

## Acute Toxicity and Antifungal Effects of *Acacia ataxacantha* (Bark)

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### ABSTRACT

The present study aimed to evaluate the antifungal activities of *Acacia ataxacantha* against six strains of *Aspergillus* and the acute toxicity of hydroalcoholic extract in rat models. Five extracts including hexane, dichloromethane, ethyl acetate, methanol and mixture of water/ethanol of *A. ataxacantha*'s barks were evaluated against six *Aspergillus* strains using agar diffusion method and counting of number fungal spores. Oral acute toxicity at a dose of 2000 mg/kg was conducted as per Organization for Economic Co-operation and Development (OECD) 423 guidelines. Results obtained showed that all the extracts inhibited mycelial growth and sporulation of fungi with percentages of inhibition ranging from 5.37-53.02% and 33.77 to 99.70% respectively. The antifungal activity of the extracts at the same concentration is more marked on the sporulation of fungi. Ethyl acetate and dichloromethane extracts exhibited the most significant antifungal activity. In the acute toxicity evaluation, all animals were physically active and no deaths of rats were observed during the test. No significant change was observed in body weight, haematological and biochemical parameters of treated rats compared with controls. The histopathological analysis of liver and kidney showed normal architecture suggesting no morphological disturbances. The overall finding of this study suggests that *A. ataxacantha* inhibited the mycelial growth and sporulation of *Aspergillus* strains. Equally, hydroalcoholic extract of this plant is non-toxic up to 2000 mg/kg body weight. Thus, *A. ataxacantha* could be used as an antifungal.

**Keywords:** *Acacia ataxacantha* bark, *Aspergillus*, antifungal activity, acute toxicity.

### INTRODUCTION

*Acacia ataxacantha* is a spiny plant in the Fabaceae family. All parts of this plant have medicinal properties and have been used as folk medicine in many regions of Africa. Several pharmacological properties of *A. ataxacantha* have been reported in the literature. Used over a period of 3 to 5 days, *A. ataxacantha* allows treating headaches, pneumonia and bleeding<sup>1</sup>. Pods and seeds are used to treat dysentery<sup>2</sup>. The dough of the leaves is used in local application in dealing with abscesses while the decoction of leaves is used per os in hyperthermic convulsions<sup>3</sup>. The sap of the stem barks fight against chickenpox<sup>4</sup>. The whole plant is used in the treatment of excessive coughing and yellow fever<sup>5</sup>. Earlier studies on this plant reported it antidiabetic activity<sup>6</sup>. The antimicrobial and antioxidant activity of some species of the *Acacia* genus is well established<sup>7,8,9</sup>. Since, there is no scientific report on the antifungal activity of *Acacia ataxacantha*. Over recent years, the incidence of infectious diseases caused by fungi has increased considerably worldwide. Despite the expanded armamentarium of antifungal agents available, invasive fungal infections continue to produce significant morbidity and mortality<sup>10</sup>. This affection is a common health problem, especially in tropical developing countries and subtropical<sup>11</sup>. Although a large number of

antimicrobial agents have been discovered, pathogenic microorganisms are constantly developing resistance to these agents<sup>12</sup>. Also, many of the available antifungal drugs have undesirable side effects or are very toxic or lead to the development of resistance<sup>13</sup>, thus they became less effective in therapeutic strategies. Several scientific studies have shown that plant biodiversity could open new avenues in the discovery of effective drugs. Drugs derived from natural sources play a significant role in the prevention and treatment of human diseases<sup>14</sup>. Before they can be used as herbal medicines, or medicines, safety should also be checked. A key stage in ensuring the safety of drugs is to conduct toxicity tests in appropriate animal models, and acute toxicity studies are just one of a battery of toxicity tests that are used<sup>15</sup>.

As part of our ongoing research program on the value Benin medicinal plants, this study was designed to evaluate *Acacia ataxacantha*'s antifungal effects against *Aspergillus* species and oral acute toxicity on Wistar rats.

