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# Mini-review on the phyto-chemistry, pharmacology and toxicology of *Cola nitida* (Vent.) Schott & Endl. (Malvaceae): A medically interesting bio-resource of multiple purposes in Africa

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**ABSTRACT:** The purpose of this mini-review was to summarize and update knowledge on the phytochemistry, pharmacology, and toxicity of *Cola nitida*, with the view of providing baseline data for herbal drug formulation. In January 2021, a non-exhaustive online search of relevant articles was carried out on the phytochemistry, pharmacology, and toxicology of *C. nitida* from scientifically well-established databases such as Science Direct, PubMed, Web of Science, Scopus, Google Scholar, and SciELO. The plant's scientific name as well as phytochemistry, pharmacology, pharmacognosy, bioactivity and toxicology were used as keywords. The chemical structures of the compounds isolated from this plant were drawn using ChemBioDraw Ultra 12.0 software. A literature survey has revealed that *C. nitida* is highly appreciated by African populations in various cultures, especially in West Africa. Phytochemical analyses showed that *C. nitida* contains interesting compounds like catechin, caffeine, epicatechin, polyphenols, alkaloids, tannins, saponins, bromelain, cardenolides, proanthocyanidins, triterpenes, glycosides, flavonoids, anthraquinones, steroids, anthocyanins, glycosides, alkaloids, etc. The presence of these phyto-compounds in the investigated plant species justifies its used as an antimicrobial, anti-malarial, anti-inflammatory, anti-diabetic, anti-coagulant agent. Thus, *C. nitida* could be used as a raw material for manufacturing efficient medication against various diseases, including sickle cell disease.

## 1. INTRODUCTION

The African continent is known to be rich in biodiversity with a high number of plants used for their medicinal properties (Ngbolua, 2020). Unfortunately, its populations are frequently exposed to a variety of diseases, resulting in a high rate of mortality, which is exacerbated by acute poverty (Hope, 2009; Ikejiaku, 2009; Mongeke et al., 2018; Ngbolua, Lengbiye, et al., 2019). In order to treat and/or prevent disease, a large percentage (70-80%) of African population uses medicinal plant-based folk medicine (Ngbolua, 2018; Ngbolua et al., 2018; Ngbolua, Inkoto, et al., 2019). Among medicinal plants with therapeutic virtues, there are species belonging to the *Cola* genus (Adewale & Adekunle, 2018; Erukainure et al., 2019). The genus *Cola* belongs to the family Sterculiaceae (Dah-Nouvlessounon et al., 2015; Salahdeen et al., 2015).

This genus is well-known for its medicinal benefits as well as for its many uses throughout Africa (Ouattara et al., 2018; Sery et al., 2019). It contains several species, but only two are cultivated for their scientific and economic values. These are *Cola acuminata* and *Cola nitida* (Akinoso et al., 2014; Gbedie et al., 2019; Lowor et al., 2010; Ouattara et al., 2018). The first is reported to be native to Central African countries, while the second is recognized as being from West Africa (S.-O. Atawodi et al., 2007; Dah-Nouvlessounon et al., 2015; Lowe et al.,

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2014). *C. nitida* (Figure 1) has long been used for its stimulating properties (Amadi & Nwachukwu, 2020), and it is used to enhance cultural, religious, and funeral ceremonies in a variety of ways (S.E. Atawodi et al., 1995; S.-O. Atawodi et al., 2007; Sonibare et al., 2009; Umoh et al., 2014).This plant has various medicinal properties and is involved in the treatment of many diseases such as coughs, asthma and malaria (Zailani et al., 2020).

Several phytochemical compounds have been isolated from *C. nitida*, such as catechin, caffeine, epicatechin, procyanidin B1, procyanidin B2, theobromine, polyphenols, alkaloids, tannins, saponins, and so on (Akinoso et al., 2014; Dah-Nouvlessounon et al., 2015). Because of its very high caffeine content, *C. nitida* is a significant source in the production of beverages such as Coca-Cola and Pepsi-Cola. In addition, it is also used for the production of drugs, soft drinks, and wines (Dah-Nouvlessounon et al., 2015). Because of its different secondary metabolites, *C. nitida* has a variety of biological properties, including anti-malarial activity (Zailani et al., 2020). The purpose of this mini-review was to summarize current understanding of the phytochemistry, pharmacology, and toxicity of *Cola nitida*, an African medicinal plant.

