UFSM

CIÊNCIA e NATURA

ISSN 2179-460X
OPEN ACCESS

Ci. e Nat., Santa Maria, v. 48, e88048, 2026 • https://doi.org/10.5902/2179460X88048
Submitted: 06/28/2024 • Approved: 10/22/2025 • Published: 15/05/2026

Chemistry

Synergistic effect of *Copaifera langsdorfii* oil with essential oils for anti-inflammatory activity

Efeito sinérgico do óleo de *Copaifera langsdorfii* com óleos essenciais para atividade anti-inflamatória

Alisson Louzeiro Barros[I], **Thamires de Jesus Teles Ribeiro**[I], **Américo Pinheiro Neto**[I], **Victor Elias Mouchrek Filho**[I], **Gustavo Oliveira Everton**[I]

[I] Universidade Federal do Maranhão, São Luís, MA, Brazil

ABSTRACT

Copaifera langsdorffii essential oil belongs to the Leguminosae family and has anti-inflammatory, antibacterial, antifungal, analgesic, healing action, antiseptic, and antitumor potential, among others. Considering the importance of essential oils, this study aims to evaluate the total phenolic content, antioxidant and anti-inflammatory activity of *Copaifera langsdorffii* essential oil and its synergistic effect in association with essential oils of *Aniba duckei Kostermans*, *Syzygium aromaticum* (L.) Merr., *Citrus limonia* Osbeck, *Citrus limettioides* Tanaka, and *Eucalyptus globulus* Labill. Essential oils were extracted by hydrodistillation technique. The determination of the total phenolic compounds of the essential oil was performed by the Folin-Ciocalteu method. Antioxidant activity was assessed by the spectrophotometric method for eliminating hydroxyl radicals from salicylic acid, while anti-inflammatory activity was assessed by the protein denaturation method. The total phenolic content of *Copaifera langsdorffii* was 63.99 mg EAT g^{-1}. The essential oil showed an antioxidant activity of EC_{50} 16.67 mg L^{-1} being classified as active, as well as the anti-inflammatory potential, with EC_{50} 52.46 mg L^{-1} also being classified as active. Finally, this study showed that the essential oil of *Copaifera langsdorffii*, as well as their synergies, have excellent antioxidant and anti-inflammatory potential.

Keywords: *Copaifera langsdorffii*; Synergism; Anti-inflammatory

RESUMO

O óleo essencial de *Copaifera langsdorffii,* pertence à família Leguminosae, apresenta propriedades anti-inflamatórias, antibacteriana, antifúngica, analgésicas, ação cicatrizante, potencial antisséptico, antitumoral e entre outras. Com vista a considerar a importância dos óleos essenciais, o estudo tem por objetivo avaliar o conteúdo fenólico total, atividade antioxidante e anti-inflamatória do óleo essencial de *Copaifera langsdorffii* e seu efeito sinérgico em associação aos óleos essenciais de *Aniba duckei* Kostermans, *Syzygium aromaticum* (L.) Merr., *Citrus limonia* Osbeck, *Citrus limettioides* Tanaka, *Eucalyptus globulus* Labill. Os óleos essenciais foram extraídos pela técnica de hidrodestilação. A determinação dos compostos fenólicos totais do óleo essencial foi realizada pelo método de Folin-Ciocalteu. A atividade antioxidante foi feita pelo método espectrofotométrico de eliminação de radicais hidroxila do ácido salicílico e a atividade anti-inflamatória foi avaliada pelo método de desnaturação proteica. O conteúdo fenólico total de *Copaifera langsdorffii* foi de 63,99 mg EAT g-1. O óleo essencial apresentou atividade antioxidante de CE_{50} 16,67 mg L^{-1} se classificando como ativo, da mesma forma com o potencial anti-inflamatório, com CE_{50} 52,46 mg L^{-1} também sendo classificado como ativo. Por fim, esse estudo mostrou que o óleo essencial de *Copaifera langsdorffii* assim como suas sinergias possuem ótimos potenciais antioxidantes e anti-inflamatórios.

Palavras-chave: *Copaifera langsdorffii*, Sinergismo, Anti-inflamatório

1 INTRODUCTION

In recent years, there has been a great scientific advance involving the chemical and pharmacological studies of medicinal plants, to obtain new compounds with therapeutic properties (Moraes, Correa e Vanin, 2018). Among the products obtained from medicinal plants, essential oils stand out. These consist of secondary metabolites, which are volatile, odoriferous, liquid substances with an oily appearance at room temperature that can be extracted from leaves, flowers, fruits, stems and roots of plants. Among the substances present in essential oils, the class of terpenes is mostly found, including their alcoholic and aldehyde derivatives (Aciole, 2009).