### MATERIALS AND METHODS

#### Plant material

The barks of *Acacia ataxacantha* were collected in September 2012 from Ouidah, Department of Atlantic, South Bénin. Botanical determination was performed by

taxonomists from the Herbar National of Abomey-Calavi University in Benin and a specimen was deposited at the same Herbarium (AA 6509/ HNB). The collected material was dried for two weeks in laboratory (20±2°C) and ground to a fine powder using an electric grinder (Excella mixer grinder).

#### Preparation of the extracts

Two hundred and fifty grams (250 g) of dry powder of the plant were successively extracted by maceration with hexane, dichloromethane, ethyl acetate and methanol for 72 h stirring. A second extraction of fifty grams (50 g) of dry powder was carried out with a mixture of ethanol-water (80:20). Each extraction is repeated three times. The macerates were filtered and concentrated using a rotary evaporator (BUCHI Rotavapor RII, Switzerland) and the extracts were stored at 4° C until biological assay.

#### Media preparation

Thirty nine grams (39 g) of potato dextrose agar (PDA) were dissolved in one liter (1 L) of distilled water with continuous stirring until complete dissolution and then autoclaved for 15 minutes at 121 ° C.

#### Antifungal assay

##### Test organisms

Fungi species used in determining the antifungal activities of *A. ataxacantha* were *Aspergillus flavus* CMBB75, *A. parasiticus* CMBB20, *A. ochraceus* CMBB91, *A. nidulans* CMBB90, *A. clavatus* NCPT24 and *A. fumigatus* CMBB89 obtained from the laboratory of biochemistry and molecular biology at the University of Abomey. These microorganisms are the most common fungal pathogens of vegetables, animals and humans. They play an important role in opportunistic infections in immunocompromised patients<sup>16</sup>.

##### Antifungal test

The in vitro antifungal activity of extracts was evaluated on mycelia development and sporulation of fungi as described previously with minor modifications<sup>17</sup>. The Potato Dextrose Agar (PDA) plates were prepared by pouring 10 ml of the mixture of PDA-extract at 1 mg/ml into sterile petri plates. The plates were allowed to solidify for 15 min and 100 spores prepared in tween (5%) were dropping in the center of petri dishes which were then incubated at 25°C. After 5 days, the diameter of mycelia was measured and the number of spores was counted microscopically using malassez cell. Each test was performed in triplicate. Three petri dishes containing PDA without extract were used as negative control and Fluconazol (100 µg/ml) was used as positive control. The inhibitory percentage (PI) of extracts was determined according to the formula below:

$$IP (\%) = \frac{A_v \text{ control} - A_v \text{ tested dishes}}{A_v \text{ control}} \times 100$$

In which  $A_v \text{ control}$  and  $A_v \text{ tested extract}$  represent the average diameter of the mycelia or estimated number of spores of control and the tested dishes.

#### Oral Acute Toxicity

##### Experimental Animals

The selected female rats were nulliparous and non-pregnant with body weight ranged from 180-200 g. The rats were fed with standard laboratory diets, given water

*ad libitum* and maintained under laboratory conditions of temperature 22°C (± 3°C), a relative humidity between 30-70% and a constant light-dark schedule (12 h light/dark cycle).

#### Oral Acute Toxicity Testing

The oral acute toxicity of the crude hydroethanolic extract of *A. ataxacantha* was evaluated on rats using the procedures described by Organization for Economic Co-operation and Development 423 guidelines<sup>18</sup>. A total of six female animals were divided into two groups with three animals each and kept in different cages for easy observation during experiment. Distilled water (10 ml/kg body weight) was given to control group (group I). The animals of group II were given with a single dose of 2000 mg/kg body weight of hydroalcoholic extract of *A. ataxacantha* dissolved in distilled water. Gavage dosing was performed using a curved, ball-tipped intubation needle affixed to a 5 ml syringe. The dose was determined based on the previous studies in which whole plant extract was used to study the anti-diabetic effect<sup>6</sup>. Following administration of extract, rats were closely monitored for 30 min and 2, 4, 8 and 24 h. Mortality, food and water consumption and general acute toxicity or clinical symptoms were recorded. Body weight was recorded on day 0, 7 and 14.