## 2. METHODOLOGY

Various electronic databases like Science Direct, PubMed, Web of Science, Scopus, Google Scholar, and SciELO were used in January 2021 to conduct a non-exhaustive literature review of pertinent publications available online. These terms were employed in conjunction with the plant's scientific name: phytochemistry, pharmaceuticals, and toxicology. The ChemBioDraw Ultra 12.0 software tool was used to sketch the chemical structures of chemicals isolated from this plant.

## 3. RESULTS AND DISCUSSION

### 3.1. Botany description

In the literature, *Cola nitida* (Family: Malvaceae) is described as a tree that can reach a height of 25 meters. The large branches and stems are cracked and mixed with whitish or greyish lichen spots. The leaves have long petioles and vary in shape from obviate to oblanceolate, measuring about 15 cm in length. The ovary is yellow, light yellow, or lemon yellow. The fruit consists of 1 to 10 elongated green follicles, each containing 4 to 10 seeds. The seed, red, pink, or white in color, is also protected by a vitreous white arillus and includes 2 cotyledons, very rarely fragments. The inflorescences are panicle-like cymes with terminal flowers that grow in a determinate manner. *C. nitida* is functionally monoecious, with male and hermaphrodite flowers blooming in the same order. Male and female flowers are either produced on distinct inflorescences or coexist on the same inflorescence (Adebola, 2011; Bohou & Ijb, 2009; Burdock et al., 2009).

**Figure 1.** Pod and seeds of *Cola nitida* nut

### 3.2. Origin and geographic distribution

*Cola nitida* is a plant species native to Africa, particularly in West Africa (S.E. Atawodi et al., 1995; Mbete et al., 2011; Sunday et al., 2007). According to the literature, the first survey of this plant was carried out in 1594 in the Ivory Coast (S.E. Atawodi et al., 1995). Because of its increasing economic importance, *C. nitida* is nowadays cultivated in several countries around the African continent, in Asia, and various parts of Central and South America (during the Slave Trade of the 17th century) (Dah-Nouvlessounon et al., 2015; Gbedie et al., 2019; Niemenak et al., 2008).

### 3.3. Ethno-botany

The literature survey revealed that the use of *C. nitida*, especially its nuts or seeds, is very widespread in many countries in Africa. It takes a key place in various ceremonies (weddings, funerals, customary) in the West African country from which it originates (S.E. Atawodi et al., 1995).

For example, in Nigeria, *C. nitida* is known by several names, such as "kola nut" or "gworo", "guru nuts", "bissy nuts" or "sudan coffee". It has various uses, and is an essential item in cultural, religious, wedding, or funeral ceremonies (Abidoye & Chijioke, 1990; S.-O. Atawodi et al., 2007). It is chewed for its stimulating virtues Adewale and Adekunle (2018). It is also known to have aphrodisiac properties (Abulude, 2004; S.E. Atawodi et al., 1995).

In addition, *C. nitida* is also an excellent remedy in the treatment of coughs and asthma Akinoso et al. (2014). Consumption of cola nuts is more commonly reported in men than in women for the purpose of eliminating fatigue (Umoh et al., 2014). Jayeola (2001) has demonstrated that fresh *C. nitida* nuts can be used to produce a soft drink. Dah-Nouvlessounon et al. (2015) reported that the nuts of *Cola nitida* are regularly chewed and have varied socio-cultural importance in Benin.

### 3.4. Phytochemistry

Phytochemical profiling of *C. nitida* showed several secondary metabolites. The nuts from *C. nitida* revealed the presence of various chemical compounds, including catechin, caffeine, epicatechin, procyanidin B1, procyanidin B2, polyphenols, alkaloids, tannins, saponins, bromelain, cardenolides, proanthocyanidins, triterpenes, glycosides,

flavonoids, anthraquinones, steroids (Adedayo et al., 2019; Daels-Rakotoarison et al., 2003; Dah-Nouvlessounon et al., 2015; Ganiyu et al., 2014; Momo et al., 2009; Niemenak et al., 2008; Sonibare et al., 2009). Bark from *C. nitida* contains tanins, saponosides, anthocyanins, flavonoids, glycosides, alkaloids, and polyphenols (Dah-Nouvlessounon et al., 2015; Dawole et al., 2013; Eddy, 2010) (Figure 2 andTable 4). Table 1 gives the proximate composition of *C. nitida.*

