# *Original Research Article*

**Antityphoid and antioxidant activities of leaf extracts of *Dracaena deisteliana* Eng. (Dracaenaceae)**


## ABSTRACT

Salmonellosis is a major public health problem in developing countries where it is endemic. The genus *Salmonella* express the oxyR gene that codes for several proteins that allow them to resist free radicals. To investigate the antioxidant activity in vitro (aqueous and hydroethanolic extracts *in vivo* (of the 55% hydroethanolic extract)) of *Dracaena deisteliana* leaves in albino's rats of Wistar strain previously infected with the *Salmonella* Typhi ATCC 6539 strain. The *in vitro* antioxidant activity of these extracts was determined by studying their anti-radical power with DPPH●, then their iron-reducing power and determining their flavonoids and total phenols content. The *in vivo* antioxidant activity was determined in plasma and tissues of albino's rats of wistar strain aged between 8 and 10 weeks previously infected with *Salmonella typhi* ATCC 6539. These infected rats concurrently received daily doses of *Dracaena deisteliana* extract (10, 20 and 51.84 mg/kg) and ciprofloxacin (14 mg/kg) as positive control, for 15 days. At the end of the treatment period, the animals were sacrificed and blood, liver, kidney, heart, lung, spleen testis and ovaris were collected for evaluation of antioxidants parameters, which included malondialdehyde, nitric oxide, catalase and peroxidase, as well as biological responses. Regarding the *in vitro* antioxidant tests, the 55% hydroethanolic extract had the best $IC_{50}$ (11.99 µg/ml). The iron reducing power of this extract was higher than the other extracts at 200 µg/ml. The highest levels of flavonoids and total phenols were obtained respectively with this extract. This extract (10, 20 and 51.84 mg/kg) cured the infected rats between the 8th and 12th day of treatment. The extract also significantly reduced blood malondialdehyde and nitric oxide levels, and significantly increased the activity of catalase and peroxidase in the infected rats. The results suggest that leaves extract of *Dracaena deisteliana* contains antisalmonella and antioxidant substances, which could be used for the treatment of typhoid fever and reduces the state of oxidative stress caused by *Salmonella*. Typhi during rat's infection.



**Keywords:** Antioxidant, *Dracaena deisteliana*, infection, *Salmonella.*


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## INTRODUCTION

Typhoid fever is an acute generalized infection of the mononuclear phagocyte system, intestinal lymphoid tissue, and gallbladder caused by *Salmonella enterica* serovar Typhi (*S.* Typhi) and associated with poor sanitation and untreated water supplies. During microbial infections, macrophages produce free radicals in order to destroy microorganisms within phagosomes. However, some enterobacteriaceae such as those of the genus *Salmonella* express the oxyR gene which codes for several proteins allowing it to resist these free radicals [1, 2]. This resistance of *Salmonella* is often the cause of an overproduction of free radicals that can lead to oxidative stress in *Salmonella* infected patients [3,4]. In addition, during a *Salmonella* infection, or following the exposure of the body to exogenous toxins, the production of free radicals such as superoxide anion and nitric oxide ($O^{2-}$, $NO^{\cdot}$), athough controlled by antioxidant defense systems under normal physiological conditions, what can increase and generate oxidative stres [5]. This state of oxidative stress is the direct cause of various pathological conditions such as aging and cancer: it is the indirect cause of lipid peroxidation in food. In all cases, the risk is increased with the accumulation of these molecules in the body resulting in a radical chain reaction that degrades vital biological molecules, namely DNA, lipids, proteins and carbohydrates [6, 7, 8]. Frequent exposure to high concentrations of free radicals can lead to direct damage to biological molecules (protein oxidation and nitration, lipid peroxidation, DNA oxidation), but also secondary lesions due to the cytotoxic and mutagenic nature of the metabolites released during lipid oxidation [9,10]. Thus, treatment sources to combat both *Salmonella* infection and oxidative stress would improve the management of patients suffering from these infections [11, 12, 13, 14, 15]. Since ancient times, medicinal plants have always been part of the basic knowledge of all human societies [16]. In this era of rapid advances in medical technology, herbal preparations used in "alternative or complementary medicine" are gaining a lot of popularity [17], and increased interest in their use has encouraged more detailed studies of plant resources [18]. Previous studies have found that *Dracaena deisteliana* leaves commonly used in combination with *Senecio biafrae* leaves and stems help fight stomach upset and infertility in women [19]. The roots of this plant are used to treat toothache problems [20]. No studies on *in vitro* and *in vivo* antioxidant activities have yet been evaluated, hence the importance of this work.

This work aimed at providing information on the *in vivo* antisalmonellal activity and the antioxydant potential of leaf extract of *Dracaena deisteliana* in the treatment of infection caused by *Salmonella* Typhi in *Wistar* albino’s rats.

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# I. MATERIALS AND METHODS

## I.1. MATERIALS

### I.1.1. Plant material

The fresh leaves sample of *Dracaena deisteliana* was harvested in January 2020 at Campus of Dschang University (Department of Menoua, Western Region of Cameroon). The identification of this plant was made at the National Herbarium of Cameroon (Yaoundé) compared to the sample registered under the number 53011HNC.

### I.1.2. Bacteria strain

Stock cultures of S. Typhi (ATCC 6539) used in this study were obtained from Centre Pasteur of Cameroon. Their pure cultures were maintained in Muller-Hinton agar and stored at 4°C.

### I.1.3. Experimental animals

Young, healthy Wistar rats aged 8 to 10 weeks of each sex were bred at the University of Dschang animal house. Animal housing and *in vivo* experiments were carried out following the guidelines of the European Union on Animal Care (CEE Council 86/609)15 that were adopted by the Institutional Committee of the Ministry of Scientific Research and Innovation of Cameroon. They were housed under a natural temperature and 12 hours dark/light cycle. The animals were fed with standard diet and received water *ad libitum*.

### I.1.4. Preparation of extracts

The fresh leaves of *Dracaena deisteliana* was air dried for three weeks at room temperature (24 to 27°C) until constant weight and then mashed. The obtained powder was used for the preparation of hydroethanolic extracts (95%, 85%, 75%, 65%, 55% and 45%) and aqueous extracts (infusion, decoction, maceration). Aqueous extracts were prepared according to the methods described by [15]. Whith some modifications, while hydroethanolic extract were obtained by macerating 50 g of powder in 500 ml in hydroethanolic at different concentrations (95%, 85%, 75%, 65%, 55% and 45%). After 48 hours, these macerates were filtered using Whatman N°1 paper. Each hydroethanolic extract was evaporated at 40°C using rotary evaporator (BUCHI R-200). The filtrates were dried at 45ºC in a ventilated oven (Memmert) for seven days in order to completely evaporate the rest of solvent.

## I.2. METHODS



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### I.2.1. Typhoid fever induction and treatment

Antityphic activity was determined according to the protocol described by [14], with some modifications was used. Forty-eight male and female Albino Wistar rats aged 08 to 10 weeks were divided into 12 groups of 4 animals of each sex, including 6 male groups and 6 female groups. The selected animals were acclimatized for a week. With the exception of animals in group 1 of each sex (uninfected and untreated), all animals in the other groups (2-6) were infected. They received a single dose (1 mL) of a suspension of $1.5\times10^8$ CFU of *S. typhi* (ATCC 6539) orally. Infection monitoring in animals was performed by blood culture with colony counting on Salmonella-Shigella agar and converted to *Salmonella* CFU per milliliter of blood. The success of the infection was demonstrated when the concentration of bacteria in the blood was greater than $4\times10^5$ CFU/ml of blood, then by the excretion of watery stools, the presence of mucus in the stool, the reduction of activity and the exponential increase in the systemic load of *S. typhi* in rats [24]. Each animal in each group was housed in its own cage and these animals were treated as follows: group 1 (neutral control group) received distilled water; group 2 (typhoid control group, infected and untreated) received distilled water; group 3 (positive control group) received ciprofloxacin (14 mg/kg); groups 4, 5 and 6 (test groups) received a hydroethanolic extract 55% of *Dracaena deisteliana* (10, 20 and 51.84 mg/Kg respectively). Dose 51.84 mg/kg body weight was obtained from the daily dose of the traditional practitioner, the dose of 10 mg/kg body weight was obtained from the MIC of the extract and 20 mg/kg body weight is double the dose obtained from the MIC. Then, every 2 days during the experimental period, blood was taken from the caudal vein located on the tail of the rats and introduced into heparinated tubes. Then diluted to 1/10th with physiological water, 50 µl of the mixture was taken and introduced into the sterile petri dishes previously filled with Salmonella-Shigella agar for the enumeration of the bacterial load. The decrease in the bacterial load in the blood indicated the effectiveness of the treatment. The test was completed when no more than two colonies of *Salmonella* were found in the animals' blood after the blood culture. Food consumption as well as body weight of animals were recorded daily as described by [12].