#### Haematological and biochemical parameters

At the end of the experiment, all the rats were anaesthetized using thiopental at 0.5 ml/Kg body weight. Animals were then sacrificed and the blood for biochemical and hematological analysis were collected through cardiac puncture into ethylenediaminetetraacetic acid (EDTA) tubes. Each blood sample was analyzed for haematological parameters like hematocrit (Ht), red blood cells (Rbc), hemoglobin concentration (Hc), mean corpuscular hemoglobin concentration (MCHC), mean corpuscular volume (MCV), mean corpuscular hemoglobin levels (MCH), white blood cells (Wbc), basophils (B), lymphocytes (L), monocytes (M) using an automatic hematological analyzer (Sysmex, XP-300, Japan). Biochemical parameters such as Glucose (GLU), Creatinine (CREA), cholesterol (CHOL), alanine aminotransferase (ALT), aspartate transaminase (AST) were determined using an autoanalyzer (Erba Chem 7, Germany).

The liver and kidneys of animals (group I and II) were also collected, weighed immediately and transferred to a saline solution. These organs were fixed in 10% buffered formalin for histological examination. The samples were then treated with increasing concentrations of ethanol and infiltrated with paraffin. Then, the thin cuts were made and stained with hematoxylin and eosin stains.

#### Statistical analysis

Data were presented as mean ± SD. The graphical representation of the data was performed using the Graph Pad Prism 5.0 software (Microsoft, USA). The difference was considered statistically significant when the  $p < 0.05$ .

## RESULTS

### Antifungal assay

Table 1: Inhibitory effect of *A. ataxacantha*'s extracts against the sporulation of fungi.  
Inhibition percentage of sporulation (%)

Strains Extracts	<i>A. flavus</i>	<i>A. parasiticus</i>	<i>A. clavatus</i>	<i>A. ochraceus</i>	<i>A. nidulans</i>	<i>A. fumigatus</i>
Hexane	85.91±0.20	93.41±0.11	98.95±0.17	33.77±0.21	81.43±0.11	78.26±0.17
CH <sub>2</sub> Cl <sub>2</sub>	88.47±0.05	99.12±0.34	99.67±0.10	91.65±0.34	92.85±0.05	80.43±0.10
AcOEt	94.49±0.17	93.14±0.05	99.70±0.10	73.51±0.15	86.96±0.05	73.18±0.11
MeOH	85.20±0.11	99.49±0.20	99.42±0.20	62.25±0.20	86.60±0.10	68.11±0.05
Et/eau	40.82±0.15	99.36±0.15	99.07±0.11	60.26±0.26	81.07±0.05	82.24±0.11
Fluconazol	98.99±0.47	99.94±0.10	99.83±0.10	98.16±0.30	99.82±0.10	99.16±0.96

CH<sub>2</sub>Cl<sub>2</sub>: dichlorométhane ; AcOEt : ethyle acetate ; MeOH : methanol ; Et/eau : ethanol/water

Table 2. Inhibitory effect of *A. ataxacantha*'s extracts against mycelia growth of fungi.  
Inhibition percentage of mycelia development (%)