**Table 1**
Proximate composition of *Cola nitida*

| Parameter | Mean value | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Moisture | 2.30±0.33 | 9.81±0.01 | 12.46 ± 0.80 | 6.00±0.10 |
| Dry matter | 97.70±0.26 | - | 87.53 ± 0.80 | - |
| Crude protein | 10.50±0.14 | 15.24±0.58 | 10.06 ± 0.75 | 3.50± 0.10 |
| Ash | 3.10±0.60 | 2.21±0.01 | 3.00 ± 0.50 | 3.10±0.10 |
| Crude fat | 13.30±0.35 | 2.20±0.01 | 0.20 ± 0.00 | - |
| Crude fiber | 17.60±0.40 | 4.18±0.09 | 4.31 ± 1.02 | - |
| Carbohydrate | 53.20±0.22 | 66.45±0.53 | 5.18 ± 0.56 | 69.20±1.20 |

1 — Abulude (2004), 2 — Dawole et al. (2013), . 3 — Dah-Nouvlessounon et al. (2015), 4 — Arogba (2000).

Lowor et al. (2010) reported the moisture concentrations of different types of *Cola nitida* grains, from red to white to pink. The contents are 44.16 ± 0.5% for reds, 42.49 ± 1.3 for whites and 42.76 ± 1.0 for roses. Table 2 gives the mineral composition of *C. nitida*.

**Table 2**
Mineral composition (mg/Kg) of *Cola nitida*

| Mineral/Vit | Mean value | |
|---|---|---|
| | 1 | 2 |
| Ca | 4.72±0.16 | 4.33 ± 1.41 |
| Mg | 16.13±0.01 | 11.48 ± 0.05 |
| Na | 198.00±0.007 | - |
| K | 92.00±0.21 | - |
| Fe | 2.20±0.05 | 4.37 ± 0.53 |
| Mn | 0.04±0.01 | - |
| Zn | 0.80±0.04 | 0.69 ± 0.19 |
| Cu | 0.29±0.10 | 0.59 ± 0.08 |
| Co | 0.20±0.05 | - |
| P | 50.23±0.10 | - |
| Vit C (mg/100ml) | - | 6.26 ± 0.46 |

1 — Abulude (2004), 2 — Dah-Nouvlessounon et al. (2015).

Table 3 gives some phytochemicals isolated from the *Cola nitida*.

Figure 2 gives the chemical structure of selected medically interesting secondary metabolites isolated from *Cola nitida*.

### 3.5. Pharmaco-biology and toxicology

#### *3.5.1 Antimicrobial activities*

Lateef, Azeez, Asafa, Yekeen, Akinboro, et al. (2015); Lateef, Azeez, Asafa, Yekeen, Oladipo, et al. (2015); Lateef et al. (2016) synthesized silver nanoparticles from *Cola nitida* and evaluated their antimicrobial and antioxidant properties, as well

**Table 3**
Free amino-acids composition of kola nut (dry weight)

| Amino acids | Total (%) | Free (%) |
|---|---|---|
| Aspartic acid | 0.53 ± 0.28 | 0.53 ± 0.28 |
| Arginine | 1.06 ± 0.06 | 0.69 ± 0.06 |
| Threonine | 0.39 ± 0.01 | - |
| Alanine | 0.50 ± 0.01 | 0.20 ± 0.01 |
| Proline | 0.83 ± 0.04 | 0.53 ± 0.04 |
| Valine | 0.35 ± 0.01 | - |
| Methionine | 0.22 ± 0.00 | - |
| Cysteine | 0.27 ± 0.00 | - |
| Lysine | 0.30 ± 0.02 | 0.16 ± 0.02 |

Source: Dah-Nouvlessounon et al. (2015)

**Table 4**
Some compounds isolated from *Cola nitida*.

| NO | Compound | References |
|---|---|---|
| 1 | Phenolic compounds (Catechin, Epicatechin, Apigenin, Narigenin) | Ganiyu et al. (2014) |
| 2 | Flavonoids (Catechin, Quercetin, Kaempferol, Naringin, Epicatechin, Myricetin, Rutin) | Azeez et al. (2017) |
| 3 | hexadecanoic acid, ethyl ester , 9, 12-Octadecadienoic acid, ethyl ester, 9-Octadecadienoic acid, ethyl ester, ethyl oleate, cyclohexanone, 2-methyl-5-(1-methylethenyl) Octadec-9-enoic acid decanoic acid, 10-(2-hexylcyclopropyl). | Salahdeen et al. (2015) |
| 4 | 2-Heptanol, trans-2-Decen-1-ol, Spilanthol, L-Methionine, N-(2-thienylcarbonyl)-, methyl ester, Cinchonine | Erukainure et al. (2019) |
| 5 | Theobromine, Caffeine, Catechin | Burdock et al. (2009) |
| 6 | Procyanidin B1, procyanidin B2 | Dah-Nouvlessounon et al. (2015) |