The day before the end of treatment, the animals were subjected to a 12 hour fast at the end of which the urine was collected in the previously washed cages and lined with wire mesh. Subsequently, the animals were anesthetized by intraperitoneal injection of Diazepam and Ketamine (0.2+0.1) mL; then placed in supine position on a board, and all four limbs were immobilized to allow easy access to the abdomen. A dissection was performed on the

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abdomen and the blood was collected by cardiac puncture and then first introduced into two tubes (for each animal) each containing an anticoagulant (EDTA); one for the determination of hematological parameters and the other for the preparation of plasma. This plasma was obtained by centrifugation at 3000 rpm for 15 minutes after letting stand for 4 hours of time. Organs such as the heart, kidneys, liver, lung and spleen were removed and the homogenates of the heart, kidneys, liver, lungs and spleen were prepared in a physiological water solution, at the rate of 15 g of tissue per 100 ml of buffer, then centrifuged at 3000 rpm for 15 min. The resulting crush was also centrifuged for 15 minutes at 3000 rpm and the supernatant was recovered for the different dosages. The plasmas and homogenates thus obtained were kept at -18°C for the determination of antioxidant parameters.

### I.2.2. *In vitro* antioxidant activities of aqueous and hydroethanolique extracts of *Dracaena deisteliana* leaves

#### I.2.2.1. 2, 2-Diphenyl-picryl-hydrazyl (DPPH) radical scavenging assay

The free radical scavenging activities of *Dracaena deisteliana* leaves extracts were evaluated using the DPPH assay method as described by [21] and [22]. Briefly, the extract (2000 µg/ml) was twofold serially diluted with methanol, hence 100 µl of diluted extract were mixed with 900 µl of 0.3 mM 2,2-diphenyl-1- picrylhydrazyl (DPPH) methanol solution to give a final extract concentration of 12.5, 25, 50, 100 and 200 µg/ml. After 30 min of incubation in the dark at room temperature, the optical densities were measured at 517 nm. Ascorbic acid (Vitamin C) was used as control. Each assay was done in triplicate and the results, recorded as mean ± standard deviation of three findings, were illustrated in a tabular form. The percentage of DPPH scavenging activity (%DPPH) was calculated according to the following equation:

**%DPPH = [(Absorbance of DPPH - Absorbance of sample)/Absorbance of DPPH] × 100.**

The $IC_{50}$ is automatically determined from the percentages of inhibitions obtained from the absorbances of DPPH● according to the different concentrations of extracts and vitamin C.

#### I.2.2.2. Ferric reducing antioxidant power (FRAP) assay

The ferric reduction potential (conversion potential of $Fe^{3+}$ to $Fe^{2+}$) of extracts was determined according to the method described by [23]. To do this, 1 ml of extract at different

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concentrations (200, 100, 50, 25 and 12.5 µg/ml) was mixed with 2.5 ml of a 0.2 M phosphate buffer solution (pH 6.6) and 2.5 ml of a solution of potassium ferricyanide $K_3Fe(CN)_6$ at 1%. The mixture was incubated in a water bath at 50°C for 20 min; then 2.5 ml of 10% trichloroacetic acid was added to stop the reaction, and tubes were centrifuged at 3000 rpm for 10 min. An aliquot (2.5 ml) of supernatant was combined with 2.5 ml of distilled water and 0.5 ml of 0.1% methanolic FeCl3 solution. The absorbance of the reaction medium was read at 700 nm against a similarly prepared control, replacing the extract with distilled water. The positive control was represented by a solution of a standard antioxidant, ascorbic acid whose absorbance was measured under the same conditions as the samples. Increased absorbance of the reaction mixture indicates higher reduction capacity of the tested extracts [24, 25].

#### I.2.2.3. Evaluation of total phenolic contents

The total phenol content was determined by the method described by Ramde- [26]. The Folin-Ciocateu method was used for the quantitative determination of total phenolic compounds. The reaction mixture consisted of 0.02 ml of extract (2000 µg/ml), 1.38 ml of distilled water, 0.02 ml of 2N Folin-ciocalteu reagent and 0.4 ml of a 20% sodium carbonate solution. The mixture was then incubated at 40°C for 20 min and the absorbance was measured at 760 nm. The blank was prepared with distilled water instead of the plant extracts. Each test was performed in triplicate and the results were expressed as milligrams of Equivalents Gallic Acid (mgEGA) per gram of extract using a standard calibration curve of gallic acid (0.2 g/l; 0-70 µl).

#### I.2.2.4. Evaluation of total flavonoids contents

The flavonoid content of the extracts was determined using the aluminum trichloride colorimetric method [27]. The determination of total flavonoids content was done using the colorimetric aluminum chloride method. In fact, 100 µl of extract (2 mg/ml) were mixed with 1.49 ml of distilled water and 30 µl of NaNO2 (5%). After 5 min incubation at room temperature, 30 µl of AlCl3 (10%) was added and the mixture was reincubated for 6 min; then 200 µl of sodium hydroxide (0.1 M) and 240 µl of distilled water were added. The solution was well mixed and the absorbance was read at 510 nm using a spectrophotometer. Each test was performed in triplicate and the results were expressed as milligrams of Equivalents Catechin (mgECat) per gram of extract using a standard calibration curve of Catechin (0.1 g/l; 0-70 µl).

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### I.2.3. *In vivo* antioxidant activity of the 55% hydroethanolic extract of the leaves of *Dracaena deisteliana*

The animals were infected with *Salmonella* Typhi and then treated; during treatment, the evolution of the bacterial load in the animals' blood was studied. For this study, which lasted 15 days, 48 albino rats (male and female) of Wistar strain aged 8 to 10 weeks were used. The animals were selected by sorting after culture of their blood on *Salmonella*-Shigella agar.

#### I.2.3.1. Determination of nitric oxide (NO)

Nitric oxide content in plasma and tissue homogenates was estimated from the accumulation of nitrite ($NO_2^-$) using Griess' reagent, as described by [28]. With some modifications. Absorption of the chromophore during ionization of nitrite with sulfanilamide coupled with naphthylethylenediamine (NED) was read at 520 nm. Three hundred and forty microliters of 1% sulfanilamide (prepared in 5% orthophosphoric acid) was introduced into 340 µL of plasma and homogenates. The resulting mixture was homogenized and left in the dark for 5 minutes at room temperature. Next, 340 µL of 0.1% NED was added to the reaction medium and the whole was left once more in the dark for 5 minutes. Optical densities were read against the control at the wavelength of 520 nm and the results were expressed in terms of micromoles of NO per gram of tissue or per milliliter of blood as a function of the standard equation of NO ($y = 0.0563x + 0.1077$).

#### I.2.3.2. Determination of malondialdehyde (MDA)

The lipid peroxidation index by the measurement of malondialdehyde (MDA) was measured in tissues using thiobarbituric acid (TBA) according to the method of [29], with certain modifications, malondialdehyde is one of the final products of the decomposition of polyunsaturated fatty acids (PUFAs) under the effect of free radicals released during stress. In a hot acidic medium (pH 2 to 3; 100°C), an MDA molecule condenses with two thiobarbituric molecules (TBA) to form a pink colored complex (reading at 532 nm). Five hundred microliters of 1% orthophosphoric acid and 500 µL of precipitation mixture (1% thiobarbituric acid in 1% acetic acid) were added to 100 µL of homogenate. The resulting reaction mixture was homogenized and incubated for 15 minutes in a boiling water bath. After cooling in an ice bath, the mixture was centrifuged at 3500 rpm for 10 min. The absorbance of the supernatants was read at 532 nm against the blank. Lipid peroxidation was calculated on

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the basis of the MDA molar extinction coefficient and expressed in micromoles of MDA per gram of tissue using the Beer-Lambert law.

