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Evaluation of the anti-edematous activity of *Sclerocarya birrea*, a medicinal plant of the Anacardiaceae family

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Abstract
The use of medicinal plants in traditional African medicine remains vital, particularly in rural areas, for managing inflammatory conditions. This study investigates the anti-edematous and anti-inflammatory potential of the ethanolic bark extract of *Sclerocarya birrea*, a species commonly used in traditional medicine. The bark was collected in Djingliya (Koza district) and extracted via maceration in ethanol. Qualitative phytochemical screening revealed the presence of several bioactive compounds, notably flavonoids, sterols, triterpenes, polyphenols, quinones, and tannins, all known for anti-inflammatory properties.

Anti-edematous activity was evaluated using the carrageenan-induced paw edema model in albino Wistar rats, divided into four groups (control, ibuprofen 10 mg/kg, extract at 250 mg/kg and 500 mg/kg). Edema progression was monitored over six hours. Results indicated a significant reduction in edema volume in rats treated with both extract doses compared to the control. The 250 mg/kg and 500 mg/kg doses showed 48.3% and 65.5% edema inhibition, respectively, similar to ibuprofen (65.7%). The anti-inflammatory effect of the 500 mg/kg extract was statistically comparable to that of ibuprofen at T_3, suggesting that the extract may exert its effect via inhibition of inflammatory mediators such as histamine, serotonin, and prostaglandins.

The findings support the traditional use of *Sclerocarya birrea* in managing inflammation and highlight its potential as a natural source of anti-inflammatory agents with fewer side effects than synthetic drugs. Further studies on compound isolation and mechanisms of action are recommended to explore its full therapeutic potential.

Keywords: Wistar rats, *Sclerocarya birrea*, anti-inflammatory activity, carrageenan-induced edema, phytochemical screening, medicinal plants, natural therapeutics, flavonoids and polyphenols, ethanolic plant extract, traditional medicine

Introduction
Humans have used the resources present in their environment, rich in medicinal plants, to treat various minor pathologies and conditions that cause inflammatory reactions. The use of medicinal plants for therapeutic purposes is a centuries-old practice in Africa, particularly in rural areas [1, 2].

Inflammation is a reactive phenomenon triggered by the body whenever the integrity of its morphological and biological constants is threatened. It is therefore not synonymous with infection, but infection can be the cause of inflammation [3, 6].

Inflammation is a defense mechanism of the body against attacks of physical, chemical, biological, or infectious origin, essential to its integrity [4]. This protective immune response can sometimes be harmful due to the aggressiveness of the pathogen, its persistence, and abnormalities in the regulation and production of cells involved in inflammation. [5, 6]. Inflammation can manifest itself through various symptoms such as edema (swelling or tumor), pain, and heat or fever. However, plants could be used as an alternative to conventional medications, which are becoming increasingly expensive for people in remote rural areas. Several studies have been conducted on the biological properties of extracts from certain plants, leading to the discovery of numerous active ingredients used in modern medicine [5, 6, 8].

Taking anti-inflammatory drugs often presents gastrointestinal risks (peptic ulcers, perforation, stenosis), renal risks such as acute renal failure, and sometimes cardiac complications. The search for new medicinal molecules without the risk of side effects is essential for treating patients. Therefore, increasing emphasis is being placed on finding new molecules in medicinal plants that reduce edema [6-8].

It is in this context that this research project is being conducted, the objective of which is to evaluate the anti-edematous activity in the bark of *Sclerocarya birrea*.

Materials and Methods

Plant Material

The plant material included bark from the trunk of *Sclerocarya birrea* collected in Djingliya in the Koza district. The bark was harvested in December, specifically in the morning.

Animal Material

Albino rats of the Wistar strain, male and female, were raised in the animal facility of the Faculty of Medicine and Pharmaceutical Sciences at the University of Douala, where the average temperature ranged between 25-26°C, with a 12-hour light/dark photoperiod cycle. The rats were housed in plastic bowls and were periodically fed with diet prepared by experts at the faculty's animal facility. They received tap water in baby bottles as drinking water. Preparation of Ethanolic Extracts.

The extract is obtained by macerating 200 g of pulverized material in 1 L of 96% ethanol for 72 hours followed by evaporation in a Rotavapor at 40 degrees.

To investigate the different classes of secondary metabolites in *Sclerocarya birrea* root extracts, we conducted a phytochemical screening by performing a series of characterization reactions (precipitation reaction or color change using specific reagents) of the various chemical compounds, such as: flavonoids, saponins, tannins, terpenoids, alkaloids, coumarins, proteins, quinones, and anthocyanins. Figure 2 shows the results of phytochemical screening.

