Journal of Advances in Medical and Pharmaceutical Sciences
3(4): 147-154, 2015, Article no.JAMPS.2015.036
ISSN: 2394-1111

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A Comprehensive Review on Ethno-Medicine, Phytochemistry and Ethnopharmacology of *Chrysophyllum albidum*

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Authors' contributions

This work was carried out in collaboration among all authors. Authors EOE and EGM and KEE did the literature search. Authors EOE and JOTE wrote the manuscript. Authors JOTE and EOE proof read the manuscript. All Authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAMPS/2015/18641
Editor(s):
(1) Dongdong Wang, Department of Pharmacogonosy, West China College of Pharmacy, Sichuan University, China.
Reviewers:
(1) Atef Mahmoud Mahmoud Attia, Biochemistry Department, Biophysical Laboratory, National Research Centre, Egypt.
(2) Anonymous, University of Pernambuco (UFRPE), Brazil.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=1016&id=36&aid=9578

Review Article

Received 2nd May 2015
Accepted 19th May 2015
Published 4th June 2015

ABSTRACT

Chrysophyllum albidum (Sapotaceae), commonly called white star apple is a very useful medicinal plant common in the tropical and sub-tropical regions of the world. This review is an update assemblage on the traditional, phytochemical and ethno-pharmacological studies carried out on it. Its reported pharmacological activities in this review include; antioxidant, anti-microbial, anti-plasmodial anti-inflammatory, analgesic and anti-diabetic properties, which justifies its traditional uses. The information in this work is intended to serve as a reference guide to researchers in the fields of ethnopharmacology, drug discovery and development of natural products from medicinal plants.

Keywords: Chrysophyllum albidum; ethnopharmacology; ethno-medicine, phytochemistry; medicinal plants.

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1. BACKGROUND

Medicinal plants play a significant role in the health of humanity [1]. Most conventional medicines, food supplements, folk medicines and pharmaceutical intermediate are derived from medicinal plants [2]. The affordability, accessibility, wider acceptability factor among the population as well as low toxic profile of medicinal plants has negated the numerous problems associated with synthetic therapeutics [3].

As an avenue to unveil the hidden potential of medicinal plants and also advance research in ethnopharmacology, information update on medicinal plants had aided the frontier of research. Review updates on *Buchhoizia coriacea* [4], *Terminalia catappa* [5], *Mangifera indica* [6], *Ageratum conyzoides* [7], among others had been published in different scientific journals.

In other to promote the avalanche of medicinal plant review, there is need to carry out more search by gathering information on the medicinal values of natural remedies from plants. This had necessitated this present review on the ethnomedicine, phytochemistry and ethno-pharmacology of *Chrysophyllum albidum,* a fruit of high commercial and medicinal values in Nigeria and other countries.

1.1 *Chrysophyllum albidum*

1.1.1 Description

Chrysophyllum albidum (*C. albidium*), commonly called white star apple, belonging to the family of *Sapotaceae* (which has up to 800 species) is a lowland rain forest tree species that grows up to 25 to 37 m in height at maturity with a girth varying from 1.5 to 2 m [8]. The Scottish botanist George Don described it as a forest fruit tree [9]. It is common throughout the tropical Central, East and West Africa regions and other parts of the world [10]. When it is ripe, the fruit is ovoid to sub-globose, pointed at the apex, and up to 6 cm long and 5 cm in diameter. The skin or peel, is orange to golden yellow when ripe and the pulp within the peel may be orange, pinkish, or light yellow. Within the pulp are three to five seeds which are not usually eaten. The seed-coats are hard, bony, shiny, and dark brown, and when broken reveals white-coloured cotyledons. The (Fig. 1) fruit is seasonal (usually from the months of December to March). The plant is a crop of commercial value in Nigeria [11]. The seeds are also used for local games or discarded. The fleshy fruit pulp is suitable for jams and is eaten especially as snack by many locals [10].