#### I.2.3.3. Determination of catalase

The catalase activity was assessed in plasma and tissues by the method of [30], with some modifications. Twenty-five microliters of plasma homogenate or tissues were added to 375 µl of phosphate buffer pH 7.4. Then 100 µl of $H_20_2$ (50 mM) was introduced into the test tubes. One minute later, 1 ml of potassium dichromate (5%) prepared in 1% acetic acid was introduced into the reaction medium. The tubes were then incubated for 10 minutes in a boiling water bath and then cooled in an ice bath. The absorbance was recorded at 570 nm using the Schimadzu 1501 spectrophotometer, Japan. The enzymatic activity of catalase was deduced according to the Beer-Lambert law by [31], in mmol/min per milliliter of plasma or gram of tissue.

#### I.2.3.4. Determination of peroxidase

Peroxidase activity was determined using the method described by [32]. To do this, 0.5 ml of homogenate or plasma was added to 1 ml of a solution of potassium iodide (10 mM) and 1 ml of sodium acetate (40 mM) was added. The absorbance of the sample was read at 353 nm, which indicated the amount of peroxidase. Then 20 µl of $H_2O_2$ (15 mM) was added, and the change in absorbance in 5 min was recorded. The enzymatic activity of peroxidase was expressed in µmole/min per milliliter of blood or gram of tissue according to Beer-Lambert's law by [28].

### I.2.4. STATISTICAL ANALYSES

The results were expressed as mean ± Standard deviation. Statistical analysis of data was performed by one way analysis of variance (ANOVA), followed by Waller-Duncan test. P values < 0.05 were considered as significant. $IC_{50}$ were determined using Graph pad prism software (5.0).

## III. RESULTS

### III.1. *In vivo* antisalmonellal activity: Evolution of bacterial load

Although traditionally used as an aqueous decoction, the hydro-ethanolic extract 55% of the leaves of *Dracaena deisteliana* showed *in vitro* an activity (MIC of 128 µg/mL) on the strain of *Salmonella* Typhi ATCC 6539 much better than the decocted extract. Figures 1 and 2

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show respectively the evolution of the bacterial load in the blood of male and female rats after infection and during treatment. Overall, except for the uninfected and untreated animals (T0) where the load remained zero throughout the test and infected and untreated animals (T-) where the bacterial load was constantly growing throughout the test, the bacterial load of animals in the other groups had a bell structure with three main phases. The first phase between day 0 and day 2 corresponds to the adaptation of bacteria in the rat's body and materialized by a small increase in the number of bacterial colonies. Subsequently, between day 2 and 6, there is an exponential increase in the number of colonies of *Salmonella typhi* (ATCC 6539) in the blood of animals and corresponds to the invasion of the body by bacteria. Finally, between day 6 and day 16, there is a significant decrease in the number of colonies in animals treated with the extract and ciprofloxacin, corresponding to the phase of decline. Animals of both sexs treated with different doses of *Dracaena deisteliana* extract had their bacterial load cancel out on the 8th, 10th and 12th days of treatment at doses 51.84, 20 and 10 mg/kg respectively. Those who received ciprofloxacin (T+) were cured on the 7th day of treatment.

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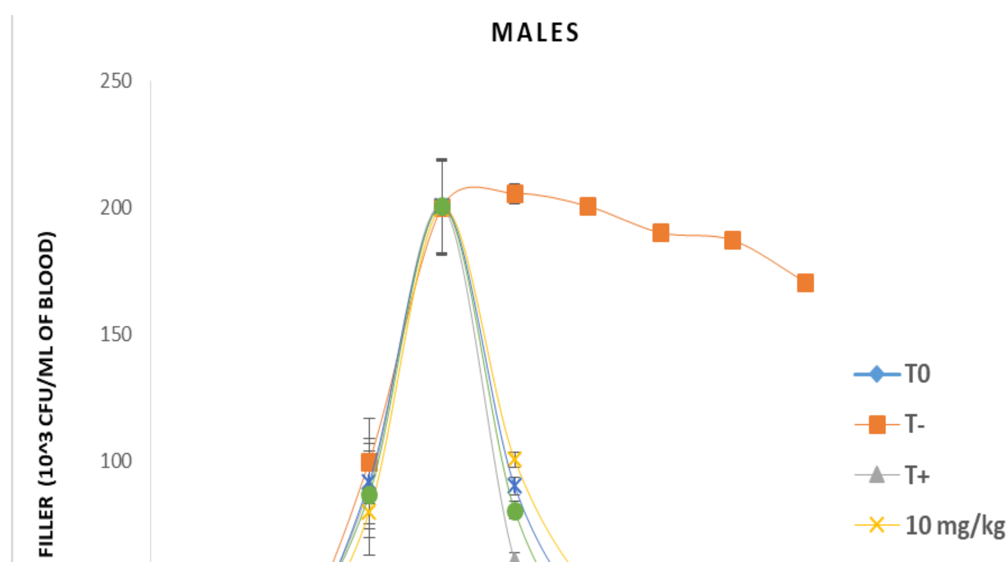

INFECTION

T0: neutral control; T-Negative control; T+: Positive control (Cipro 14 mg/kg)

**Figure 1:** Evolution of the bacterial load after infection and during treatment with different doses of hydroethanolic extract 55% of *Dracaena deisteliana* leaves in male rats in function of time.

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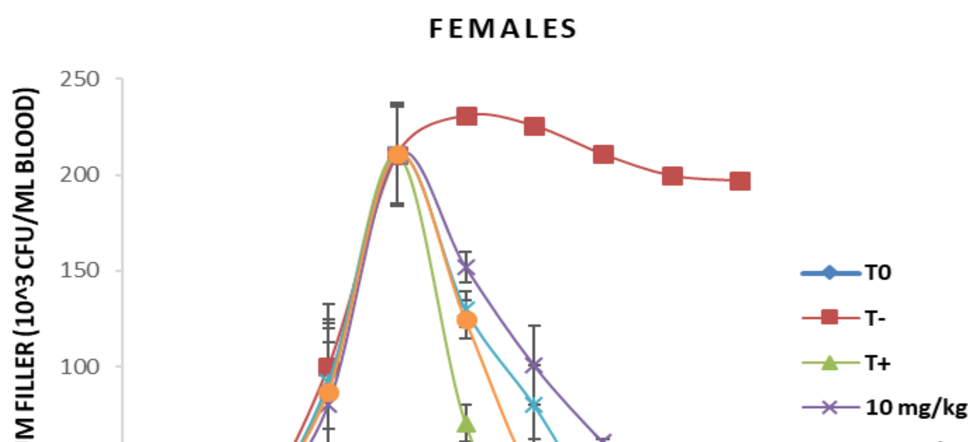

T0: neutral control; T-Negative control; T+: Positive control (Cipro 14 mg/kg)

**Figure 2:** Evolution of the bacterial load after infection and during treatment at different doses of hydroethanolic extract 55% of *Dracaena deisteliana* leaves in female rats as a function of time.

## III.2. *In vitro* antioxydant activity

### III.2.1. Effects of *Dracaena deisteliana* leaves extracts on DPPH● radical

The results of the DPPH antiradical activity of the different extracts are shown in figure 3. This figure shows that these extracts possess antiradical activities. In addition, these activities are concentration dependent for each extract tested. However, 65% hydroethanolic extract showed a higher activity than the other extracts in 200 µl/mg concentration. In addition, 55% hydroethanolic extract showed a higher activity than the other extracts in 100 µl/mg concentration and the infused extract showed lower antiradical activity than all extracts at 12.5 and 200 ug/ml concentrations. In general, the activity of L-ascorbic acid was significantly higher ($p < 0.05$) than all extracts at all concentrations.