Another important point is the ability of oils to mix, known as synergy, which is a harmonic mixture of multiple oils. There are several essential oils with countless possibilities for combinations. In addition, the interaction potentiates the active principles and allows for a more accurate and adequate treatment (Spiassa, 2017).

The species *Copaifera langsdorffii* is one of the most studied plants. The name “copaíba” comes from the tupi kupa’ iwa which means “deposit tree” and refers to the fact that these species belong to the genus *Copaifera L.* This plant is highly valued in the market due to its multiple uses, such as in the pharmaceutical, cosmetics and perfume industries. Copaibas are also sources of raw materials for the timber industry, being highly exploited (Martini et al., 1998). Brazil is the country with the highest production and exportation of copaiba oil, as the Amazon region is the main source of raw material and its main supplier (Santana, et al, 2014).

The oil of *C. langsdorffii* has a solid and non-volatile part of resin (volatile substances are easier to detach, that is, they evaporate faster) which is formed by diterpenes responsible for 55% to 60% of the resin, and an essential oil composed of sesquiterpenes, which can be divided into oxygenated sesquiterpenes and sesquiterpene hydrocarbons, favoring its use in the pharmaceutical, cosmetic and perfumery industries (Perfecto, 2020).

Copaifera langsdorffii essential oil consists of a set of forty terpenes and paraffins, with sesquiterpenes (96.36%) as the main components, the three principal ones being α-trans-bergamotene (48.38%), α-himachalene (11.17%) and β-caryophyllene (5.47%) (Gelmini et al., 2013). This oil also has scientifically proven effects such as diuretic, laxative, anti-tetanus, healing, tumor inhibitor and anti-inflammatory action. It can be used orally and topically, as each therapeutic action of the treatment differs according to the species of each copaiba tree where the oil-resin is extracted. (Rodrigues And Souza, 2017). Thus, this study aimed to evaluate the total phenolic content, antioxidant and anti-inflammatory activity of *Copaifera langsdorffii* essential oil and its synergistic effect in association with essential oils *Aniba duckei* Kostermans, *Syzygium aromaticum* (L.) Merr., *Citrus limonia* Osbeck, *Citrus limettioides* Tanaka, and *Eucalyptus globulus* Labil.

2 METHODOLOGY

2.1 Extraction of essential oils

To extract the EOs *Copaifera langsdorffii* (barks), *Aniba duckei* Kostermans (leaves), *Syzygium aromaticum* (L.) Merr. (shoots), *Citrus limonia* Osbeck (barks), *Citrus limettioides* Tanaka (barks), and *Eucalyptus globulus* Labill (barks), the hydrodistillation technique was used with a glass Clevenger extractor coupled to a round-bottom flask placed in an electric blanket as a source of heat. 100g of plant materials were used, adding distilled water (1:10). Hydrodistillation was conducted at 100°C for 3h, collecting the extracted EO. Each EO was dried by percolation with anhydrous sodium sulfate (Na_2SO_4) and centrifuged. These operations were performed in triplicate and the samples were stored in amber glass vials under refrigeration at 4°C, then subsequently submitted to analysis.

2.2 Synergies

The identification of samples for the tests of total phenolics, antioxidant action and anti-inflammatory action followed the description presented in Table 1.

Table 1 – Identification of samples and synergies for action tests

Samples	Identification	Species	Proportion
1	OB	*Copaifera langsdorffii* essential oil	
2	OAD	*Aniba duckei* Kostermans essential oil	
3	OSA	*Syzygium aromaticum* (L.) Merr. essential oil	1:0:0
4	OCL	*Citrus lemon* Osbeck essential oil	
5	OCT	*Citrus limettioides* Tanaka essential oil	
6	OEG	*Eucalyptus globulus* Labill essential oil	
7	S1	OB+OAD	
8	S2	OB+OSA	
9	S3	OB+OCL	1:1:0
10	S4	OB+OCT	
11	S5	OB+OEG	
12	S6	OB+OAD+OSA	
13	S7	OB+OAD+OCL	
14	S8	OB+OAD+OCT	
15	S9	OB+OAD+OEG	
16	S10	OB+OSA+OCL	
17	S11	OB+OSA+OCT	1:1:1
18	S12	OB+OSA+OEG	
19	S13	OB+OCL+OCT	
20	S14	OB+OCL+OEG	
21	S15	OB+OCT+OEG	