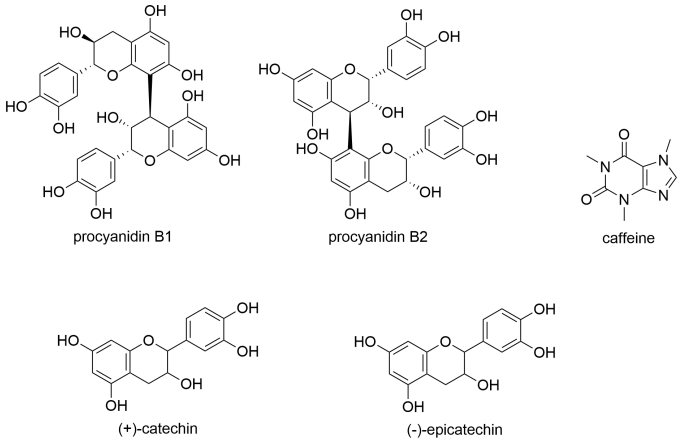


**Figure 2.** Chemical structure of compounds isolated from *Cola nitida*

as their potential for usage as an antimicrobial addition in paint. The results indicated that silver nanoparticles significantly inhibited the growth of multi-resistant strains at concentrations between 50 and 150 μg/mL and that at 5 μg/mL, silver nanoparticles completely inhibited the growth of *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Aspergillus niger*, *A. flavus*, and *A. fumigatus*. Previously, the same scientists showed antibacterial activity of biogenically generated silver nanoparticles (AgNPs) derived from *C. nitida* seed and seed shell extracts against a number of multidrug-resistant clinical isolates.

The results indicated that AgNPs have high activity; at doses ranging from 50–150 μg/mL, the AgNPs suppressed the growth of multidrug-resistant *Klebsiella granulomatis*, *P. aeruginosa*, and *E. coli* by a factor of 10–32 mm. In comparison, seed shell extract-mediated AgNPs demonstrated superior activity with a minimum inhibitory concentration (MIC) of 50 g/mL against all tested isolates, whereas seed extract-mediated AgNPs demonstrated MICs of 50, 80, and 120 μg/mL against *E. coli*, *P. aeruginosa* (wound), and *P. aeruginosa* (burn), respectively Lateef, Azeez, Asafa, Yekeen, Akinboro, et al. (2015). Continuing the same research, Lateef et al. (2016) discovered similar results one year later when they synthesized silver-gold alloy nanoparticles (Ag-AuNPs) from extracts of *C. nitida* leaves, seeds, seed envelopes, and pods and evaluated their antifungal, antiplasmodial, anticoagulant, and thrombolytic activities.

According to their findings, Ag-AuNPs suppressed the growth of *A. flavus*, *A. fumigatus*, and *A. niger* by 69.51-100 percent. Within 24 hours of exposure to Ag-AuNPs, Anopheles mosquito larvae died at a rate of 80-100%. After 24 hours, malachite green and methylene blue showed catalytic degradation of > 90 and > 60 percent, respectively. In the blood, the particles demonstrated significant anticoagulant and thrombolytic activity. Ganiyu et al. (2014) examined the inhibitory effect of phenolic-rich extracts from *C. nitida* seeds on key enzymes associated with type-2 diabetes and $Fe^{2+}$-induced pancreatic oxidative stress. *C. nitida* extract reduced the activities of amylase ($EC_{50}$ = 0.34 mg/mL) and glucosidase ($EC_{50}$ = 0.32 mg/mL).

#### 3.5.2 Antioxidant activities

Several recent studies have demonstrated that the lipid peroxidation generated by iron in the rat pancreas can be inhibited by *Cola nitida* extract in a dose-dependent manner (Ganiyu et al., 2014), and that the extract also has high DPPH radical scavenging activity ($EC_{50}$ = 2. 2 mg/mL) (Adedayo et al., 2019).

At concentrations ranging from 20 to 100 μg/mL, *Cola nitida*-based-Silver nanoparticles demonstrated significant antioxidant activity, with an $IC_{50}$ of 43.98 mg/mL against the DPPH radical and a decrease in ferric ions of 13.62 to 49.96 percent at the concentrations of 20 to 100 μg/mL (Lateef, Azeez, Asafa, Yekeen, Oladipo, et al., 2015). Aside from that, *C. nitida* extract had a scavenging impact on DPPH and oxygen radicals, as well as chelating activity against $Fe^{2+}$ in rat brain homogenate (Ganiyu et al., 2018).