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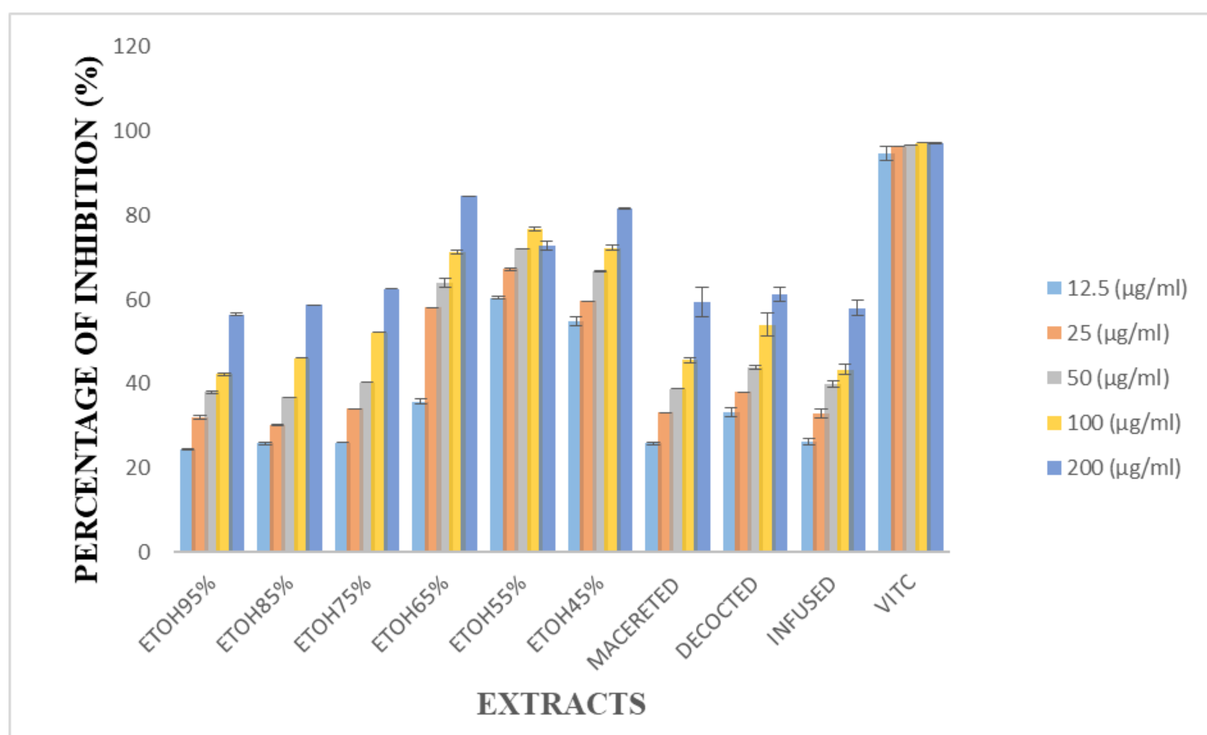


**Figure 3:** Percentage change in DPPH reduction of hydroethanolic and aqueous extracts in function of the concentration of *Dracaena deisteliana* leaves extracts. ETOH: Ethanol.

**Determination of $IC_{50}$ extracts of *Dracaena deisteliana* leaves.**

In order to better express the antioxidant capacity of the different extracts, inhibition percentages were used for the determination of $IC_{50}$ (concentration needed to reduce 50% of the DPPH● radical). The $IC_{50}$ values obtained for all extracts tested are shown in Figure 4. The 55% hydroethanolic extract had the lowest $IC_{50}$ 11.99 µg/ml among the hydroethanolic extracts, while the decoctate had the smallest $IC_{50}$ 96 µg/ml among aqueous extracts.

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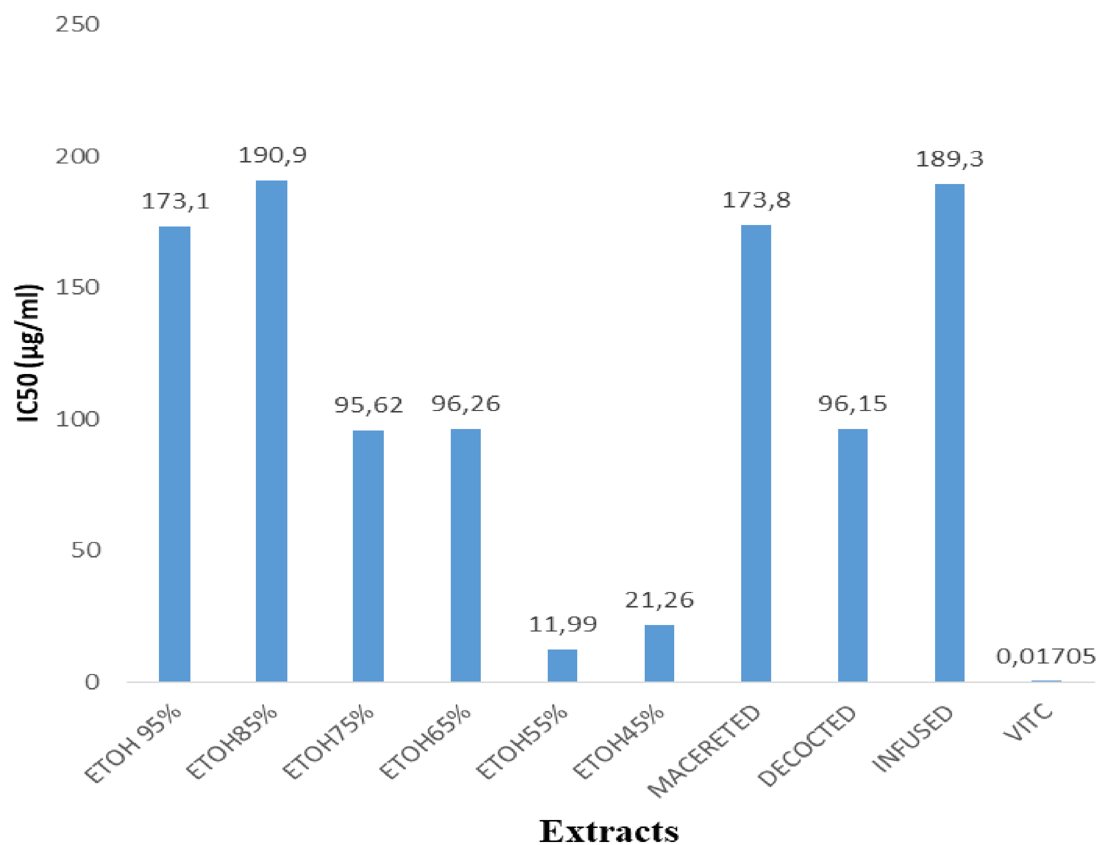


**Figure 4**: Determination of the $IC_{50}$ of hydroethanolic and aqueous extracts in function of the concentrations of *Dracaena deisteliana* leaves. ETOH: Ethanol Vitamin C was the most active with $IC_{50}$ 0.01705 µg/ml.

### III.2.2. Iron reducing power (FRAP) of extracts from *Dracaena deisteliana* leaves

The results of the iron reducing power of Dracaena deisteliana extracts leaves are presented in figure 5. The hydroethanolic extract 55% of the leaves of Dracaena deisteliana had the highest reducing power ($p>0.05$) compared to all extracts at concentrations of 100 and 200 µg/ml. The infused extract had the lowest reducing ($p<0.05$) power compared to all extracts at all concentrations.