Note: OB- *Copaifera langsdorffii* essential oil; OAD- *Aniba duckei* Kostermans *essential oil*; OSA- *Syzygium aromaticum* (L.) Merr *essential oil*.; OCL- *Citrus limonia* Osbeck essential oil; OCT- *Citrus limettioides* Tanaka essential oil ; OEG- *Eucalyptus globulus* Labill essential oil ; S1- OB+OAD; S2- OB+OSA; S3- OB+OCL; S4- OB+OCT; S5- OB+OEG; S6- OB+OAD+OSA; S7- OB+OAD+OCL; S8- OB+OAD+OCT; S9OB+OAD+OEG; S10- OB+OSA+OCL; S11- OB+OSA+OCT; S12- OB+OSA+OEG; S13- OB+OCL+OCT; S14- OB+OCL+OEG; S15- OB+OCT+OEG
Source: Autorship (2024)

2.3 Total Phenolics

The determination of the total phenolic compounds of the oils and synergies was carried out with an adaptation of the Folin-Ciocalteu method (Waterhouse, 2002). 5 mg of samples diluted in 1 mL of ethanol were used. To this solution, 7 mL of distilled water, 800 μL of Folin-Ciocalteu reagent and 2.0 mL of 20% sodium carbonate were added. After two hours, the reading was performed in triplicate by a UV-VIS spectrophotometer at a length of 760 nm. The standard curve was expressed in mg L^{-1} of tannic acid.

2.4 Evaluation of antioxidant activity by scavenging hydroxyl radicals (R-OH·)

Antioxidant activity was determined by the spectrophotometric method of elimination of hydroxyl radicals from salicylic acid, according to the methods described by Smirnoff & Cumbes (1989) and Sundararajan et al. (2016). The oils and synergies in different concentrations from 10-100 mg L were dissolved in phosphate buffered saline (PBS). To these concentrations were added 1 mL of salicylic acid (9 mM), 1 mL of ferrous sulfate (9 mM) and 1 mL of hydrogen peroxide (9 mM). Ascorbic acid was used as a positive standard. The reaction mixture was incubated for 60 min at 37 °C in a water bath; after incubation, the absorbance of the mixtures was measured at 510 nm in a UVVis spectrophotometer. The elimination of hydroxyl radicals was expressed in percentage and the Efficient Concentration 50% (IC_{50}) and 90% (IC_{90}) able to inhibit 50% and 90%, respectively, of the elimination was expressed in mg L.

2.5 Anti-inflammatory activity by albumin protein denaturation

The anti-inflammatory activity was evaluated by the albumin protein denaturation method by thermal degradation (Padmanabhan & Jangle, 2012). The reaction mixture (4000 μL) consisted of 1000 μL of different concentrations of oils and synergies (100-500 mg L^{-1}) diluted in PBS and 2000 μL of a 10% albumin solution diluted in PBS and incubated at (37±1) ° C for 15 minutes. Denaturation was induced by keeping the reaction mixture at 70°C in a water bath for 10 minutes. After cooling, absorbance was measured at 660 nm in a UV Vis spectrophotometer. Inhibition of protein denaturation was expressed in percentage and the 50% Efficient Concentration (IC_{50}) capable of inhibiting 50% of denaturation was expressed in mg L^{-1}.

3 RESULTS AND DISCUSSION

3.1 Total Phenolics

Table 2 – Total phenolic content (mg EAT g-1) for the tested oils and synergies

Identification	CFT (mg EAT/g)	Equation	R^2
OB	63.99		
OAD	58.08	y=0.0586x+0.06	0.9999
OSA	179.26		
OCL	217.34		
OCT	228.54		
OEG	124.86		
S1	177.54		
S2	200.00		
S3	221.63		
S4	231.22		
S5	213.88		
S6	328.43		
S7	249.05		
S8	286.57		
S9	250.56		
S10	332.27		
S11	342.14		
S12	319.40		
S13	251.73		
S14	268.00		
S15	279.43		

Note: OB- *Copaifera langsdorffii* essential oil; OAD- *Aniba duckei* Kostermans *essential oil*; OSA- *Syzygium aromaticum* (L.) Merr *essential oil*.; OCL- *Citrus limonia* Osbeck essential oil; OCT- *Citrus limettioides* Tanaka essential oil ; OEG- *Eucalyptus globulus* Labill essential oil ; S1- OB+OAD; S2- OB+OSA; S3- OB+OCL; S4- OB+OCT; S5- OB+OEG; S6- OB+OAD+OSA; S7- OB+OAD+OCL; S8- OB+OAD+OCT; S9OB+OAD+OEG; S10- OB+OSA+OCL; S11- OB+OSA+OCT; S12- OB+OSA+OEG; S13- OB+OCL+OCT; S14- OB+OCL+OEG; S15- OB+OCT+OEG

