prevention of diseases related to oxidative stress. Further study should be conducted in order to evaluate the ability of *Syzygium aromaticum* essential oil in delaying lipid oxidation in food.

Conflict of interest

The authors declare that they do not have any conflict of interest.

Ethics

This Study does not involve Human or Animal Testing.

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