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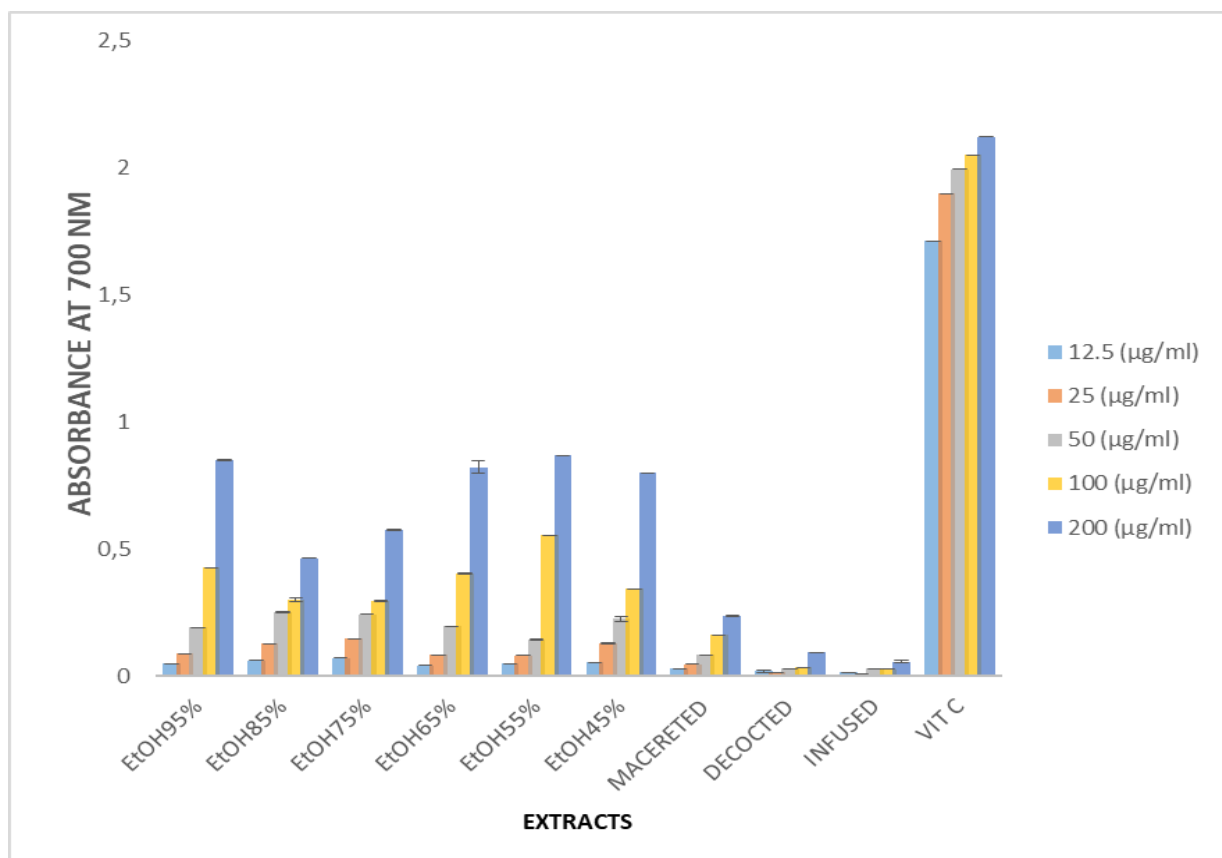


**Figure 5:** Iron reducing power of hydroethanolic and aqueous extracts of *Dracaena deisteliana* leaves. ETOH : Ethanol.

### III.2.3. Total flavonoid content

Figure 6 shows the total flavonoid content of the extracts of the leaves of *Dracaena deisteliana*. It should be noted that the flavonoid content of the infused was significantly higher ($p>0.05$) than that of all other extracts. The 85% hydroethanolic extract had the lowest ($p < 0.05$) content compared to other extracts.

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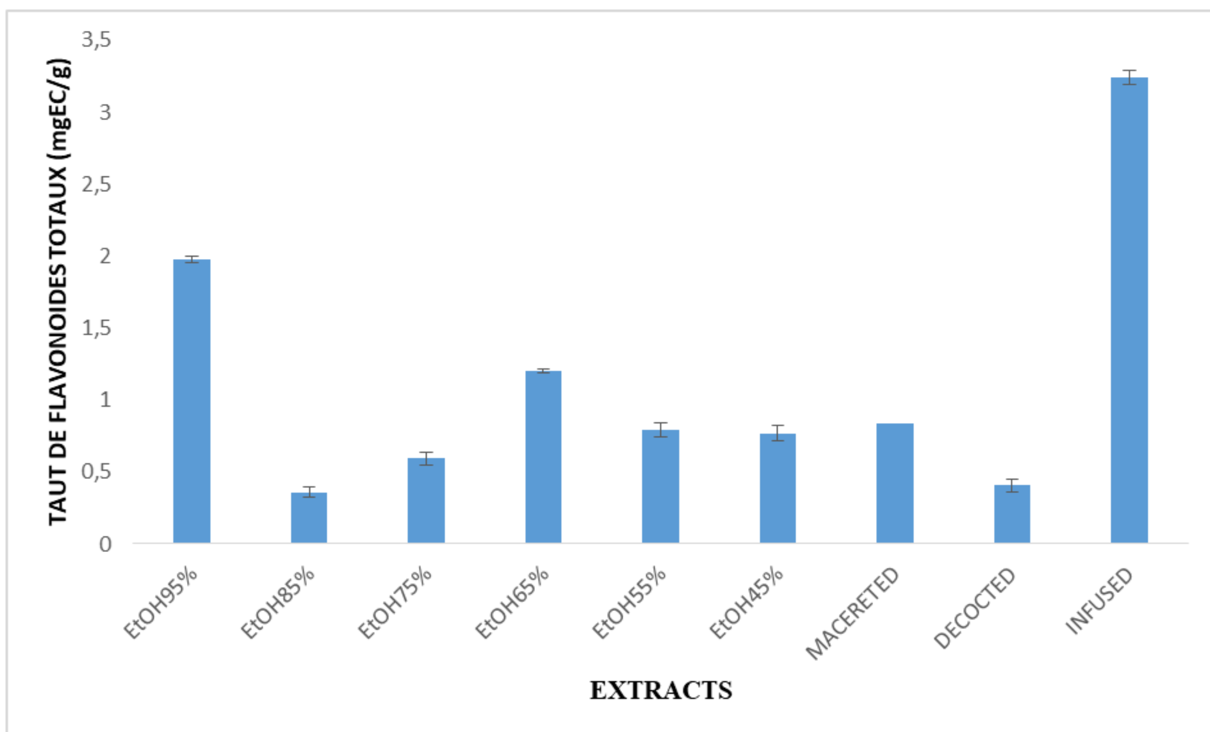


**Figure 6:** Total flavonoid content of hydroethanolic and aqueous extracts of *Dracaena deisteliana* leaves**.** ETOH: Ethanol.

### III.2.4. Total phenol content

The total phenol content of the different extracts of the Dracaena deisteliana leaves was determined and the results are presented in figure 7. It should be noted that the total phenol content of the infused extract was significantly higher ($p>0.05$) than that of all other extracts, the 75% hydroethanolic extract had the lowest ($p<0.05$) content compared to other extracts.

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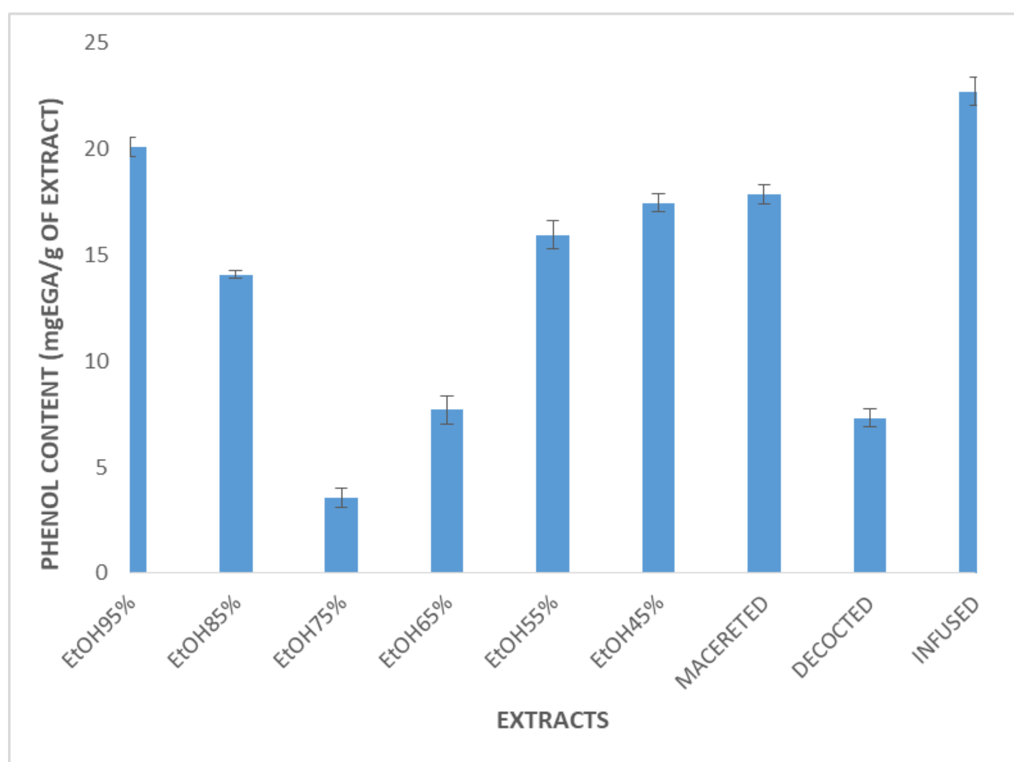


**Figure 7:** Total phenol content of hydroethanolic and aqueous extracts of *Dracaena deisteliana* leaves. ETOH: Ethanol.