Source: Autorship (2024)

The result of the quantification of the total phenolic content of the essential oils is shown in Table 1. The total phenolic content (TPC) was expressed as tannic acid equivalents (mg EAT g-1 of plant material) the equation of the straight line obtained was y = 0.0586x + 0.06 (R^2 = 0.9999), where y represents the absorbance and x equivalent concentration of tannic acid.

With the end of the analysis, it was observed that the result with the highest individual phenolic content was the essential oil of *Citrus limettioides* Tanaka (OCT) of 228.54 mg EAT g-1 and in synergy were from *Copaifera langsdorffi, Syzygium aromaticum* (L.) Merr. and *Citrus limettioides* Tanaka (S11), of 342.14 mg EAT g-1. Lower results for total phenolics of *Copaifera langsdorffii* oil were found by Vigo (2019) who presented values of 0.49 mg EAT g^{-1} when analyzing oil in the province of Coronel Portillo, Ucayali. Similarly, Penido et al. (2017) found a lower value of 48.03 mg EAT g^{-1}. Regarding *Aniba duckei* Kostermans essential oil, Zieniuk & Betkowska (2021) showed a lower value of 0.11 mg EAG g^{-1} in Warsaw, Poland. Likewise, Sankomkai et al. (2017) also observed a lower value of 23.65 mg EAG g^{-1}. Regarding *Syzygium aromaticum* (L.) Merr essential oil; values were found with better efficacy by Turgay & Esen (2015), being 560 mg EAG g^{-1}. Ramadan (2013) found a result of 5.9 mg EAG g^{-1} which had a lower efficacy. As for the essential oil of *Citrus limonia* Osbeck, a lower value was found by Gravena et al. (2009) who presented 14.5 mg EAG g^{-1}. Consistely, Mehmood et al. (2020) also presented a lower value of 138.66 mg EAG g^{-1}.

In regard to the essential oil of *Citrus limettioides* Tanaka, a higher value was observed by Moraes Barros et al. (2012) which reported 310.18 mg EAG g^{-1}. However, Sankomkai et al. (2017) indicated 12.13 mg EAG g^{-1} being a lower result. Superior results for total phenolics of *Eucalyptus globulus Labill oil* were mentioned per Dezsi et al. (2015) which presented 235.87 mg EAG g^{-1}. It also reported an inferior finding by Lin et al. (2009) which presented 6.79 mg EAG g^{-1}.

3.2 Antioxidant activity

Table 3 presents the results of the oils' antioxidant activities and synergies.

Table 3 – Efficient Concentration 50% (EC_{50}-IC_{50}) for antioxidant action of oils and synergies

Identification	CE_{50} mg L^{-1}	Equation	R^2
OB	16.67	y = 27.651x + 16.212	0.9934
OAD	22.17	y = 26.226x + 14.704	0.9968
OSA	20.53	y = 18.855x + 25.255	0.9984
OCL	67.21	y = 21.142x + 11.365	0.9952
OCT	20.38	y = 21.359x + 22.037	0.9919
OEG	14.00	y = 33.036x + 12.136	0.9969
S1	13.94	y = 30.008x + 15.663	0.9934
S2	15.03	y = 27.246x + 17.93	0.9971
S3	14.66	y = 31.851x + 12.854	0.9914
S4	21.06	y = 31.533x + 8.2674	0.9921
S5	32.29	y = 30.915x + 3.3487	0.9911
S6	11.38	y = 23.943x + 24.713	0.9905
S7	10.61	y = 25.352x + 23.988	0.991
S8	12.55	y = 28.833x + 18.317	0.9937
S9	14.09	y = 23.034x + 23.535	0.9934
S10	46.88	y = 25.272x + 7.7696	0.9993
S11	28.86	y = 27.616x + 9.669	0.9948
S12	46.36	y = 13.672x + 27.22	0.9997
S13	66.73	y = 20.419x + 12.748	0.9958
S14	17.31	y = 40.049x + 0.3999	0.9917
S15	28.33	y = 30.151x + 6.2093	0.9947