Fungi Extracts	<i>A. flavus</i>	<i>A. parasiticus</i>	<i>A. clavatus</i>	<i>A. ochraceus</i>	<i>A. nidulans</i>	<i>A. fumigatus</i>
Hexane	17.48±0.11	45.94±0.10	33.93±0.05	29.56±0.10	41.61±0.10	15.43±0.26
CH <sub>2</sub> Cl <sub>2</sub>	28.67±0.17	43.24±0.17	40.18±0.11	44.35±0.05	53.02±0.05	45.63±0.10
AcOEt	25.87±0.11	43.24±0.00	39.28±0.05	39.13±0.05	51.00±0.05	26.17±0.05
MeOH	9.79±0.10	42.34±0.11	29.46±0.05	30.43±0.05	47.65±0.01	17.45±0.10
Et/eau	14.68±0.05	38.74±0.05	30.35±0.10	27.83±0.11	32.21±0.15	5.37±0.10
Fluconazol	50.34±0.05	70.27±0.10	39.28±0.05	50.43±0.10	64.42±0.05	55.03±0.15

CH<sub>2</sub>Cl<sub>2</sub>: dichlorométhane ; AcOEt : ethyle acetate ; MeOH : methanol ; Et/eau : ethanol/water

Five extracts from *A. ataxacantha* were tested for their antifungal activity on sporulation and mycelial growth of six fungal strains of the genus *Aspergillus*. The results obtained showed that dichloromethane and ethyl acetate extracts inhibited the sporulation and mycelial growth of large number of fungal species than the other extracts. The effect of the extracts at the same concentration is more marked on the inhibition of sporulation than the mycelial growth.

The inhibitory percentage (IP) of extracts on sporulation ranging from 33.77 to 99.70 % (Table 1). The ethyl acetate extract exhibited the strongest activity against *A. clavatus* with an IP value of 99.70%, while the lowest inhibition was obtained with the hexane extract (IP = 33.77%) against *A. ochraceus*. The dichloromethane and ethyl acetate extracts showed interesting inhibitory effect against all fungal strains tested with an IP value greater than 70%. The inhibitory effect of the extracts on sporulation was more pronounced against *A. parasiticus* and *A. clavatus* (93.14% ≤ IP ≤ 99.70%).

The IP values of extracts on mycelial growth ranging from 5.37 to 47.65% (Table 2). The extracts showed high to moderate activity against four fungi including *A. parasiticus*, *A. clavatus*, *A. ochraceus* and *A. nidulans* compared to the control (fluconazole). The dichloromethane and ethyl acetate extracts showed the highest activity against *A. nidulans* with the respective IP values of 53.02% and 51% in comparison to the reference molecule (64.42%). Other extracts are less active (5.37 to 47.65%).

#### Oral Acute Toxicity

Drugs from medicinal plants have become nowadays popular in primary health care, especially in developing countries. Some of these products may have wrongly

been considered safe just because they are a natural source. Given the considerable importance that takes the use of plants for therapeutic purposes, it is necessary to check the safety of these plants to avoid poisoning. Thus, the oral acute toxicity of hydroalcoholic extract of *Acacia ataxacantha*'s bark which has antifungal activity has been evaluated.

The oral acute toxicity evaluation showed that animals have tolerated the hydroalcoholic extract of *A. Ataxacantha* bark at 2000 mg/kg body weight. Throughout the 14 days of study period, the eating, drinking habit and behaviour of all the animals used were normal. No mortality and no visible symptoms of acute toxicity were observed. These results indicated that the LD<sub>50</sub> value of hydroalcoholic extract is greater than 2000 mg/kg body weight. The body weight of treated rats gradually increased but was not significantly different compared to control rats (Fig 1).

During the 14 days of observation, there were no significant changes in the relative weight of the kidneys and liver of treated rats compared to control rats (Fig 2). The histological examination of the kidneys and liver was performed in both control and treated animals. Organ weight revealed that administration of extract at dose of 2000 mg/kg body weight did not produce any organ swelling, atrophy and hypertrophy. All the sample tissue sections were within the normal limits and degenerative or infiltrative lesions were not observed in the animals treated with hydroalcoholic extract.