### III.3. *In vivo* antioxidant effect of *Dracaena deisteliana* leaves extracts

#### III.3.1. Effects of treatment on nitric oxide (NO) concentration

Table 1 shows the effect of treatment on nitric oxide (NO) content in the tissues of male and female rats. It was found that infection significantly ($p< 0.05$) decreased the level of NO in all tissues of animals of both sexs compared to neutral controls. Treatment with different doses of extract resulted in a significant decrease in NO levels in all organs on which the tests were performed in a dose-dependent manner. Overall, the treatment has normalized NO levels in rats of both sexs compared to neutral controls (uninfected/untreated) at doses 20 and 51.84 mg/kg.

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**Table 1:** Effects of different doses of treatment on the activity of nitric oxide (NO).

| Sex | Doses | Heart (µM/g) | Liver (µM/g) | Lungs (µM/g) | Spleen (µM/g) | Kidneys (µM/g) |
|---|---|---|---|---|---|---|
| **Males** | Neutral Control | 3,145±0,305$^{c}$ | 1,893±0,098$^{c}$ | 2,514±0,234$^{c}$ | 2,705±0,369$^{c}$ | 1,857±0,324$^{c}$ |
| | Négatif Control | 0,822±0,151$^{a}$ | 0,352±0,273$^{a}$ | 1,022±0,277$^{a}$ | 1,182±0,231$^{a}$ | 0,227±0,093$^{a}$ |
| | Positif Control | 2,802±0,131$^{c}$ | 1,693±0,298 $^{c}$ | 3,026±0,247$^{c}$ | 3,295±0,141$^{c}$ | 2,377±0,404$^{c}$ |
| | 10 mg/kg | 2,914±0,298 $^{b}$ | 1,182±0,923 $^{b}$ | 1,514±0,390$^{b}$ | 1,403±0,386$^{b}$ | 0,299±0,206$^{b}$ |
| | 20 mg/kg | 2,820±0,153$^{c}$ | 1,890±0,101$^{c}$ | 3,012±0,287$^{c}$ | 3,404±0,189$^{c}$ | 1,804±0,119$^{c}$ |
| | 51. 84 mg/kg | 2,722±0,251$^{c}$ | 1,873±0,100$^{c}$ | 3,122±0,177$^{c}$ | 3,275±0,121$^{c}$ | 1,198±0,264$^{c}$ |
| **Females** | Neutral Control | 2,878±0,337$^{c}$ | 4,917±0,528$^{c}$ | 1,804±0,175$^{c}$ | 2,073±0,235$^{c}$ | 2,612±0,529$^{c}$ |
| | Négatif Control | 0,929±0,126$^{a}$ | 1,018±0,524$^{a}$ | 0,467±0,427$^{a}$ | 1,067±0,526$^{a}$ | 0,818±0,131$^{a}$ |
| | Positif Control | 3,069±0,071$^{c}$ | 4,908±0,534$^{c}$ | 2,467±0,427$^{c}$ | 1,769±0,261$^{c}$ | 3,169±0,233$^{c}$ |
| | 10 mg/kg | 2,010±0,369$^{b}$ | 2,274±0,222$^{b}$ | 1,013±0,144$^{b}$ | 1,75±0,081$^{b}$ | 1,818±0,131$^{b}$ |
| | 20 mg/kg | 3,089±0,091$^{c}$ | 4,907±0,538$^{c}$ | 3,465±0,429$^{c}$ | 2,138±0,217$^{c}$ | 2,808±0,141$^{c}$ |
| | 51. 84 mg/kg | 3,306±0,245$^{c}$ | 4,915±0,530$^{c}$ | 3,447±0,447$^{c}$ | 2,271±0,365$^{c}$ | 2,816±0,133$^{c}$ |

The values in the table are the means ± standard deviation of 4 repetitions. a, b, c, d: In the same column and by sex, the assigned values of the different letters are significantly different ($p < 0.05$).

### III.3.2. Effects of treatment on malondialdehyde concentration

Table 2 shows the variation in malondialdehyde (MDA) levels in animal tissue homogenates. It was found that infection induced a significant increase ($p<0.05$) in the level of MDA in all tissues studied from animals of both sexs compared to neutral controls. Treatment with different doses of extract resulted in a significant decrease ($p<0.05$) in the level of MDA in these tissues in animals of both sexs compared to animals in the negative control group. Treatment normalized the harms caused by infection in animals of both sexs at 20 and 51.84 mg/kg body weight.

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**Table 2:** Effects of different doses of treatment on malondialdehyde concentration as a function of extract doses.

| Sex | Doses | Heart (µmol/g) | Liver (µmol/g) | Lungs (µmol/g) | Spleen (µmol/g) | Kidneys (µmol/g) |
|---|---|---|---|---|---|---|
| **Males** | Neutral Control | 0.171±0.016[a] | 0.138±0.083[a] | 0.102±0.017[a] | 0.38±0.122[a] | 0.283±0.015[a] |
| | Négatif Control | 0.541±0.044[d] | 0.683±0.13[d] | 0.775±0.055[c] | 0.763±0.177[b] | 0.948±0.016[f] |
| | Positif Control | 0.402±0.019[c] | 0.728±0.062[d] | 0.360±0.033 [a] | 0.711±0.125[b] | 0.777±0.014[e] |
| | 10 mg/kg | 0.368±0.019[bc] | 0.791±0.016[d] | 0.353±0.054 [b] | 0.787±0.093[b] | 0.694±0.009[d] |
| | 20 mg/kg | 0.323±0.012[b] | 0.511±0.036[c] | 0.499±0.011 [a] | 0.517±0.221[ab] | 0.559±0.043[c] |
| | 51. 84 mg/kg | 0.203±0.056[a] | 0.263±0.012[b] | 0.516±0.221 [a] | 0.397±0.189[a] | 0.331±0.017[b] |
| **Females** | Neutral Control | 0.089±0.010[a] | 0.298±0.031[b] | 0.208±0.008[a] | 0.239±0.083[a] | 0.126±0.031[a] |
| | Négatif Control | 0.378±0.026[e] | 0.792±0.007[e] | 0.391±0.044[b] | 0.376±0.083[b] | 0.586±0.056[e] |
| | Positif Control | 0.094±0.009[b] | 0.366±0.052[c] | 0.286±0.038[a] | 0.256±0.070[ab] | 0.273±0.029[bc] |
| | 10 mg/kg | 0.324±0.007[d] | 0.469±0.020[d] | 0.253±0.110[a] | 0.32±0.043[ab] | 0.355±0.003[d] |
| | 20 mg/kg | 0.258±0.005[c] | 0.242±0.019[b] | 0.245±0.025[a] | 0.273±0.056[ab] | 0.336±0.018[cd] |
| | 51. 84 mg/kg | 0.151±0.020[b] | 0.302±0.032[b] | 0.209±0.018[a] | 0.296±0.065[ab] | 0.214±0.079[b] |

The values in the Table are the means ± standard deviation of 4 repetitions. a, b, c, d : In the same column and by sex, the assigned values of the different letters are significantly different ($p < 0.05$).

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### III.3.3. Effects of treatment on catalase activity

Table 3 presents the effect of treatment on catalase activity in the tissues and plasma of male and female rats. It was found that infection induced a significant decrease ($p<0.05$) in the rate of catalase in the liver, spleen and plasma of animals of both sexs compared to neutral controls. Treatment with different doses of extract resulted in a significant increase ($p<0.05$) in the level of catalase in the liver, spleen and plasma of rats of both sexs compared to animals in the negative control group. Infection and treatment had no effect on the rate of catalase in the heart, lungs and kidneys of animals of either sex compared to animals in the neutral and negative control groups. Treatment normalized the harms caused by infection in animals of both sexs at doses 20 and 51.84 mg/kg body weight.