Note: OB- *Copaifera langsdorffii* essential oil; OAD- *Aniba duckei* Kostermans *essential oil*; OSA- *Syzygium aromaticum* (L.) Merr *essential oil*.; OCL- *Citrus limonia* Osbeck essential oil; OCT- *Citrus limettioides* Tanaka essential oil ; OEG- *Eucalyptus globulus* Labill essential oil ; S1- OB+OAD; S2- OB+OSA; S3- OB+OCL; S4- OB+OCT; S5- OB+OEG; S6- OB+OAD+OSA; S7- OB+OAD+OCL; S8- OB+OAD+OCT; S9OB+OAD+OEG; S10- OB+OSA+OCL; S11- OB+OSA+OCT; S12- OB+OSA+OEG; S13- OB+OCL+OCT; S14- OB+OCL+OEG; S15- OB+OCT+OEG.
Source: Autorship (2024)

According to Table 3, all analyzed bioproducts and synergies were classified as active, according to the criteria of Campos et al. (2003). Since they have a concentration of less than 500 mg L^{-1}. According to Sousa et al. (2011), the lower the EC_{50} value, the greater the activity of the plant compound, as a lower concentration of oil is required to reduce the radical by 50%.

With the end of the analyzes it was observed that the result of the best individual antioxidant activity was the essential oil of *Eucalyptus globulus* Labill of 22.17 μg mL^{-1} and in synergy were the oils of *Copaifera langsdorffii, Aniba duckei* Kostermans and *Citrus lemon* Osbeck (S7) of 10.61 μg mL^{-1}.

With regard to the essential oil of *Copaifera langsdorffii,* when evaluating the antioxidant activity was found by Carmo et al. (2016) a more effective value of EC_{50} 3.95μg mL^{-1}. Like Costa et al. (2015) who also presented a more efficient result of 10.52μg mL^{-1}. In reference to *Aniba duckei* Kostermans essential oil, Teles et al. (2020) when evaluating the antioxidant activity, found a more efficient value of EC_{50} 15.46μg mL^{-1}. However, Ferreira et al. (2020) found a lower value of EC_{50} 40.06 μg mL^{-1}.

When evaluating the antioxidant activity of the essential oil of *Syzygium aromaticum*, Selles et al. (2020) results in EC_{50} 4.82 μg mL^{-1} which is a more efficient result. However, Alfikri et al. (2020) found a less efficient EC_{50} value of 22.2 μg mL^{-1}. About the essential oil *Citrus limonia* Osbeck, Bhuvaneswari et al. (2020) ends up finding a less efficient value of 150 μg mL^{-1} when analyzing the antioxidant activity. Like Osanloo et al. (2021) who had 1280 μg mL^{-1} as a result.

About the essential oil of *Citrus limettioides* Tanaka, in the analyzes of the antioxidant activity Barros et al. (2012) found a more effective EC_{50} value of 7.44 μg mL^{-1}. Like Janoti et al. (2014) who also had a more efficient result of EC_{50} 15.35 μg mL^{-1}. Regarding the antioxidant activity of the essential oil of *Eucalyptus globulus* Labill, inferior results were found by Dezsi et al. (2015) who showed EC_{50} 15.27 μg mL^{-1}. However, Lin et al. (2009) found a more efficient EC_{50} value of 12.53 μg mL^{-1}.

The observed antioxidant actions may represent the presence of compounds capable of delaying or inhibiting the oxidation process through the inactivation of radicals. Phenolic compounds, for example, determined in the previous item, fit into this category, acting as switches in reaction chains, making them stable or creating antioxidant lipid complexes (Luzia & Jorge, 2009).

Copaifera langsdorffii essential oil, used in all synergies consists of a set of forty terpenes and paraffins, consisting of sesquiterpenes (96.36%), the three main ones being α-trans-bergamotene (48.38%), α-himachalene (11.17%), β-caryophyllene (5.47%). These properties are not due to the presence of phenolic, polyphenolic species, but to various volatile sesquiterpenes and the concomitant presence of unsaturated diterpene acid components (of which copalic acid is the most abundant in *Copaifera langsdorffii*, followed by abietic acid, polyaltic acid, kaurenoic acid and diterpene and sesquiterpene species (Gelmini et al. 2013).

Finally, synergism as an improvement in antioxidant activity is stated by Halliwell & Gutteridge (2015) when they define antioxidant synergism as the effect of the interaction between different bioactive compounds and/or macronutrients, which provide an antioxidant effect greater than the sum of the expected antioxidant effects for individual species.

3.3 Anti-inflammatory activity

The results obtained for the anti-inflammatory action regarding the analyzed oils and synergies are shown in Table 4.