The results obtained revealed that there were no significant changes in the histology of the kidneys and liver of the rats treated with hydroalcoholic extract of *A. ataxacantha* as compared to the control rats (Fig 3). The haematological analysis (Table 3) shows no significant

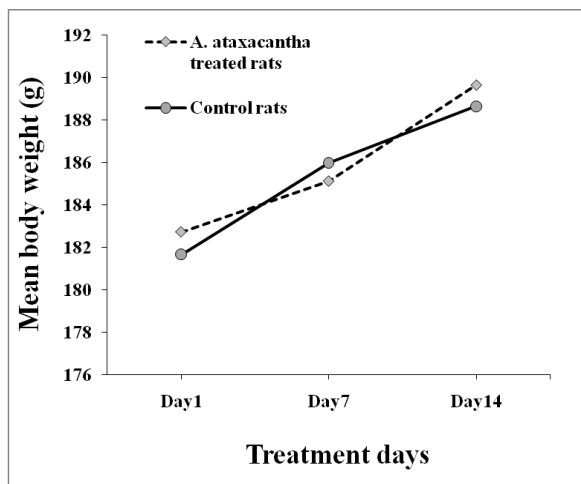


Figure 1 : Effect of hydroalcoholic extract (2000 mg/kg) on Mean body weight of rats for 14 days

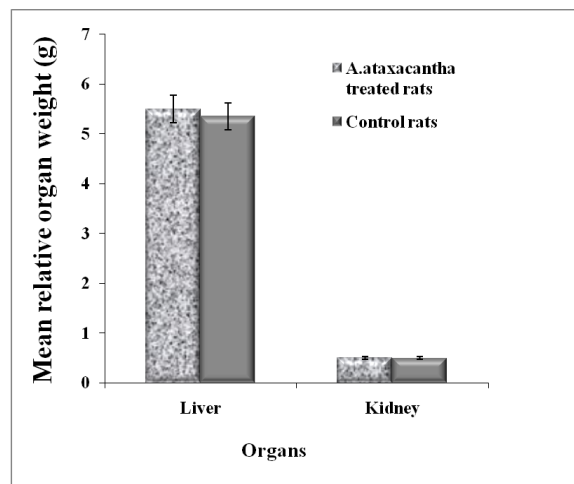


Figure 2: Effect of hydroalcoholic extract of *A. ataxacantha* (2000 g/kg) on Mean relative weight of organs in rats for 14 days