1.1.2 Local names

African star apple (*C. albidium*) is an edible tropical fruit known by various tribal names. It is called Utieagadava in Urhobo, *agbalumo* in Yoruba, *udara* in Ibo, Efik and Ibibio, e*hya* in Igala, agwaluma in Hausa tribes of Nigeria [10,12]. In southern Benin, it is called azongogwe or azonbobwe in local language "Fon, Goun" and azonvivo, azonvovwe or azonbebi in local language "Aïzo" [13].

1.1.3 Scientific classification

Kingdome: Plantea
Division: Angiosperm
Class: Eudicots
Order: Ericales
Family: Sapotaceae
Genus: Chrysophyllum
Species: *C. albidum*

1.1.4 Ethno-medicinal values

In folklore medicine, *Chrysophyllum albidum* bark is employed for the treatment of yellow fever and malaria [12]. The leaf is used as an emollient and for the treatment of stomachache and diarrhoea. The leaf and cotyledons from its seed are used as ointments in the treatment of vaginal and dermatological infections in Western Nigeria [14]. The roots, barks and leaves of *C. albidum*is are widely used as an application to sprains, bruises and wounds in southern Nigeria. The seeds and roots extracts of *C. albidium* is used to arrest bleeding from fresh wounds, and to inhibit microbial growth of known wound contaminants and also enhance wound healing process [15].

1.1.5 Other uses

Chrysophyllum albidum leaves were occasionally used for fodder. Rotten or damaged fruits are also used to feed pigs. In southern Benin, it is useful in traditional rituals and also has medico-magical properties apart from its common uses. According to local socio-cultural considerations, it was also mentioned to be used to chase bad spirits and the trees can only be cultivated by older people in order to avoid early death of a young person who would attempt to propagate the species from seed [13].

1.2 Phytochemical and Nutrient Composition

Study by Okoli, [15] on the phytochemistry of *Chrysophyllum albidum* stem slash, seed cotyledon, leaves and root revealed the presence of alkaloids, tannins, phenols and flavonoids; except cardiac glycosides in the root; tannins in leaves; and phenol in seed. The study by Ushie et al. [16] on the methanol leaf extracts of *C. albidum* also revealed the presence of flavonoids, phenols, glycosides, terpenoids, saponins, steroids and alkaloids. MacDonald et al. [17] also revealed the presence of alkaloids, flavonoids, saponins and tannins in *Chrysophyllum albidum*. According to Duyilemi and Lawal, [18], leave extract of *Chrysophyllum albidum* contains anthraquinone, tannin and cardiac glycoside and with no traces of reducing sugars, saponin and alkaloids.

According to Amusa et al. [10], eleagnine, tetrahydro- 2 -methylharman and skatole are present in the methanol extract of *Chrysophyllum albidum* cotyledon seeds. The fruit was found to have the highest content of ascorbic acid per 100 g of edible fruit, which is about 100 times that of oranges and 10 times of that of guava and cashew. *Chrysophyllum albidum* is also an excellent source of vitamins, irons and flavours to diets [19]. The fruits also contain 90% anacadic acid, which is used industrially in protecting wood and as source of resin. Ajewole and Adeyeye [20] also confirmed that unsaturated fatty acids are the main components of the oil (74%) of *Chrysophyllum albidum*.

The physicochemical and minerals analyses of *Chrysophyllum albidum* according to Imaga and Urua [21] revealed the following; moisture (48.38 and 47.02%), crude protein (2.75 and 2.68%),

Fig. 1. Showing pictures of *Chrysophyllum albidum* fruit, tree and seed

carbohydrate (24.26 and 25.17%), ash (4.175 and 4.68%), crude fat (10.94 and 10.79%) and energy value (206.50 and 208.53 Kcal) for ethanol and aqueous extract. Also, 100 g mineral composition (mg) of the fruit contains sodium (123.05), iron (42.45), zinc (34.45), magnesium (34.05), calcium (24.55), manganese (4.1) and potassium (2.05). The vitamins analyzed in mg/100 g indicated vitamin K (35.36), vitamin B1 (18.68), folate (2.02), vitamin C (3.084) and vitamin B6 (3.26). Tannins, phenols, flavonoids, cardiac glycosides, terpenoids, reducing sugar and phlobatannins were also present in both extracts. Saponins, steroids and alkaloid were present in the aqueous extract. However, anthraquinone was absent in both extracts [21].