According to Table 4, the essential oil was classified as active, according to the criteria of Jonville et al. (2011): very active EC_{50} < 50 mg L^{-1}; EC_{50} active between 50-130 mg L^{-1} and moderate EC_{50} greater than 130 mg L^{-1}. At the end of the analysis, it was observed that the essential oil of *Citrus limettioides* Tanaka (OCT) of 28.02 μg mL^{-1} had the best individual anti-inflammatory activity, while the essential oils of *Copaifera langsdorffii* and *Syzygium aromaticum* (S2) 31.91 μg mL^{-1} had the best synergy.

The anti-inflammatory potential of essential oils, as observed in this study, is attributed to their ability to scavenge free radicals, since the inflammatory response normally involves oxidative stress, and to their interactions with signaling cascades involving cytokines and regulatory transcription factors, and to the expression of pro-inflammatory genes (Miguel, 2010; Boscardin, 2012).

Table 4 – Efficient Concentration 50% (EC_{50}-IC_{50}) for anti-inflammatory action of oils and synergies

Identification	CE_{50} mg L^{-1}	Equation	R^2
OB	52.46	y = 1.6891x + 47.095	0.9991
OAD	153.32	y = 15.275x + 16.615	0.9951
OSA	86.30	y = 16.643x + 17.779	0.9985
OCL	42.44	y = 3.1036x + 44.948	0.9951
OCT	28.02	y = 3.7209x + 44.614	0.9967
OEG	100.50	y = 4.0481x + 41.895	0.9999
S1	198.39	y = 2.6768x + 43.85	0.9986
S2	31.91	y = 5.6581x + 41.491	0.9963
S3	47.86	y = 2.6638x + 45.525	0.996
S4	171.31	y = 3.7x + 41.735	0.995
S5	372.27	y = 13.385x + 12.913	0.9947
S6	117.53	y = 19.642x + 9.3384	1
S7	57.23	y = 39.364x - 19.188	0.9933
S8	177.92	y = 15.118x + 15.981	0.9982
S9	252.64	y = 6.4083x + 34.604	0.999
S10	133.95	y = 3.7053x + 42.119	0.9914
S11	275.54	y = 5.3098x + 37.188	0.9985
S12	91.27	y = 5.3098x + 37.188	0.9958
S13	36.69	y = 5.3098x + 37.188	0.9973
S14	258.75	y = 5.3098x + 37.188	0.9982
S15	36.41	y = 2.5805x + 45.971	0.9996

Note: OB- *Copaifera langsdorffii* essential oil; OAD- *Aniba duckei* Kostermans *essential oil*; OSA- *Syzygium aromaticum* (L.) Merr *essential oil*.; OCL- *Citrus limonia* Osbeck essential oil; OCT- *Citrus limettioides* Tanaka essential oil ; OEG- *Eucalyptus globulus* Labill essential oil ; S1- OB+OAD; S2- OB+OSA; S3- OB+OCL; S4- OB+OCT; S5- OB+OEG; S6- OB+OAD+OSA; S7- OB+OAD+OCL; S8- OB+OAD+OCT; S9OB+OAD+OEG; S10- OB+OSA+OCL; S11- OB+OSA+OCT; S12- OB+OSA+OEG; S13- OB+OCL+OCT; S14- OB+OCL+OEG; S15- OB+OCT+OEG

Source: Autorship (2024)

Among the most common chemical groups of natural origin with possible anti-inflammatory effect we can mention phenolic compounds, lignans, terpenes (sesquiterpenes, diterpenes, triterpenes, clerodanes and saponins), some phytosteroids and alkaloids (Calixto et al. 2004).

The component of copaiba oil responsible for the anti-inflammatory effect has not yet been definitively confirmed, but several studies attribute this activity mainly to β- caryophyllene (Leandro et al., 2012; Veiga Júnior et al., 2007). Likewise, the anti-inflammatory mechanism of copaiba oil has not yet been adequately proven. However, Gelmini et al. (2013) analyzing the action of the chemical components of copaiba oil on the secretion of cytokines, demonstrated that there is an inhibition of the translocation of the NFκB protein complex from the cytosol to the nucleus, thus explaining the health benefits resulting from topical or upon oil administration. Finally, an additional mechanism that contributes to the anti-inflammatory activity of phenolic compounds is their ability to regulate the cellular redox state through antioxidant action by capturing free radicals, thus reducing the inductive signal in the production of cytokines and factors transcriptional (NFκB) (González-Gallego et al., 2007).