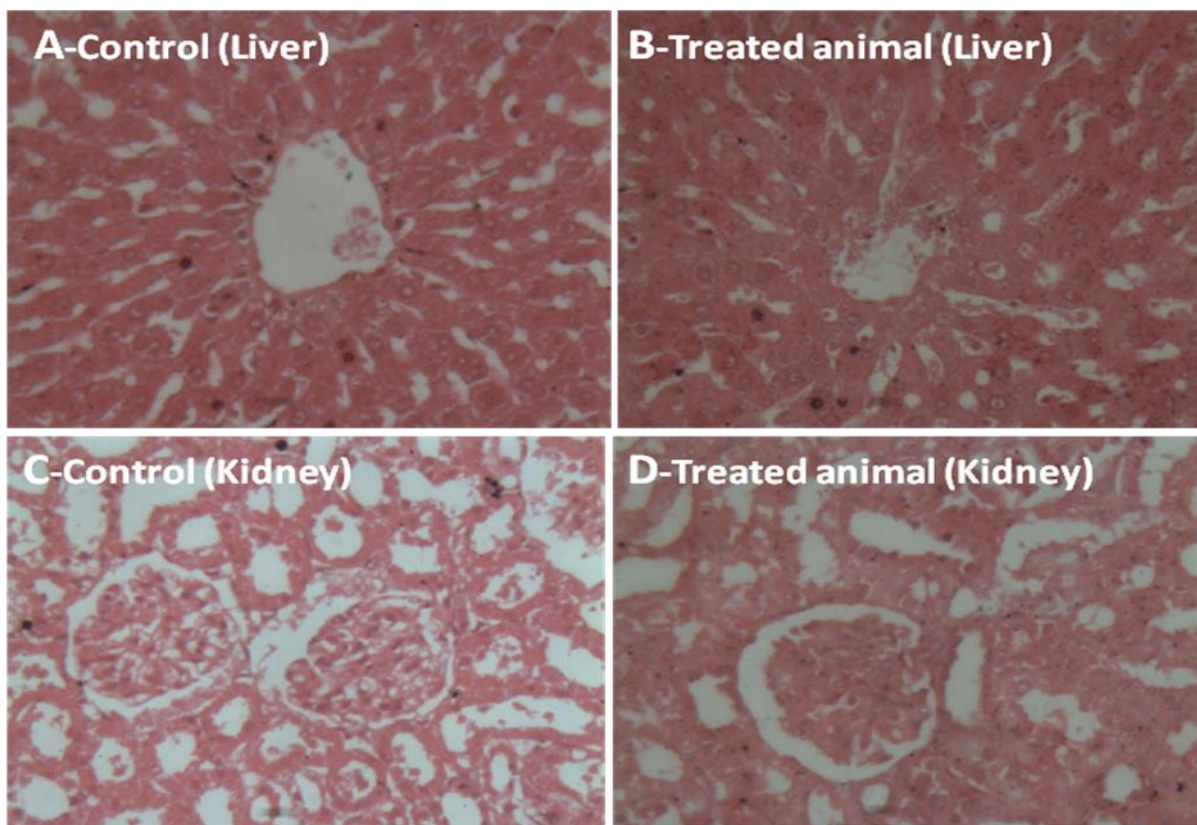


Figure 3: Histopathological observation of liver and kidney tissues. A: Liver of control animal; B: liver of treated animal; C: kidney of control animal; D: kidney of treated animal

change of blood parameters analyzed such as total red blood cell, hematocrit, hemoglobin, total white blood cell, lymphocytes and platelets in treated animals compared to the control. The biochemical analysis (Table 4) of creatinine, glucose, total cholesterol, aspartate aminotransferase (AST) and alanine aminotransferase (ALT) shows no significant difference in any of the biochemical parameters examined in either of the control or treated animals.

#### DISCUSSION

Several studies have shown that despite the expanding number of antifungal agents, death rate caused by *Aspergillus* species has been increased during the recent decades due to drug-resistance occurrence, increased MIC and cross-resistance among the isolated species<sup>19</sup>. Regarding the lack of effective response to conventional therapy and antifungal susceptibility patterns of the most common *Aspergillus* species, this study was undertaken

Table 3: Effect of hydroalcoholic extract of *A. ataxacantha* on haematological parameters

Haematological parameters		
Parameters	Experimental	Control
Hc (g/dl)	13.37±0.92	14.13±0.74
Ht (%)	39±3.61	43±4
MCV (fl.)	66.33±1.53	70.33±2.52
MCH (Pg)	23±1	23±2
MCHC (%)	34.33±1.15	33.33±3.06
Rbc (T/L)	5.9±0.54	6.42±0.60
Wbc (g/L)	3.94±2.06	2.47±0.47
B(%)	0.29±0.37	0.33±0.58
L(%)	79±1	74.33±0.58
M(%)	9.67±0.58	6.33±2.08
Platelets (g/L)	870.33±137	763±28,58

Hematological values of experimental and control rats in the treatment. Ht: hematocrit; Rbc: red blood cells; Hc: hemoglobin concentration; MCHC: mean corpuscular hemoglobin concentration; MCV: mean corpuscular volume; MCH: mean corpuscular hemoglobin levels; Wbc: white blood cells; B: basophils; L: lymphocytes; M: monocytes. Values are mean ± SEM (n=3 per group), differences were considered significant when p-values were less than 0.05 (p<0.05).

