Anti-inflammatory activity of aqueous extracts from the fruits of two tomato varieties cultivated in Cote dIvoire.

Abstract:

Inflammatory diseases constitute a major risk factor for the development of chronic diseases. In this context, the search of natural alternatives about treatments is essential. This study aims to evaluate the anti-inflammatory effect of extracts from two tomato varieties (*Lycopersiconesculentum* var. Cobra F1 and var. Locale Côtelette) cultivated in Côte d'Ivoire. Anti-inflammatory activity was studied in rats (*Rattus norvegicus*) using a paw edema induction model, followed by treatment with the extracts. Edema evolution was monitored after administration. Hematological parameters were also analyzed to evaluate extract safety. Results showed a significant reduction in edema as early as three hours after treatment, with a more pronounced effect over time. No significant changes were observed in leukocyte and platelet counts ($p > 0.05$), while a slight increase in red blood cells and hemoglobin levels was recorded. These findings indicate that both tomato varieties exhibit notable anti-inflammatory activity without apparent immunotoxic effects, suggesting their potential in preventing inflammatory diseases.

Keywords: inflammation, Lycopersiconesculentum, anti-inflammatory activity, chronic diseases.

Introduction

Inflammatory diseases currently constitute one of the major public health problems worldwide **(Lutu, 2026; Sarter, 2024)**. They trigger excessive reactions from the immune system, thereby leading to inflammation throughout the body. These reactions occur in response to various assaults on the organism by antigens of physical, chemical, or biological origin **(Joulia, 2022)**.

Inflammatory diseases are divided into four (4) categories: rheumatic diseases (rheumatoid arthritis), auto-immune diseases (lupus, type 1 diabetes), chronic inflammatory bowel diseases (Crohn's disease), and type 2 inflammatory diseases (asthma) **(Laurent, 2023)**. The global prevalence of inflammatory diseases varies considerably depending on the type of disease. Indeed, the overall prevalence of autoimmune diseases is estimated at between 5% and 10% of the global population, with high peaks among women **(Nihad, 2023)**. This predominance among women could be due to several factors, notably hormonal factors **(Casimir, 2026; ZenkoufiSawsen and Zinedddine, 2024)**, the extra chromosome X in women **(Lacombe, 2025)**, and the microbiota **(Chloé et al., 2024)**.

Nowadays, the treatment of inflammatory diseases aims to suppress or modulate the immune response using medications such as non-steroidal anti-inflammatory drugs (NSAIDs), corticosteroids, or immunosuppressants. Although effective, these molecules can cause long-term adverse effects. Might

a diet rich in fruits and vegetables, particularly tomatoes offer an interesting alternative for preventing or treating this disease? This study was conducted to address this issue. It aims to evaluate the effect of several tomato varieties (*Lycopersiconesculentum*) grown in Côte d'Ivoire on inflammatory diseases. To this end, inflammation was induced in the animals, which were then treated with extracts from two (2) tomato varieties (Lycopersiconesculentum Mill.). The results obtained following treatment were compared with the corresponding controls.

1.1 Materials and methods

1.1.1 Plant material

The tomato (*Lycopersiconesculentum* Mill.) is the plant material used in this study. They were collected on April 24, 2025 from Yamoussoukro's plantations. The collected varieties are the hybrid *Lycopersiconesculentum* var. Cobra F1 *(Figure 1A)* and the traditional *Lycopersiconesculentum* var. Locale Côtelette (*Figure 1B*).

A B

Figure 1*: Different varieties of the Lycopersiconesculentum Mill tomato fruit*
A= Cobra F1, B= Local cotelette

1.1.2 Animal material

This experiments were conducted on Wistar rats of species *Rattus norvegicus*, aged 2 to 3 months (figure 2). The average weights ranging of these animals were from 90 to 200 g. These animals were raised in plastic cages and acclimated to the experimental laboratory conditions. They were fed with pellets provided by the Ivorian Society for the Manufacture of Animal Feed (FACI) and watered with tap water without discontinuity.

Figure 2 : Rat Wistar *(Rattus norvejicus).*

1.1.3 Technicalequipment

A digital caliper with 0.01 mm precision was used to measure edema in the animals' paws. (***Figure 3***).