#### 3.5.3 Anticholinesterase, antimonoamine oxidase and antioxidant effects

A rat brain homogenate was used in an *in vitro* investigation to examine the anti-disease Alzheimer's potential of alkaloid extracts from two species of Cola (*C. nitida* and *C. acuminata*). Researchers found that alkaloid extracts had an impact on disease pathophysiology pathways *in vitro*. Based on gas chromatography analysis, the alkaloids augustamine and undulatine were found to be the most prevalent. The inhibitory effects of the extracts on cholinesterase activity were not significantly different ($p>0.05$). However, the *C. acuminata* extract had substantially greater monoamine oxidase inhibitory activity than *C. nitida* ($p< 0.05$) (Ganiyu et al., 2018).

#### 3.5.4 Antimalarial activity

Zailani et al. (2020) reported that the ethanolic extract from *C. nitida* leaves showed the highest antiplamodial activity by reducing 97.05% of the parasiteamia. Indeed, to evaluate the antimalarial activity of *Cola nitida* leaf, 12.5, 25, and 50 mg/kg body weight were administered to mice per os. After treatment, parasitaemia was evaluated. The final results suggested that all used doses showed good antimalarial effects against *Plasmodium berghei* in a dose-dependent way.

#### 3.5.5 Anti-fertility activity

Adisa et al. (2010) investigated the effects of *C. nitida* aqueous extract on reproductive hormones in rats. Thirty adult male rats were randomly assigned to three groups: group A served as the control group and got just water; groups B and C received only kola nut extract (8 mg/kg body weight); and group C served as the recovery group. After four weeks of therapy, testosterone levels in the plasma were significantly elevated ($p < 0.05$), whereas luteinizing hormone levels were dramatically decreased ($p < 0.05$) in comparison to control animals.

Table 5 gives comparative bioactivity of *Cola nitida* and used model systems.

The recovery group demonstrated values that were not statistically different from those of the control animals but were slightly closer to those of the control animals. Umoh et al. (2014) verified a similar observation by examining the effects of *C. nitida* aqueous seed extract on serum reproductive hormones and sperm count in male albino Wistar rats.

The results indicated a considerable decrease in luteinizing hormone and testosterone levels in the serum. All animal groups showed a drop in sperm count. However, no significant difference in testicular or epididymis weight was seen between the experimental groups.

#### 3.5.6 Anti-diabetic activity

An anti-diabetic property of the hot water extract of *C. nitida* seeds against type 2 diabetic rats was carried out. The doses of 150 mg/kg bw (low dose) and 300 mg/kg bw (high dose) were administered to the rats for six weeks. The final results indicated