Table 4: Effects of hydroalcoholic extract of *A. ataxacantha* on biochemical parameters in Wistar rats.

Biochemical parameters		
Parameters	Experimental	Control
GLU	1.28±0.22	1.34±0.08
CREA	8.01±0.49	7.73±0.53
CHOL	0.72±0.20	0.68±0.09
AST	233.3±70.68	255.67±10.26
ALT	86.3±17.03	111.33±44.29

GLU, Glucose; CREA, Creatinine; CHOL, cholesterol, ALT, alanine aminotransferase; AST, aspartate transaminase. Values are mean ± SEM (n=3 per group), differences were considered significant when p-values were less than 0.05 (p<0.05).

to study *A. ataxacantha* used in traditional medicine as an antimicrobial and could be a potential source of novel antifungal compounds. The antifungal properties of medicinal plants are being increasingly reported from different parts of the world<sup>20,21,22</sup>. The World Health Organization estimates that plant extract or their active constituents are used as folk medicine in traditional therapies of 80% of the world's population<sup>14</sup>. In the present work, the extracts obtained from *A. ataxacantha* showed strong activity against most of the tested fungal strains. The results were compared with standard antifungal drug. During the present work, antifungal activity was determined by agar diffusion method. The effectiveness of the plant extracts varies according to the fungus species. *A. parasiticus* and *A. clavatus* are more sensitive to all extracts while *A. ochraceus* is less sensitive when compared to the standard drug. The basis of the varying degree of sensitivity of tested fungi may be due to the intrinsic tolerance of microorganisms to the extracts. In fact, the results obtained show that the dichloromethane and ethyl acetate extracts showed maximal effect on the sporulation of all tested fungi. Other extracts showed moderate to high activity against fungi sporulation compared to the standard drug. The difference observed between the effectiveness of plant

extracts might be explained by a variation in the concentration of the active substances, depending on the solvent extracting type. Similar results were obtained by Thevasundari and Rajendran, who showed that the ethyl acetate extract of *Heterostemma tanjorensis* is more effective by inhibiting the germination of *Aspergillus Niger*, *Aspergillus flavus* and *Aspergillus terreus*, compared to the ethanol chloroform and aqueous extracts<sup>23</sup>. Duraipandiyan and Ignacimuthu indicated that, from 45 species studied, the ethyl acetate extracts showed antifungal activity more pronounced than other extracts<sup>24</sup>. Similarly, Saheb et al. assayed various extracts like aqueous, alcoholic and ethyl acetate extracts of leaves of five *Terminalia* species against five pathogenic fungi like *A. flavus*, *A. niger*, *Alternaria brassicicola*, *A. alternate* and *Helminthosporium tetramera* and found that the ethyl acetate extract showed better inhibitory effect against all the tested fungi<sup>25</sup>. Senguttuvan et al. found that ethyl acetate extracts of leaf and root parts of *Hypochoeris radicata* showed higher antifungal activity than the other solvent extracts such as petroleum ether, chloroform, methanol and water<sup>21</sup>. In our study, ethyl acetate and dichloromethane extracts have shown a strong inhibitory effect on mycelial growth and sporulation of *A. nidulans*. In fact, *A. nidulans* is a filamentous fungus, an excellent model system for the study of mitotic crossing over and whose cells pass the great part of their cell cycle in G2 phase. Since in this phase, chromosomes are in duplicate, they significantly favor mitotic recombination<sup>26</sup>. Two molecular mechanisms may explain the *A. nidulans*-toxicity induced by these extracts: (a) the active substance (s) of these extracts induces mitotic spindle disorganizations, stimulating the occurrence of nondisjunction events, or (b) the antifungal compounds containing in these extracts induces chromosome breaks, resulting in mitotic crossing-over or chromosome break-deletions<sup>27</sup>. Moreover, the secondary metabolites also play an important role in the inhibition of microbial growth. Previous phytochemical screening of *A. ataxacantha* revealed the presence of alkaloid, tannins,

lignan, triterpenoids, anthracene derivatives, flavonoids, saponins and coumarins at different level. The antifungal activity of ethyl acetate extract could be due to flavonoids such as flavones, flavonoids, and flavonols. Their activity is probably due to their ability to complex with extracellular and soluble proteins and to complex with bacterial cell walls. More lipophilic flavonoids may also disrupt microbial membranes<sup>28</sup>. In the same way, the higher activity of the dichloromethane extract could be due to the presence of triterpenoids. Potential fungicide of triterpenoids has been reported<sup>29</sup>.