Figure 3 : Pied à coulisse *(Précision 0,01).*

1.2 Methods

1.2.1 Samplepreparation

Sampling involved firm, ripe fruits, i.e. at the red stage. The tomatoes were washed, cut, and dried in an oven at 55°C for 72 hours before being ground in a porcelain mortar. The tomato extracts were obtained by maceration and decoction according to the method described by **Bidié*et al.*(2011).**

1.2.1.1 Preparation of aqueous extracts by maceration

In 1 L of distilled water, 100 g of tomato powder was dissolved. This powder was homogenized in water at room temperature (30 ± 2°C) under stirring for 24 h. Afterwards, the mixture was centrifuged at 1000 rpm for 10 min. The supernatant obtained was then collected and dried in an oven at 55°C for 48 hours.

1.2.1.2 Preparation of aqueous extracts by decoction

This consisted of heating under reflux for 10 min a mixture of 100 g of tomato powder in 1 L of distilled water. After cooling, this mixture was centrifuged at 1000 rpm for 10 min. The supernatant obtained was recovered and dried in an oven at 55°C for 48 hours.

1.2.2 Induction of inflammation by carrageenan

The rats were fasted for 17 hours before the test. Paw edema (inflammation) was induced according to the method described by **Sy *et al.*, (2011)** . Except for the control group (T0), each rat received an injection under the plantar pad of the right hind paw of a 1% carrageenan solution (40 µL). The volume of the edema caused by this phlogogenic agent was measured with the caliper.

1.2.3 Treatment of animals with the extracts

After induction, the rats were divided into groups. A total of fifty (50) rats were used for this study, i.e. 10 groups of 5 rats. One group underwent no procedure (neither induction nor treatment). This group was simply fed and given water. This was the control (T0). The other rats in each group were treated intraperitoneally (ip) with the aqueous extracts and an anti-inflammatory drug used therapeutically (Ibuprofen). Table 1 presents the treatment administered to each group.

Table 1 : Treatment administered to each group after induction of inflammation

Aqueousextract		*Maceration*		*Decoction*	
Group	**Negative control**	**Group 1**	**Group 2**	**Group 3**	**Group 4**
Number of rats	5	5	5	5	5
Extract dose (mg/kg BW)	water	25	50	25	50
Meanweight (g)	172.33	157.00	173.33	149.67	176.33
Concentration (mg/mL)	-	3.925	8.666	3.742	8.816
Volume to administer (mL)	1	1	1	1	1
		Local côtelette			
Group	**Positive control**	**Group 5**	**Group 6**	**Group 7**	**Group 8**
Number of rats	5	5	5	5	5
Extract dose (mg/kg BW)	25 (Ibuprofen)	25	50	25	50
Meanweight (g)	193.33	183.67	193.67	180.33	161.33
Concentration (mg/mL)	4.833	4.592	9.683	4.508	8.066
Volume to administer (mL)	1	1	1	1	1

1.2.4 Measurement of edema size and anti-inflammatory activity

The equipment used to measure edema size is the caliper *(Figure 3).* It involves determining the swelling of the paw by using the external jaws to grip the foot (or any other affected body part) between them. The sliding part is moved until the jaws are in firm contact. The measurement is then displayed on the digital screen.

The percentage increase in paw volume was determined using the following formula:

$$\%\mathbf{AUG} = \frac{\mathbf{Paw\ volume\ (Vt) - Initial\ volume\ (V0)\ X\ 100}}{\mathbf{Initial\ volume\ (V0)}}$$

Vt = Paw volume of the treated animal at time t,
V0 = Paw volume of the T0 control

Anti-inflammatory activity was evaluated by calculating the percentage inhibition of edema (% INH),

$$\%\mathbf{INH} = \frac{\%\ \mathbf{AUG\ (negative\ control)} - \%\ \mathbf{AUG\ (treated)\ X\ 100}}{\%\ \mathbf{AUG\ (negative\ control)}}$$

%AUG = Percentage increase in paw volume.

1.2.5 Statisticalanalysis

The comparison of mean percentages of increase and inhibition was performed using Student's t-test. A significant difference is represented by $p < 0.05$ and $p < 0.01$; the graph was

constructed using the *Graph Pad Prism 10* software, n = 5 represents the number of experiments per group.

2 Results and discussion

2.1 Results

Table II presents the percentage increase in edema at 1 hour, 2 hours, and 3 hours after treatment of rats induced with carrageenan. Three hours after treatment with the extracts, a decrease in edema size was observed. This decrease was more pronounced two hours after treatment. Furthermore, animals treated with the macerate of the *Locale côtelette* variety at a dose of 25 mg/kg BW showed the lowest percentage increase, dropping from 29.22% one hour after treatment to 9.39% three hours after treatment. These results are significantly different from those of the corresponding control groups ($p < 0.05$). In addition, animals treated with the same extract (macerate of *Locale côtelette*) at a dose of 50 mg/kg BW showed percentage increases significantly different from those of the corresponding controls after two hours of treatment ($p < 0.01$)

Table II : Percentage increase in paw edema following treatment with tomato extracts.