Study by Ureigho and Ekeke, (2010) [22] on nutrient analysis of *Chrysophyllum albidum* revealed the presence of the following; carbohydrate (11%), crude fibre (4%), lipids (3%), protein (7%), Calcium (17.11 ppm), Iron (<1 ppm), phosphorus (9.92 ppm), vitamin C (25.03 ppb), A (10.74 ppb), B1 and B2 (<1 ppb). Chukwuemeka, [23] showed that the fresh fruit samples (both untreated and treated with 2, 4-dichlorophenoxyacetic acid), showed the presence of the following minerals elements; K, P, S, Ca, Mg, Fe, Al and Zn. The crude fiber showed no significant difference between samples.

1.3 Pharmacological Activities

1.3.1 Antioxidant activities

Adebayo, et al. [8] investigated the antioxidant (DPPH free radical scavenging activity) properties of the leaves of petroleum ether, ethanol, butanol, ethylacetate, and water fractions of *Chrysophyllum albidum* by employing the *in vitro* and *in vivo* experimental models. Result from animal study showed that *C. albidum* exhibited significant ($p < 0.05$) differences on the activity of CAT, MDA and GSH. *C. albidum* has antioxidant properties by scavenging free radicals, decreasing lipid peroxidation and increasing the endogenous blood antioxidant enzymes levels. Adebayo and co-workers recommended that *Chrysophyllum albidum* could be employed as sources of natural antioxidant boosters for the treatment of free radical implicated oxidative stress disorders.

Imaga and Urua [21] evaluated the antioxidant properties of *Chrysophyllum albidum* fruit components. Ethanol extract showed more scavenging activity of free radicals compared to the aqueous extract. Reducing power increased remarkably at 75 µg/ml in the extracts. The ethanol extract showed more reducing power than the aqueous at equal concentrations. Nitric oxide showed significant increase in the scavenging activity of the ethanol extract at 75 µg/ml ($p < 0.05$), while there was a significant ($p<0.05$) decrease in the scavenging activity of the aqueous extract. The ethanol extract showed greater scavenging activity at all concentrations than the aqueous extract.

In vitro and *in vivo* antioxidant properties of *Chrysophyllum albidum* petroleum ether, ethanol, butanol, ethylacetate, and water fractions were determined in experimental models. The petroleum ether fraction showed the least antiradical activity (4057.5±809.6 g/kg) while ethyl ether exhibited the highest activity (414.4±92.0 g/kg). Myricetin rhamnoside also exhibited an excellent radical scavenging activity (314.1±60.2) which was comparable to the positive control. In animal studies, *C. albidum* exhibited significant ($p < 0.05$) differences on the activity of CAT, MDA and GSH. The authors recommended that *Chrysophyllum albidum* could be employed as sources of natural antioxidant boosters and for the treatment of some free radicals implicated oxidative stress disorders [24].

Idowu and co-workers [25] had also reported that eleagnine, an alkaloid isolated from *C. albidum* seed cotyledon has antioxidant activities.

1.3.2 Hypoglycemic and hypolipidemic effects

Olorunnisola, et al. [26] evaluated the anti-hyperglycemic and hypolipidemic effect of ethanol extract of *Chrysophyllum albidum* seed cotyledon in model of alloxan-induced diabetic rats. Their results showed that the daily treatment of diabetic rats with ethanol extract twice daily for 7 days (100 and 200 mg/kg orally) significantly decreased ($p<0.001$) the blood glucose levels by 11.92 and 12.10%, respectively in the treated induced diabetic rats compared to the diabetic control rats. The 200 mg/kg (except 100 mg/kg) doses of the extract showed significant ($p<0.001$) decrease in the hepatic lipids (except HDL-cholesterol) concentrations in the treated diabetic rats and treated non-diabetic rats. The various doses of the extract showed no significant effect on the hepatic HDL-cholesterol in the treated non-diabetic rats.