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**Table 3:** Effects of different doses of treatment on catalase activity as a function of doses.

| Sex | Doses | Plasma (mmol/min/ml) | Heart (mmol/min/g) | Liver (mmol/min/g) | Lungs (mmol/min/g) | spleen (mmol/min/g) | Kidneys (mmol/min/g) |
|---|---|---|---|---|---|---|---|
| **Males** | Neutral Control | 0,252±0,002$^{c}$ | 3,215±0,201$^{a}$ | 19,862±0,588$^{c}$ | 8,800±0,181$^{a}$ | 5,193±0,422$^{a}$ | 15,073±1,779 $^{a}$ |
| | Négatif Control | 0,145±0,020$^{a}$ | 2,463±0,356$^{a}$ | 18,085±0,308$^{a}$ | 8,810±0,044$^{a}$ | 7,745±0,074$^{c}$ | 15,073±1,779 $^{a}$ |
| | Positif Control | 0,351±0,004$^{a}$ | 3,105±0,311$^{a}$ | 20,568±0,644$^{c}$ | 8,160±0,604$^{a}$ | 5,553±0,483$^{ab}$ | 15,073±1,779 $^{a}$ |
| | 10 mg/kg | 0,191±0,004$^{b}$ | 3,202±0,214$^{a}$ | 18,599±0,092$^{b}$ | 8,710±0,271$^{a}$ | 5,907±0,234$^{b}$ | 15,073±1,779 $^{a}$ |
| | 20 mg/kg | 0,325±0,040$^{c}$ | 2,205±1,211$^{a}$ | 20,630±0,324$^{c}$ | 8,790±0,151$^{a}$ | 5,264±0,261$^{a}$ | 15,073±1,779 $^{a}$ |
| | 51. 84 mg/kg | 0,365±0,018$^{c}$ | 3,225±0,231$^{a}$ | 20,548±0,664$^{c}$ | 7,810±1,171$^{a}$ | 5,173±0,442$^{a}$ | 15,073±1,779 $^{a}$ |
| **Females** | Neutral Control | 0,374±0,007$^{c}$ | 0,948±0,206 $^{a}$ | 13,267±0,806$^{c}$ | 5,702±0,139$^{a}$ | 4,697±0,510$^{a}$ | 14,352±0,574 $^{a}$ |
| | Négatif Control | 0,193±0,036 $^{a}$ | 0,938±0,216 $^{a}$ | 10,872±0,199$^{a}$ | 5,720±0,121$^{a}$ | 7,326±0,607 $^{c}$ | 14,424±0,339 $^{a}$ |
| | Positif Control | 0,479±0,013$^{c}$ | 0,947±0,207 $^{a}$ | 14,911±0,551$^{a}$ | 5,622±0,219$^{a}$ | 3,821±0,444 $^{a}$ | 14,374±0,552 $^{a}$ |
| | 10 mg/kg | 0,298±0,012$^{b}$ | 0,848±0,306 $^{a}$ | 11,911±0,750$^{b}$ | 5,722±0,119 $^{a}$ | 5,559±0,954 $^{b}$ | 13,424±1,339 $^{a}$ |
| | 20 mg/kg | 0,445±0,003$^{c}$ | 0,958±0,196 $^{a}$ | 14,892±0,179$^{c}$ | 6,048±0,649 $^{a}$ | 4,397±0,810 $^{a}$ | 14,424±0,339 $^{a}$ |
| | 51. 84 mg/kg | 0,429±0,002$^{c}$ | 0,946±0,206 $^{a}$ | 14,672±0,399$^{c}$ | 6,594±0,118 $^{a}$ | 4,677±0,530 $^{a}$ | 14,312±0,434 $^{a}$ |

The values in the Table are the means ± standard deviation of 4 repetitions. a, b, c, d : In the same column and by sex, the assigned values of the different letters are significantly different ($p < 0.05$).

### III.3.4. Effects of treatment on peroxidase activity

Table 4 presents the effect of treatment on peroxidase activity in the tissues of male and female rats. It was found that infection induced a significant decrease ($p > 0.05$) in peroxidase levels in all tissues of animals of both sexs compared to neutral controls. Treatment normalized peroxidase levels in rats of both sexs at doses 20 and 51.84 mg/kg body weight.

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**Table 4:** Effects of different doses of treatment on peroxidase activity as a function of dose.

| Sex | Doses | Heart (µmol/min/g) | Liver (µmol/min/g) | Lungs (µmol/min/g) | Spleen (µmol/min/g) | Kidneys (µmol/min/g) |
|---|---|---|---|---|---|---|
| **Males** | **Neutral Control** | 1,831±0,117$^{c}$ | 2,716±0,147$^{c}$ | 1,434±0,257$^{c}$ | 2,071±0,576$^{b}$ | 2,076±0,197$^{c}$ |
| | **Négatif Control** | 0,405±0,073$^{a}$ | 1,386±0,393$^{a}$ | 0,785±0,123$^{a}$ | 1,264±0,305$^{a}$ | 0,95±0,049$^{a}$ |
| | **Positif Control** | 2,641±0,052$^{c}$ | 1,654±0,241$^{ab}$ | 0,998±0,047$^{c}$ | 1,976±0,267$^{b}$ | 1,704±0,072$^{c}$ |
| | **10 mg/kg** | 0,791±0,044$^{b}$ | 1,596±0,234$^{b}$ | 1,012±0,290$^{b}$ | 1,141±0,307$^{a}$ | 1,410±0,081$^{b}$ |
| | **20 mg/kg** | 1,803±0,351$^{c}$ | 1,961±0,031$^{c}$ | 1,303±0,059$^{c}$ | 1,592±0,152$^{b}$ | 1,963±0,286$^{c}$ |
| | **51. 84 mg/kg** | 1,75±0,084$^{d}$ | 2,149±0,124$^{c}$ | 1,323±0,332$^{c}$ | 1,477±0,326$^{b}$ | 1,936±0,125$^{c}$ |
| **Females** | **Neutral Control** | 1,063±0,056$^{c}$ | 2,133±0,009$^{c}$ | 1,125±0,053$^{b}$ | 1,378±0,29$^{c}$ | 1,668±0,102$^{c}$ |
| | **Négatif Control** | 0,574±0,048$^{a}$ | 1,169±0,123$^{a}$ | 0,591±0,042$^{a}$ | 0,451±0,105$^{a}$ | 0,751±0,09$^{a}$ |
| | **Positif Control** | 1,398±0,028$^{c}$ | 1,733±0,007$^{c}$ | 0,716±0,089$^{a}$ | 2,467±0,085$^{c}$ | 1,319±0,215$^{b}$ |
| | **10 mg/kg** | 0,609±0,042$^{b}$ | 1,485±0,103$^{b}$ | 0,707±0,037$^{a}$ | 0,777±0,168$^{b}$ | 0,965±0,047$^{a}$ |
| | **20 mg/kg** | 1,162±0,211$^{c}$ | 1,701±0,185$^{c}$ | 0,742±0,041$^{a}$ | 1,81±0,160$^{c}$ | 1,466±0,028$^{bc}$ |
| | **51. 84 mg/kg** | 1,065±0,103$^{c}$ | 1,870±0,048$^{c}$ | 1,206±0,279$^{b}$ | 1,164±0,179$^{c}$ | 1,675±0,216$^{c}$ |

The values in the Table are the means ± standard deviation of 4 repetitions. a, b…: In the same column and by sex, the assigned values of the different letters are significantly different ($p < 0.05$).

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## IV. DISCUSSION

### IV.1. Antityphoid activities

Orally administered substances may undergo transformations during their pharmacokinetics and metabolites resulting from these transformations may be either more active or less active than the original substance. Administration of the extracts and the reference antibiotic resulted in a gradual decrease in its load in the animals' blood. This load became almost zero on the 8 day of treatment for animals receiving the high dose of extract (51.84 mg/kg), while it was on the 12 day of treatment of the test that animals receiving the low dose (10 mg/kg) showed zero bacterial loads. The decrease in this load in treated animals testifies to the effectiveness of the extracts. Rats infected with *Salmonella* Typhi and treated with different doses of hydroethanolic extract 55% of the leaves of *Dracaena deisteliana* regained healing in a dose-dependent manner. These results corroborate those published by [14], showing the *in vivo* efficacy of *Terminalia avicennioides* extracts in the treatment of systemic salmonellosis.