**Table 5**
Model system used and comparative bioactivity of *Cola nitida*

| Parts used | Extracts | Bio- activities | Model system | Concentration | Period | Authors |
|---|---|---|---|---|---|---|
| Seeds | Aqueous extract | Pharmacokinetic interactions of *C. nitida* and metoclopramide | Male rabbits | 0.5 mg/kg of metoclopramide alone and 0.5 mg/kg of metoclopramide with 0.7 mg/kg *C. nitida* | 1 week | Amadi and Nwachukwu (2020) |
| Seed and seed shell | Aqueous extract | Antibacterial Activities | Strains of *K. granulomatis*, *P. aeruginosa* and *E. coli* | 50 $\mu$g/mL for seed shell extract and 50, 80 and 120 $\mu$g/mL for seed extract | – | Lateef, Azeez, Asafa, Yekeen, Akinboro, et al. (2015) |
| Seeds | Methanol Extract | Anti-inflammatory and analgesic activities | Rats and mice | 200 mg/kg | 24 hours | Adedayo et al. (2019) |
| Pod of seed | Aqueous extract | Antibacterial and antioxidant activities | *K. granulomatis*, *P. aeruginosa*, *E. coli*, *S.aureus*, *A. niger*, *A. flavus* and *A. fumigatus* | 49.96 at 100 $\mu$g/mL | – | Lateef, Azeez, Asafa, Yekeen, Oladipo, et al. (2015) |
| Seeds | Aqueous extract | Anti-diabetic activity | Diabetic rats | 150 mg/kg bw at 300 mg/kg bw | 6 weeks | Erukainure et al. (2019) |
| Seeds | Acetone Extract | Aminotransferase activity | Female Wistar rats | 50 mg/kg at 100 mg/kg | • | Imam-Fulani et al. (2019) |
| Leaves, fruits, seeds, seed shells and pod | Aqueous extract | Antimicrobial, antioxidant and anticoagulant activities | *S. aureus*, *P. aeruginosa E. coli*, *K. Pneumonia*, *A. niger*, *F. solani* and blood | 20 at 80 $\mu$g/mL | 24 hours | Akinola et al. (2020) |
| Stem bark | Ethanol-water (80:20, v/v) and ethanol-water (20:80, v/v) mixture | Anti-gonadotropic activities | Rat pituitary cells | 20 $\mu$g/mL | 4 hours | Benie and Thieulant (2004) |
| Leaves and bark | Aqueous and ethanol extracts | Anti-plasmodial activity | Albino mice | – | 4 days | Zailani et al. (2020) |
| Bark | Ethanol and ethyl acetate extracts | Antimicrobial | Meat isolated Staphylococcus strains | 20 mg/mL | – | Dah-Nouvlessounon et al. (2015) |
| Seed | Aqueous extract | Anti-fertility activity | Male albino Wistar rats | 2 mg/kg-10 mg/kg | 6 weeks | Umoh et al. (2014) |
| Seed | Aqueous Extract | Anti-fertility activity | Male rats | 8 mg/kg | 4 weeks | Adisa et al. (2010) |
| Seed | Ethanolic Extract | Cytotoxic effect | Wistar albino rats | 100-2000 mg/kg for acute toxicity studies and 6 mg/kg to 11.9 mg/kg) for Chronic toxicity studies | 48 hrs and 90 days | Salahdeen et al. (2015) |

the reduction of levels of blood glucose, triglycerides, LDL-c, and fructosamine. Additionally, serum insulin and HDL-c decreased (Erukainure et al., 2019).

#### 3.5.7 Antisicking activity

An ethno-medicinal survey carried out by Amujoyegbe and coworkers revealed that the medicinal plant species *Cola nitida* is traditionally used in Southern Nigeria as medicine for the management of sickle cell disorder (Amujoyegbe et al., 2016).

#### 3.5.8 Cytotoxic effect of C nitida seeds

Salahdeen et al. (2015) extracted caffeine from kola nuts and used rats as a model system to assess the extract's acute and chronic toxicity *in vivo*. The results demonstrated that prolonged caffeine administration reduced animal body weight significantly ($p < 0.05$). Total plasma protein, creatinine, bilirubin, VLDL, LDL, and total serum cholesterol levels all increased considerably ($p < 0.05$). On the other hand, the caffeine-treated groups had significantly reduced urea levels ($p < 0.05$). Erukainure et al. (2019) by using FTIR spectroscopy, they analyzed the hepatic metabolites after consumption of the infusion of caffeine-rich *C. nitida* seeds, and the results of their experiments revealed the restoration of functional groups depleted by oxidation during infusion.

The liquid chromatography-mass spectroscopy analysis of the hepatic metabolites also revealed the restoration of most of the depleted metabolites with the concomitant generation of 4-o-methylgallic acid, (-)-epicatechin sulfate, L-arginine, L-tyrosine, citric acid, and decanoic acid in the infusion-treated tissues. The prediction of the oral toxicity of caffeine showed that it belonged to class 3, with a lethal dose 50 ($LD_{50}$) of 127 mg/kg. These results indicate that the seeds of this plant should be consumed

in moderation to prevent toxicity.

## 4. CONCLUSION AND FUTURE DIRECTIONS

The aim of this mini-review was to document knowledge of the phytochemistry, pharmacology, and toxicity of *Cola nitida*, a medicinal plant species traditionally used in Africa for multiple purposes. Results revealed that *C. nitida* contains various phyto-compounds (like catechin, caffeine, epicatechin, procyanidin B1, procyanidin B2, polyphenols, alkaloids, tanins, saponins, bromelain, cardenolides, proanthocyanidins, triterpenes, glycosides, flavonoids, anthraquinones, steroids, etc.) that are responsible for the displayed bioactivity. Thus, *C. nitida* could serve as a raw material for manufacturing efficient medication against various diseases, including Sickle cell disease.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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BMM, KNN - Research concept and design, BMM, CLI, JJOA - Collection and/or assembly of data, BMM, CMA -Data analysis and interpretation, BMM, KNN - Writing the article, KNN, JMSN, PTM - Critical revision of the article, MS - Final approval of the article.

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