1.3.3 Antimicrobial properties

Okoli, [15] had demonstrated *Chrysophyllum albidum* to elicit anti-bacterial activity against *Staphylococcus aureus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Escherichia coli* and *C. tetani*, as well as anti-fungal effect against *Candida albicans*.

MacDonald et al. [17] had also investigated the antimicrobial properties of *Chrysophyllum albidum*, *Dacryodes edulis*, *Garcinia kola* chloroform and ethanol root extracts against the test isolates (*Escherichia coli*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacillus subtilis*, *Aspergillus niger*, *Penicillium notatum*, *Mucormucedo* and *Candida albicans*). Both extracts showed broad spectrum of antimicrobial activities but chloroform extracts gave higher zones of inhibition compared to corresponding concentrations of ethanol extracts. Maximal inhibitory zones were shown by *P. aeruginosa*; 30.7 mm±0.01 against *G. kola* chloroform root extract. Chloroform root extracts of *G. kola* were comparatively more potent against the test isolates than *Candida albidum* and *Dacryodes edulis* root extracts. All the respective root extracts exhibited a greater antibacterial activity in comparison with the antifungal attributes.

Antimicrobial effect of *Chrysophillum Albidum* leave extract on gastrointestinal tract pathogenic bacteria and fungi in human was also investigated by Ajetunmobi and Towolawi [27]. Results showed the plant extract has a broad spectrum antibiotic and the organisms resistant to Ciprofloxacin were susceptible to the extracts. The methanol extracts had highest antimicrobial activities than that of aqueous extracts. The methanol extract had pronounced activity against *Candida albicans* whereas it did not elicit any effect on Salmonella species.

Duyilemi and Lawal, [18] also investigated the antibacterial activity of water and methanol extracts from *Chrysophyllum albidum* leaves against *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhimurium* and *Shigella* spp. at different concentrations (125 µg/mL, 250 µg/mL and 500 µg/mL) using the agar well diffusion technique. The methanol extracts had stronger inhibitory effects on test organisms than the water extracts. The antimicrobial activity observed with the water extract ranged between 10±0.19 and 27±0.25 mm with no detectable activity at 125 µg/mL and 250 µg/mL on *Escherichia coli*. Stronger antimicrobial activity was observed with the methanol crude extracts at all concentrations with all test organisms.

1.3.4 Hepatoprotective activity

Abiodun et al. [28] studied the hepatoprotective activity of leaf extract of *Chrysophyllum albidum* against carbon tetrachloride (CCl_4) induced liver damage in Wistar rats. There was significant ($p<0.05$) increase in serum AST, ALT, ALP and total bilirubin level in rats treated with carbon tetrachloride (CCl_4), while these parameters were reduced significantly ($p < 0.05$) after treatment of rats with the extract. The histopathological studies of the liver tissue of rats in the group treated with CCl_4 showed marked centrilobular fatty degeneration and necrosis while the groups treated with plant extract showed signs of protection against carbon tetrachloride as evidenced by the absence of necrosis.

1.3.5 Anti-plasmodial activity

The anti-plasmodial, hematological, serum biochemical and pathological effects of *Chrysophyllum albidum* methanol bark extract were evaluated using Swiss albino male mice models. *C. albidum* methanol bark extract (750 - 1500 mg/kg/day) exhibited significant ($P < 0.05$) schizontocidal activities both in a 4-day (early) infection and in an established (> 7days) infection with a considerable mean survival time comparable to that of chloroquine. Appreciable anemia was developed in plant extract treated mice. Organ and tissue pathology during infection was milder at low doses, compared to the untreated mice and insignificant at higher doses of the extract. This study showed that the methanol extract of *C. albidum* contains anti-plasmodial substance(s) which help to reduce parasitaemia and hence the rate of erythrocyte destruction during infection [29].

Adewoye et al. [30] also investigated the probable mechanism of haematinic potential of methanol extract of *Chrysophyllum albidumon* (MeCaB) on the bone marrow in two separate anaemic studies. The *MeCaB* only treated and group bled and treated with *MeCaB*(*BMeCaB*) continuously for 7 days had significantly reduced methanol extract ratio (*1.67+0.00* and *1.35+0.00* respectively) compared with control, bled and treated with haematinic (*2.13+0.19*, *2.25+0.21 respectively*). This study thus establishes that *Chrysophyllum albidum* exerts haematinic properties on bone marrow cells by stimulating the production of more erythroid series which

reverted anaemia induced by *plasmodium berghei* and bleeding out models.