	Dose (mg/kg BW)	Increase in pawedema (%)		
		1h	**2h**	**3h**
Control (water)	-	80.42±17.22	101.72±6.95	59.03±16.45
Ibuprofen (reference)	25	40.37±3.30**	34.37±20.66*	31.50±26.51
Cobra F1 Macerate	25	65.64±8.79	45.78±9.96*	32.90±7.29*
	50	72.90±4.32	44.69±9.51*	31.07±17.61
Cobra F1 Decoction	25	79.98±17.65	53.00±10.55*	38.80±8.55
	50	61.49±20.74	56.03±8.38*	28.15±0.09
Locale côtelette Macerate	25	29.22±11.35*	16.13±9.49*	9.39±6.16**
	50	64.67±13.33	42.59±3.24**	36.79±2.93**
Locale côtelette Decoction	25	82.26±3.90	38.62±13.13*	28.41±22.89
	50	76.14±6.43	50.78±7.37**	25.88±10.10*

**Result significantly different from the control ($p < 0.05$), **Result significantly different from the control ($p < 0.01$), n=5.*

Figure 4 presents the percentage inhibition of edema in animals treated with the extracts compared to the control groups. The tomato extracts show a percentage inhibition close to that of Ibuprofen (reference anti-inflammatory substance), with the exception of the macerate of the *Locale côtelette* variety at a dose of 25 mg/kg BW. This extract (macerate of *Locale côtelette*) shows the highest inhibition rate, exceeding 80% three hours after treatment.

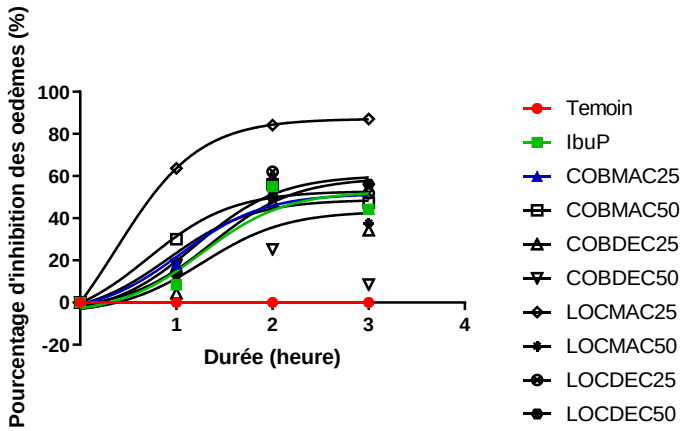

Figure 4 : Percentage inhibition of paw edema following treatment with tomato extracts.

Figures 5, 6, 7, and 8 present the hematological parameters, namely white blood cell count (WBC), hemoglobin (HBG), red blood cell count (RBC), and platelet count (PLT) of rats treated with the different extracts after 3 hours of observation. Comparing these results to those of the respective control rats, white blood cell and platelet counts did not vary considerably relative to controls. Furthermore, animals treated with extracts obtained by decoction of the tomato varieties showed hemoglobin and red blood cell levels higher than those of the respective controls at the significance threshold *($p < 0.05$).*Also, animals treated with extracts from the Locale côtelette variety showed higher red blood cell and hemoglobin levels compared to those treated with extracts from the Cobra F1 variety

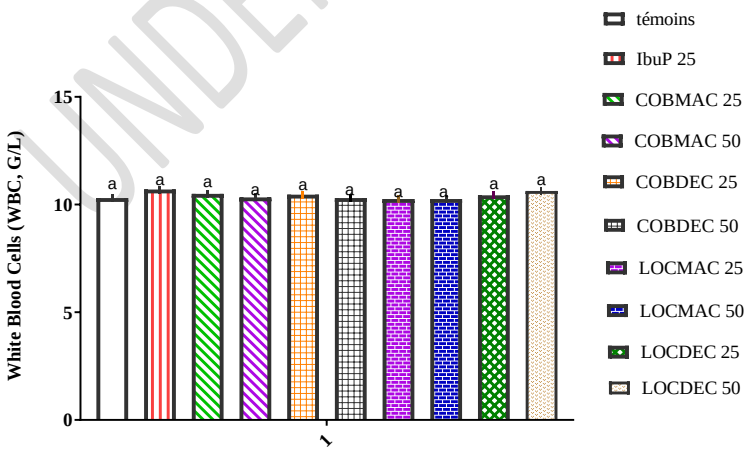

Figure 5 : White blood cell count of rats three (3) hours after treatment with tomato extracts