4 CONCLUSIONS

This study showed a great action of *Copaifera langsdorffi* essential oil, where a great result was obtained individually, mainly in the antioxidant activity, being the second-best result. Antioxidant activity obtained excellent results, mainly since all tests were classified as active. However, the anti-inflammatory action, even showing only 12 active results from the 21 samples, obtained promising results.

Therefore, based on the results, it was possible to conclude that the good anti-inflammatory action observed can be justified both due to the phenolic compounds that regulate the redox state through the antioxidant action by capturing free radicals, as well as the presence of the various volatile sesquiterpenes and the concomitant presence of unsaturated diterpene acid components of which copalic acid is the most abundant in *Copaifera langsdorffii*.

REFERENCES

Aciole, S. D. G. (2009). *Avaliação da Actividade Insecticida Dos Óleos Essenciais Nas Plantas Amazônicas Annonaceae, Boraginaceae e de Mata Atlântica Myrtaceae como Alternativa De Controle às Larvas de Aedes aegypti (Linnaeus, 1762) (Diptera: Culicidae)* [Master's thesis, Universidade de Lisboa (Portugal)]. https://repositorio.ul.pt/bitstream/10451/1418/1/20478_ulfc080628_tm.pdf

Alfikri, F. N., Pujiarti, R., Wibisono, M. G., & Hardiyanto, E. B. (2020). Yield, quality, and antioxidant activity of clove (Syzygium aromaticum L.) bud oil at the different phenological stages in young and mature trees. *Scientifica*, 2020(1), 9701701. doi: https://doi.org/10.1155/2020/9701701

Bhuvaneswari, G., Thirugnanasampandan, R., & Gogulramnath, M. (2020). Effect of colchicine induced tetraploidy on morphology, cytology, essential oil composition, gene expression and antioxidant activity of Citrus limon (L.) Osbeck. *Physiology and Molecular Biology of Plants*, 26, 271-279. doi: https://doi.org/10.1007/s12298-019-00718-9

Boscardin, P. M. D. (2012). *Avaliação anti-inflamatória e citotóxica do óleo essencial de Eucalyptus Benthamii Maiden et Cambage*. https://hdl.handle.net/1884/28038

Calixto, J. B. (2004). Anti-inflammatory compounds of plant origin. Part II. Modulation of pro-inflammatory cytokines, chemokines and adhesion molecules. *Planta Med*, *70*, 93-103.

Campos, K. E., Diniz, Y. S., Cataneo, A. C., Faine, L. A., Alves, M. J. Q. F., & Novelli, E. L. B. (2003). Hypoglycaemic and antioxidant effects of onion, Allium cepa: dietary onion addition, antioxidant activity and hypoglycaemic effects on diabetic rats. *International journal of food sciences and nutrition*, 54(3), 241-246. doi: https://doi.org/10.1080/09637480120092062

Campos, M. G., Webby, R. F., Markham, K. R., Mitchell, K. A., & Da Cunha, A. P. (2003). Age-induced diminution of free radical scavenging capacity in bee pollens and the contribution of constituent flavonoids. *Journal of agricultural and food chemistry*, 51(3), 742-745. doi: https://doi.org/10.1021/jf0206466

Carmo, J. F., Miranda, I., Quilhó, T., Sousa, V. B., Cardoso, S., Carvalho, A. M., & Pereira, H. (2016). Copaifera langsdorffii bark as a source of chemicals: Structural and chemical characterization. *Journal of Wood Chemistry and Technology*, 36(5), 305-317. doi: https://doi.org/10.1080/02773813.2016.1140208

Costa, A. R., Freitas, L. A., Mendiola, J., & Ibáñez, E. (2015). Copaifera langsdorffii supercritical fluid extraction: Chemical and functional characterization by LC/MS and in vitro assays. *The Journal of Supercritical Fluids*, 100, 86-96. doi: https://doi.org/10.1016/j.supflu.2015.02.028

Dezsi, Ș., Bădărău, A. S., Bischin, C., Vodnar, D. C., Silaghi-Dumitrescu, R., Gheldiu, A. M., ... & Vlase, L. (2015). Antimicrobial and antioxidant activities and phenolic profile of Eucalyptus globulus Labill. and Corymbia ficifolia (F. Muell.) KD Hill & LAS Johnson leaves. *Molecules*, 20(3), 4720-4734. doi: https://doi.org/10.3390/molecules20034720