1.3.6 Effects on fertility

Onyeka, et al. [31] investigated the anti-fertility activity of the ethanol root bark extract of *Chrysophyllum albidum* on sperm parameter and hormonal levels in male Wistar rats. Decrease in the caudal epididymal sperm count, motility and sperm morphology was observed in extract (100 and 200 mg/kg) treated groups compared with the control group. The ethanol extract of the root bark of *C. albidum* suppresses the hormonal (serum gonadotrophins, testosterone, luteinizing hormones and follicle stimulating hormone) levels and sperm production in rats. Onyeka and co-worker [31] suggested that the root bark extract of *Chrysophyllum albidum* merit further investigation as a potential male contraceptive agent.

In another study, Onyeka et al. [32] investigated the ethanol leaf extract of *Chrysophyllum albidum* on sperm analysis, hormonal profile, SOD and testicular histology of adult male wistar rats. The ethanol leaf extract (500 and 1000 mg/kg) significantly ($p<0.05$) increased body weights and testis weight, motility, morphology, and number of spermatozoa in caudal epididymidis. Histologically, testes in rats treated with the plant extract showed no alterations in the seminiferous tubules when compared to the control. However hormonal assay showed significantly reduced levels ($p<0.05$) of FSH, LH and Testosterone in experimental groups while there was increase in the activity of SOD, which was dose dependent. The results thus suggest that *C. albidum* treatment does not cause suppression of spermatogenesis but decrease the hormonal profile.

1.3.7 Other studies

Methanol extract of dried barks of *Chrysophyllum albidum* and its chromatographic fractions (250 mg/kg) possess potent therapeutic and healing efficacy against acetic acid induced colitis in rats, possibly due to its antioxidant and anti-inflammatory properties [33].

Antinociceptive and anti-inflammatory activities of e*leagnine* (an alkaloid isolated from seed cotyledon of *C. albidum*) had also been investigated by Idowu and co-worker [25].

Study by Adewoye et al. [29] showed that the LD_{50} of the methanol bark extract of *Chrysophyllum albidum* was 1850 mg/kg body weight in Swiss albino male mice.

Jimoh et al. [34] investigated the histological changes in the liver and kidney of *Clarias gariepinus* fed *Chrysophyllum albidum* seedmeal as maize replacer. In the study, five isonitrogenous diet containing maize were replaced by *Chrysophyllum albidum* at 0, 25, 50, 75 and 100%. The control diet was without *Chrysophyllum albidum,* but only received isonitogenous and isolipidic. The results showed marked vacuolation of hepatocytes among the treatment after the treatment period. Jimoh and co-workers suggested that it is technically feasible to replace maize with *Chrysophyllum albidum* seedmeal in the diet of *Clarias gariepinus* without adverse effect on the kidney and liver.

2. CONCLUSION

The present review showed that the phytochemistry and ethno-pharmacology (anti-oxidant, hypoglycemic, hypolipidemic, anti-microbial, hepatoprotective, analgesic, anti-inflammatory and anti-plasmodial activities) of *Chrysophyllum albidum* mentioned above can be attributed to its phytoconstituents, which justifies its benefit in alternative medicine in the treatment of numerous diseases.

3. RECOMMENDATIONS

Chrysophyllum albidium is a potential source for useful drug and its continued traditional medicinal uses should be encouraged.

Although, the ethno-pharmacological properties of *Chrysophyllum albidium* highlighted above had been determined, anti-ulcerative, anti-diarrhoeal, anti-spasmodic, wound healing activities and other reported ethno-medicinal uses should be validated ethno-pharmacology through standard experimental models.

Also, the biological mechanism of its constituents is needed to be unveiled by incoming researchers in the aforementioned areas. This would offer a persuasive support on the clinical uses of *Chrysophyllum albidium* in modern medicine.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=1016&id=36&aid=9578