Anti-edematous activity of *Sclerocarya birrea* trunk extract

Induction of rat hind paw edema with carrageenan (1%) was performed according to the method of Winterand al. Rats weighing between 180 g and 200 g were fasted for 24 hours. The rats were divided into four groups of five rats each. The diameter at time T_0 of the right hind paw was determined using a digital caliper. The different batches were constituted: The edematous controls received distilled water, the two test batches received 250 and 500 mg/kg of the ethanolic extract of the bark of *Sclerocarya birrea*. One hour after administration by gavage of the different solutions, 0.1 ml of the 1% carrageenan solution was injected cutaneously at the level of the plantar fascia of the right hind paw of each rat. The progression of right-sided edema was determined at 1, 2, 3, 4, 5, and 6 hours. The severity of edema was assessed by determining the mean percentage increase.

Anti-inflammatory activity was also assessed by calculating the percentage inhibition (%INH) of edema using the formula:

- Percentage increase in controls
- Percentage increase in treated samples

The extraction yield was calculated using the following relationship.

$$\text{Yield (\%)} = \text{Rd} = \frac{m}{m'} \times 100$$

m = mass of the extract obtained
m' = mass of dry matter

Results

Table 1: Humidity Percentage

Weight (kg)	RSB
Mass 0	20,5
Mass 1	12,1
Mass 2	11,0
% moisture	13,09

Mass 0: Weight in kg of wet material
Mass 1: Weight in kg of dry plant material
Mass 2: Weight in kg of pulverized plant material *Sclerocarya birrea roots* (RSB).

Qualitative Phytochemical Screening

In order to identify the different classes of secondary metabolites in *Sclerocarya birrea* root extracts, we conducted a phytochemical screening by performing a series of characterization reactions (precipitation reaction or color change using specific reagents) of different chemical compounds such as flavonoids, saponins, tannins, terpenoids, glycosides, coumarins, proteins, quinones, and anthocyanins. Table 2 shows the results for secondary metabolites.

Table 2: Phytochemical Screening

Metabolites	RSB
Sterols	+++
Triterpenes	+++
Flavonoids	++++
Alkaloids	-
Polyphenols	++++
Quinones	++
Saponins	-
Tannins	++
Glycosides	++
Anthraquinones	++
Coumarins	++
Anthocyanins	+

+ = present; - = absent; RSB: S. birrea roots.

Evolution of edema volume over time

The evolution of edema over time is illustrated in Figure 1. This shows that edema gradually increases in all batches, up to T_3 (3 hours), at which point it begins to regress.

T_0=1/2 h; T_1=1 h; T_2=2 h; T_3=3 h; T_4=4 h; T_5=5 h; T_6=6 h.

N=5 per group; values are means ± standard errors; $p<0.05$ compared to the control group (ANOVA).

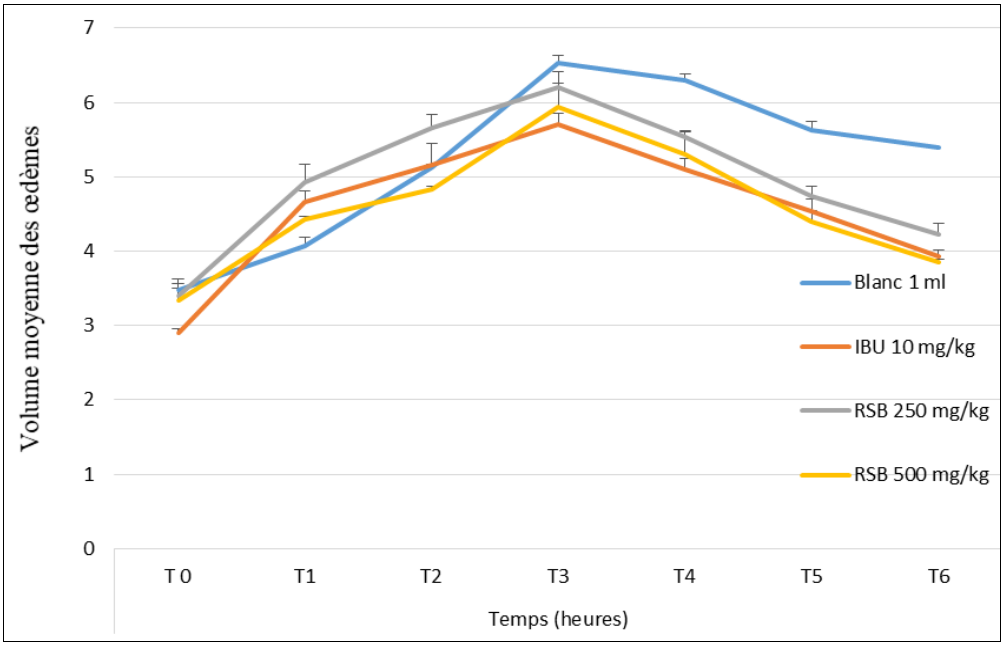

Fig 1: Edema progression in different groups over time.

Mean edema volume and percentage inhibition

The mean edema volume obtained at the end of the experiment and the percentage inhibition are presented in Table III. The results show that edema was greater in the control group. Treatments with ibuprofen 10 mg/kg and ethanolic extracts of S. birrea roots at 250 mg/kg and 500 mg/kg resulted in inhibition of edema of 34.28%, 51.66%, and 34.44%, respectively, after 6 hours of treatment. Statistical analysis shows that the difference between the treated groups and ibuprofen is not significant; however, it is significant between the treated groups (P=0.0005).