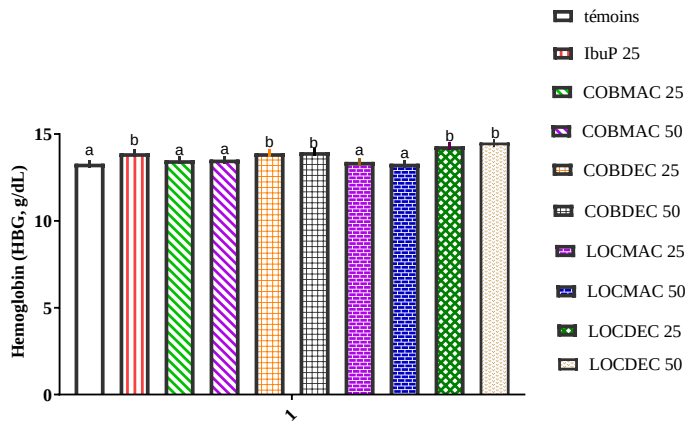

Figure 6 : Hemoglobin levels of rats three (3) hours after treatment with tomato extracts

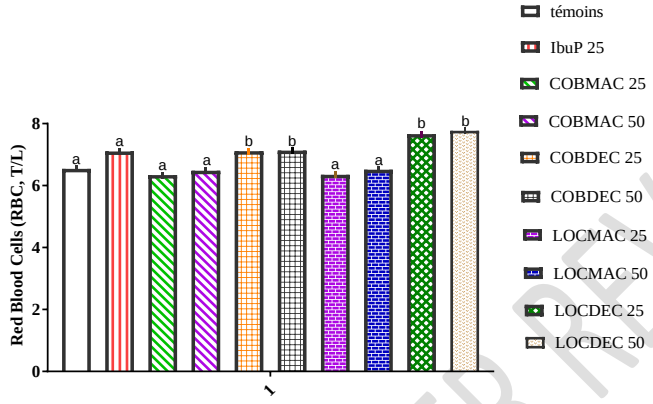

Figure 7 : Red blood cell count of rats three (3) hours after treatment with tomato extracts

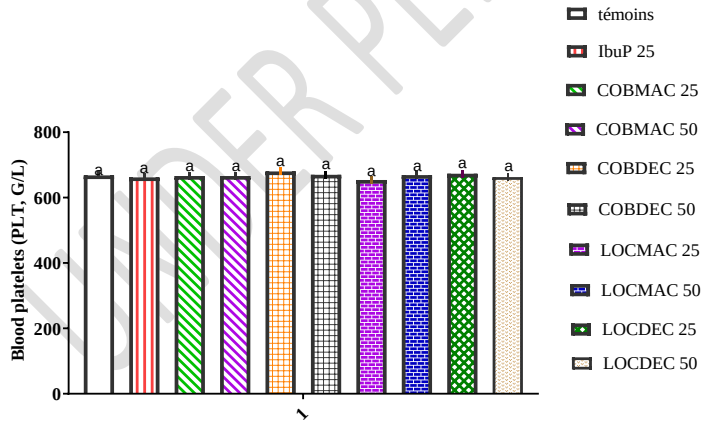

Figure 8 : Platelet count of rats three (3) hours after treatment with tomato extracts

**Result significantly different from the control ($p < 0.05$), n=5, G/L= Giga per Liter, T/L = Tera per Liter, and g/dL = Gram per deciliter.*

2.2 Discussion

Induction of inflammation in the animals (rats) with carrageenan caused edema in their paws. Following treatment of these animals with tomato extracts, a decrease in edema size was observed, ranging from 29% after 1 hour of observation to 9% after 3 hours. This reduction in edema could be due to the presence of several bioactive compounds in the tomato extracts **(Chanforan, 2010; Seddiki and Tiet Hamida, 2021)**. These bioactive compounds include notably lycopene and polyphenols.