Although extracts have proven pharmacological properties, experimental screening method is important in order to ascertain the safety and efficacy of traditional and herbal products. The oral acute toxicity study of hydroalcoholic extract at 2000 mg/kg body weight resulted in no mortality and no signs of acute toxicity throughout the 14 days study period in animals. This suggests that the LD<sub>50</sub> is greater than 2000 mg/kg body weight. No changes attributable to treatment were found in body weight and in the relative weight of organs. Generally the reduction in body weight gain and internal organ weights is a simple and sensitive index of toxicity after exposure to toxic substances<sup>30,31</sup>. The increase in body weight was not significantly different from that of the control. The progressive increase in body weight during 14 days of administration of hydroalcoholic extract may indicate the improvement in the nutritional state of the animal. The increase in body weight could be the result of the increase in the intake of food and water. Furthermore, gross examination of internal organs (kidneys and liver), from treated and control animals showed normal architecture, suggesting no detrimental changes and morphological disturbances after 14 days.

The hematopoietic system is very sensitive to toxic compounds and serves as an important index of the physiological and pathological status for both animals and humans<sup>32</sup>. Blood parameter analysis is relevant to risk evaluation as the haematological system has a higher predictive value for toxicity in humans<sup>33</sup>. In our study, the hematological status after 14 days of oral administration of hydroalcoholic extract of *A. ataxacantha* was also assessed. There were no significant changes in hematological parameters. However, a slight increased ( $P > 0.05$ ) of WBC in treated animals was observed. Reports about WBC counts have pointed out that whereas increased count of WBC is supposed to be helpful in boosting immune system<sup>34,35</sup>. Our result could suggest that hydroalcoholic extract of *A. ataxacantha* bark might have a good potentiality to boost immune system. All other hematological parameters in treated animals remained normal with no significant difference. Similarly, no significant changes in creatinin were observed in treated groups compared to the control. Creatinin is known as an effective indicator of kidney function and any significant increase in creatinin levels induces functional nephron damage<sup>36</sup>. Thus, the results obtained in this study suggest that hydroalcoholic extract does not affect renal function. Obviously, this study only serves as a preliminary test, and that for a better estimate

of the renal function, test of creatinin clearance is required. The liver is the site of removal of cholesterol or of the degradation and the major site of synthesis. Since then, no significant changes were observed in the levels of cholesterol in this study. This suggested that hydroalcoholic extract of *A. ataxacantha* had no effect on cholesterol metabolism in rats.

## CONCLUSION

This report is the first of its kinds showing the antifungal activity of *Acacia ataxacantha* bark and assessing of its acute toxicity. The present study demonstrates that *A. ataxacantha* bark extracts possess antifungal activities against tested microorganisms. We also note the lack of toxicity of its hydroalcoholic extract. No mortality was found 14 days after the administration of a single oral dose of the extract. This indicates that the extract has a high LD<sub>50</sub> value and suggests a wide margin of safety for therapeutic doses. There were no toxic effects observed with regard to the behavior, body weight, hematological and biochemical parameters of the rats. Owing to its broad spectrum of antifungal effect, in vitro, and its lack of toxicity, *A. ataxacantha* is a promising source in the search for new antifungal drugs. However, it is necessary to evaluate the chronic toxicological effects in order to be considered for a safe and effective antifungal agent.

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