Table 3: Mean volume of edema and percentage inhibition after 6 hours

Batches	Mean edema volume (ml)	% inhibition
Witness (water)	1,56±0,4	0
IBU	1,15±0,8 [ab]	65,7
RSB 250	1,35±0,4 [a]	48,3
RSB 500	1,49±0,2 [b]	65,5

Ibuprofen=IBU 10 mg/kg
Sclerocarya birrea roots (RSB) 250 mg/kg
Sclerocarya birrea roots (500) mg/kg

On the same column, the means ± standard errors followed by a different letter are significantly different at the $p<0.05$ threshold; compared to the control group (ANOVA followed by Student's t test).

Evolution of inflammation in different batches

Reduction of anti-inflammatory activity in rats treated with ibuprofen (IBU) and ethanolic extract of *Sclerocarya birrea* roots. In the presence of distilled water, subplantar injection of 1% carrageenan in rats (control) causes edema whose volume gradually increases over time. Paw measurements are 6.5 mm in the control group, 5.7 mm in the positive control group, 6.2 mm in the 250 mg/kg test group, and 5.9 mm in the 500 mg/kg test group of body weight after 3 hours. Table II shows the evolution of edema in each batch over time. The anti-inflammatory effect of RSB at 500 mg/kg BW is similar to that of ibuprofen at 10 mg/kg BW. However, this anti-inflammatory effect, evidenced by a 34.44%±4.6% ($p<0.05$) reduction in edema at the third hour, appears to be equal to that of ibuprofen at 10 mg/kg BW (34.28%±3.2%).

Table 4: Evolution of inflammation in different batches

Lots	T_0	T_1	T_2	T_3	T_4	T_5	T_6
White	3,4±2,2	4,0±3,71	5,1±4,6	6,5±5,3	6,3±5,2	5,6±3,7	5,4±5,2
IBU	2,9±3,1	4,6±4,26	5,1±4,4	5,7±5,4	5,1±4,5	4,5±3,9	3,9±2,9
RSB 250	3,4±2,5	4,9±5,48	5,67±3,7	6,2±5,7	5,53±4,3	4,7±4,2	4,2±3,1
RSB 500	3,3±2,8	4,4±3,79	4,8±4,3	5,9±,4,3	5,3±5,1	4,4±3,7	3,8±2,9

T_0: time 0; T_1: time 1; T_2: time 2; T_3: time 3; T_4: time 4; T_5: time 5; T_6: time 6

The anti-inflammatory effect of RSB at 500 mg/kg BW, reminiscent of that of ibuprofen at 10 mg/kg BW, shows that this effect is significant at high concentrations. Each value represents the mean ± SEM (standard error of the mean), N=5. *$p<0.05$; **$p< 0.01$; *** $p<0.001$.

Discussion

Our results show that carrageenan caused an inflammatory process in the rats' paws. This inflammatory process resulted in redness and, above all, edema, with the maximum effect observed after 3 hours. At the end of the experiment, i.e., after

6 hours, the edema was more developed in the control group than in the groups treated with ibuprofen and *Sclerocarya birrea* root extracts, where a significant reduction was observed [5-7]. The administration of carrageenan causes an inflammation process characterized by pain, heat, redness and especially by swelling of the rat's hind paw, i.e. edema. Analysis of the evolution of edema in the control group shows that it develops progressively until reaching its maximum after 3 hours, at which point it begins to regress [9, 10]. Although this group did not receive anti-inflammatory drugs, there are defense mechanisms in the body that can contain the development of an inflammatory process. In fact, inflammation is characterized by a vascular phase that is dependent on numerous mediators (histamine, serotonin, quinines, thromboxanes and Platelet activating factor, etc.), and a cellular phase during which numerous cells, notably neutrophils and monocytes, invade the inflammatory focus [7, 9, 11].

These anti-inflammatory tests indicate that extracts of *Sclerocarya birrea* (RSB) roots and ibuprofen reduce carrageenan-induced edema [11]. The reduction in edema could be explained by the inhibition of inflammatory mediators, notably histamine from the granulation of basophils and local mast cells, serotonins produced by the disintegration of blood platelets during the first hours of inflammation, and bradykinin released by a plasma protein system during the intermediate hours [12]. On the other hand, inflammation would be contained by the inhibition of inducible cyclooxygenase, which ultimately releases prostaglandin from arachidonic acid during the last hours.

Sclerocarya birrea root extracts, which exhibited a greater reduction in edema during these last hours, appear to possess a predominant anti-inflammatory effect, linked to secondary metabolites responsible for these activities [5, 9, 12].

Conclusion

Sclerocarya birrea root extracts possess anti-inflammatory properties likely linked to their phytochemical content, indicating the presence of saponins and flavonoids. These pharmacological data of RSB extracts demonstrate the potential role they could play in traditional pharmacopoeia and in strengthening population health in rural areas, particularly in the management of inflammation in vulnerable populations.

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