### IV.2. *In vitro* Antioxidant activity

Several methods exist in the literature to assess the *in vitro* antioxidant potential of a substance. Given the complexity and diversity of oxidation processes, coupled with the structural diversity of secondary metabolites, it is recommended to use more than one method to assess the *in vitro* antioxidant activity of a given substance [33]. This explains the use of three different methods for the evaluation of *in vitro* antioxidant activity of *Dracaena deisteliana* extracts in this work. 65% hydroethanolic extract showed a higher activity than the other extracts in 200 µl/mg concentration. In addition, 55% hydroethanolic extract showed a higher activity than the other extracts in 100 µl/mg concentration. However, the infused extract showed a lower antiradical activity than all extracts at 12.5 and 200 ug/ml concentrations. These results showed that the percentages of inhibition change according to the extracts and to their concentrations possess an anti-radical power. The anti-radical activity of these extracts is explained by the presence of different secondary metabolites such as flavonoids [31]; contained in extracts leaves of *Dracaena deisteliana*. Indeed, flavonoids have been shown to discolor DPPH due to their ability to produce hydrogen, and protective effects in biological systems are related to their ability to transfer protons to free radicals [34]. This is in line with the work carried out by [35] and [14]. Who showed that the antioxidant activity of *Satureja Montana* and *Terminalia avicennioides* extracts respectively is related to their

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richness in phenolic compounds. The anti-radical activity (DPPH.) of *Dracaena deisteliana* extracts was also expressed in $IC_{50}$. According to [36], the antioxidant potential of a plant is divided into three groups: high when $IC_{50}$< 20 µg/ml, moderate when 20 µg/ml ≤ $IC_{50}$ ≤ 75 µg/ml and low when $IC_{50}$> 75 µg/ml. Based on this theory, the $IC_{50}$ values of *Dracaena deisteliana* extracts show that they have a high antioxidant potential. Because the 55% hydroethanolic leaves of *Dracaena deisteliana* had the lowest $IC_{50}$ (11.99 µg/ml) among the hydroethanolic extracts while the decocted extract had the lowest $IC_{50}$ (96.15 µg/ml) among the aqueous extracts. $IC_{50}$ values showed that the 55% hydroethanolic extract of *Dracaena deisteliana* leaves has a high antioxidant potential because of the value of its $IC_{50}$, which is 11.99 µg/ml and less than 20 µg/ml. All other extracts have an $IC_{50}$> 75 µg/ml and therefore have a low antioxidant potential. The strong anti-radical activity of the different extracts of *Dracaena deisteliana* leaves could be explained by the strong presence of polyphenolic compounds (total phenols, anthraquinones and flavonoids) which have been highlighted via phytochemical screening. The antioxidant potential of extracts leaves of *Dracaena deisteliana* is thought to be related to the presence of phenol and total flavonoids that have been quantitatively detected in all *Dracaena deisteliana* extracts. Indeed, total phenols and flavonoids are powerful antioxidants [37]. These results suggest that the extracts tested contain free radical scavenging agents that act as primary antioxidants. For the ability of the extracts to reduce iron, the hydroethanolic extract 55% of the leaves of *Dracaena deisteliana* had the highest reducing power compared to all extracts at concentrations of 100 and 200 µg/ml. The infused had the lowest reducing power compared to all extracts at all concentrations. The activity of these different extracts could be due to the presence in high quantities of phenols and particularly flavonoids whose antioxidant potential is recognized [38]. These results are consistent with those of several authors, who have reported a positive correlation between phenolic compounds and antioxidant activity [22]; [25]; [13]). In this case, these extracts would reduce iron, preventing the Fenton reaction, and the formation of the hydroxyl radical. This hypothesis corroborates the results obtained by [39] and [11], on the effectiveness of the leaves and bark of *Drymania diandra* to stabilize the OH radical. It is believed that this high antioxidant power is due to the high presence of phenolic compounds in *Dracaena deisteliana* extracts. A compound's reducing capacity can be used as an indicator of its potential antioxidant activity [40]. The presence of reducing compounds leads to a reduction of $Fe^{3+}$ (ferricyanide) to ferrous ion ($Fe^{2+}$) [41]. Numerous studies have shown that there is a direct correlation between antioxidant activities and the reducing power of hydroéthanolic extract of *Terminalia avicennioides* [14]. The reducing properties are

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generally associated with the presence of reducers, whose antioxidant action has been demonstrated by reducing chain reactions by gaining hydrogen atom by the oxidizing agent. It should also be noted that reducers react with certain peroxide precursors to prevent the formation of peroxides [42, 43]. According to the phytochemical results obtained, the extracts of the leaves of *Dracaena deisteliana* contain several compounds, namely phenols, flavonoids, sterols, terpenes, tannins, saponins, anthocyanins, anthraquinones. *Dracaena deisteliana* extracts have antisalmonellal and antioxidant activities. These compounds are responsible for the ativity of Dracaena deisteliana extracts.

### IV.3. *In vivo* Antioxidant activities

Antioxidant systems are normally set up in living aerobic organisms to counteract the effect of oxidative stress [44, 45]. As part of this work, two enzymatic antioxidants (catalase and peroxidase) and two markers of oxidative stress (MDA and NO) were evaluated in the organs and plasma of rats infected with *Salmonella* Typhi ATCC 6539 and treated with the 55% hydroethanolic extract leaves of *Dracaena deisteliana*. Catalase is an enzyme that catalyzes the dismutation reaction of hydrogen peroxide, it functions as a destructive of the latter. Antioxidant systems are normally set up in living aerobic organisms to counteract the effect of oxidative stress. The decrease in catalase activity and total peroxidases in infected and untreated animals is thought to be due to an inhibition of catalase activity and total cellular peroxidases by an excess of "their" substrates, hydrogen peroxide. The increase in the activity of these enzymes in animals treated with different doses of extracts would be the result of a lifting of inhibition under the antioxidant effect of our extracts which would have acted directly on $H_2O_2$ or stimulated catalase activity. These results are consistent with those of (14) as well as those of (11), who showed an increase in tissue catalase levels in rats infected with S. typhi ATCC 6539 and treated with hydroethanolic extract 70% of the leaves of *Adenia lobata* and *T. avicennioides* respectively.

The elevation of MDA in infected and untreated animals compared to infected and treated animals would be due to either stimulation of the production of free radicals; destruction (inhibition) of non-enzymatic antioxidants; or an activation of phagocytes. The significant treatment-induced drop in MDA levels in almost all organs was due to the antioxidant activity of the extract, which is thought to prevent the destruction of the membrane bilayer of cells by neutralizing free radicals such as hydrogen peroxides ($H_2O_2$) and hydroxyl radical (OH•) known to (25).

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The significant decrease in nitric oxide levels in the tissues of infected and treated rats compared to infected and untreated rats reveals that extracts of Dracaena deisteliana regulate the production of nitric oxide, thus preventing oxidative stress from proliferating. This result can be explained by the presence of flavonoids that inhibit the formation of free radicals and oppose the oxidation of macromolecules such as proteins and DNA. They would form intermediate radical species that are not very reactive. They are secondary metabolites reputed to be the most antioxidant and very effective in the treatment of degenerative diseases( 25).

## CONCLUSION

The results obtained at the end of these studies lead to the conclusion that aqueous and hydroethanolic extracts of *Dracaena deisteliana* leaves have interesting antioxidant activities in vitro. The hydroethanolic extract 55% of the leaves of this plant is able not only to cure typhoid fever induced in albino's rats of the *wistar* strain, but also to manage the oxidative stress that can arise from this pathology. It is therefore imperative to determine the toxicological effects of this extract in the short and medium term to ensure the safety of this extract.

### Data Availability

No additional data are available

### Availability of data and materials

All data generated or analysed during this study are included in this published article.

### Ethical Approval

All animal procedures were performed after approval by the University of Dschang-Cameroon Ethics Committee (Project N° BCH1202/FS/UDs/2018).

### Disclaimer

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