Lycopene, the flagship compound in tomatoes, is recognized as one of the most powerful antioxidant compounds **(Laouicha, 2023; Sadoun and SiTahar, 2023)**. Its anti-inflammatory activity has been demonstrated by several authors **(Boukhari *et al.*, 2023; Chehbi and Fadila, 2018; Landri and Lina, 2020)**. Indeed, lycopene inhibits the NF-KB pathway*(Nuclear Factor kappa-light-chain-enhancer of activated B cells)* which is the activation pathway for the synthesis of inflammatory molecules **(Boucherrou, 2025; Enchery, 2017)**. NF-KB allows the cell to respond rapidly to insults (viruses, bacteria, oxidative stress) by activating hundreds of specific genes **(Le Roux, 2022; Loyer, 2023)**. Inhibition of this pathway by lycopene therefore contributes to reducing the synthesis and release of pro-inflammatory messengers such as TNF-α, IL-1β, IL-6, and IL-8. Furthermore, lycopene promotes the decrease of an enzyme involved in the inflammatory process, namely cyclooxygenase-2 (COX-2). Indeed, lycopene increases the phosphorylation of certain proteins such as AMPK-α1. This phosphorylation results in reduced expression of the COX-2 enzyme. This reduction leads to a decrease in chronic inflammation, which is the gateway to numerous diseases. These mechanisms have recently been confirmed by a review noting that lycopene also inhibits the JAK/STAT3 and MAPK pathways, further reducing the production of TNF-α, IL-1β, and IL-6 **(Carvalho and Martinez, 2025)**. This anti-inflammatory activity is not limited to isolated lycopene: a whole tomato aqueous extract recently showed, in lipopolysaccharide-stimulated RAW264.7 macrophages, a significant reduction in PGE-2, TNF-α, and IL-1β**(Adhika and Tih, 2026)**, while a tomato seed extract inhibits the expression of TNF-α and IL-1β by blocking the NF-KB transcription factor **(Kumar *et al.*, 2021)**. These observations are consistent with the results of a meta-analysis of randomized clinical trials showing that carotenoid supplementation, including lycopene, significantly reduces circulating inflammatory markers such as CRP and IL-6 **(Hajizadeh-Sharafabad et al., 2022)**.

Several phenolic compounds present in foods and plants have strong anti-inflammatory activity **(Fioroni, 2023; Moualek *et al.*, 2018).** These phenolic compounds play a crucial role in the prevention and modulation of inflammatory diseases through their antioxidant and anti-inflammatory effects. The polyphenol families responsible for these effects are flavonoids, phenolic acids, and tannins. Flavonoids reduce the production of pro-inflammatory molecules such as prostaglandins and the cytokines TNF-α and IL-6, as well as certain enzymes such as cyclooxygenase (COX) and lipoxygenase (LOX). These enzymes inhibit the metabolism of arachidonic acid, a pro-inflammatory molecule. This inhibition by certain flavonoids could contribute to reducing inflammatory processes. This mechanism has recently been supported by work showing that flavonoids simultaneously inhibit cyclooxygenase-2 (COX-2) and 5-lipoxygenase (5-LOX), the two key enzymes of the arachidonic acid pathway, giving them anti-inflammatory potential comparable to that of classic nonsteroidal anti-inflammatory drugs while limiting the gastrointestinal toxicity associated with the latter **(Al-Khayri*et al.*, 2022; Chatzipieris*et al.*, 2026).**

Furthermore, certain extracts administered to the rats led to an increase in hematological parameters (hemoglobin and red blood cells) compared to their respective controls. Red blood cells, also called erythrocytes, play a very important role in the body as they are responsible for supplying the body with oxygen. These erythrocytes contain a key component ensuring this function, namely hemoglobin (HBG). Due to its protein nature and iron content, hemoglobin plays a crucial role in the cellular respiration process. A low hemoglobin level in the body can be caused by iron deficiency, which can result in dizziness, shortness of breath, fatigue, and paleness **(Naciri, 2014; Silué *et al.*, 2023)**. The increase in red blood cell and hemoglobin levels following administration of the tomato extracts shows that tomato consumption could help prevent iron deficiency and thus promote the prevention of anemia **(WHO, 2011)** and combat fatigue **(Cheboub, 2025; Gouraud, 2020).**

These results are consistent with data from a recent review on iron deficiency, which points out that foods rich in vitamin C, such as tomatoes, promote the reduction of ferric iron (Fe3+) to ferrous iron (Fe2+) in the intestine, thereby improving the absorption of non-heme iron of plant origin **(Kolaršet *al.*, 2025)**. Regular tomato consumption, in addition to its anti-inflammatory activity, could therefore be a useful dietary supplement in preventing iron deficiency and iron-deficiency anemia, which is particularly prevalent among women of childbearing age and children in developing countries.

3 Conclusion

This work showed that the tomato varieties studied possess strong anti-inflammatory activity. Among the different extracts, the macerate of *Locale côtelette*appears to be the most effective, as it led to a decrease in inflammation of up to 80%. Moreover, these tomato extracts did not significantly affect hematological parameters. Therefore, regular consumption of these tomatoes could be a promising alternative for the prevention of inflammatory diseases.

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