Ferreira, A. M., Mouchrek Filho, V. E., Mafra, N. S. C., Sales, E. H., Júnior, P. S. S., & Everton, G. O. (2020). Constituintes químicos, toxicidade, potencial antioxidante e atividade larvicida frente a larvas de Aedes aegypti do óleo essencial de Aniba rosaeodora Ducke. *Research, Society and Development*, 9(8), e520985663-e520985663. doi: https://doi.org/10.33448/rsd-v9i8.5663

Gelmini, F., Beretta, G., Anselmi, C., Centini, M., Magni, P., Ruscica, M., Cavalchini, A., & Facino, R. M. (2013). GC–MS profiling of the phytochemical constituents of the oleoresin from Copaifera langsdorffii Desf. and a preliminary in vivo evaluation of its antipsoriatic effect. *International journal of pharmaceutics*, 440(2), 170-178. doi: https://doi.org/10.1016/j.ijpharm.2012.08.021

González-Gallego, J., Sánchez-Campos, S., & Tunon, M. J. (2007). Anti-inflammatory properties of dietary flavonoids. *Nutrición hospitalaria*, 22(3), 287-293. https://www.redalyc.org/pdf/3092/309226717002.pdf

Gravena, R., Victoria Filho, R., Alves, P. L. C., Mazzafera, P., & Gravena, A. R. (2009). Low glyphosate rates do not affect Citrus limonia (L.) Osbeck seedlings. *Pest Management Science: Formerly Pesticide Science*, 65(4), 420-425. doi: https://doi.org/10.1002/ps.1694

Halliwell, B., & Gutteridge, J. M. (2015). *Free radicals in biology and medicine*. Oxford university press. doi:

Janoti, D. S., Rana, M., & Rawat, A. K. S. (2014). Comparative antioxidant activity of essential oil of leaves of Citrus limettioides and Citrus pseudolimon of Nainital District. *Journal of Pharmacognosy and Phytochemistry*, 2(5), 24-26. doi: https://doi.org/10.1016/j.jep.2007.03.005

Jonville, M. C., Kodja, H., Strasberg, D., Pichette, A., Ollivier, E., Frédérich, M., ... & Legault, J. (2011). Antiplasmodial, anti-inflammatory and cytotoxic activities of various plant extracts from the Mascarene Archipelago. *Journal of ethnopharmacology*, 136(3), 525-531. doi: https://doi.org/10.1016/j.jep.2010.06.013

Leandro, L. M., de Sousa Vargas, F., Barbosa, P. C. S., Neves, J. K. O., Da Silva, J. A., & da Veiga-Junior, V. F. (2012). Chemistry and biological activities of terpenoids from copaiba (Copaifera spp.) oleoresins. *Molecules*, 17(4), 3866-3889. doi: https://doi.org/10.3390/molecules17043866

Lin, C. W., Yu, C. W., Wu, S. C., & Yih, K. H. (2009). DPPH free-radical scavenging activity, total phenolic contents and chemical composition analysis of forty-two kinds of essential oils. *Journal of food and drug analysis*, 17(5), 9. doi: https://doi.org/10.38212/2224-6614.2594

Luzia, D. M. M., & Jorge, N. (2009). Atividade antioxidante do extrato de sementes de limão (Citrus limon) adicionado ao óleo de soja em teste de estocagem acelerada. *Química Nova*, 32, 946-949. doi: https://doi.org/10.1590/S0100-40422009000400022

Martini, A., Rosa, N. A., & Uhl, C. (1998). Espécies madeireiras da Amazônia potencialmente ameaçadas. *Série Amazônia*, (11). https://api.semanticscholar.org/CorpusID:163137411

Mehmood, T., Afzal, A., Anwar, F., Memon, N., Memon, A. A., & Qadir, R. (2020). Variation in phenolic acids and antibacterial attributes of peel extracts from ripe and unripe [Citrus limon (L.) Osbeck] fruit. *Journal of Food Measurement and Characterization*, 14, 1325-1332. doi: https://doi.org/10.1007/s11694-020-00380-w

Miguel, M. G. (2010). Antioxidant and anti-inflammatory activities of essential oils: a short review. *Molecules*, 15(12), 9252-9287. doi: https://doi.org/10.3390/molecules15129252

Moraes Barros, H. R., de Castro Ferreira, T. A. P., & Genovese, M. I. (2012). Antioxidant capacity and mineral content of pulp and peel from commercial cultivars of citrus from Brazil. *Food chemistry*, 134(4), 1892-1898. doi: https://doi.org/10.1016/j.foodchem.2012.03.090

Moraes, R. P., Correa, I. C., & Vanin, A. B. (2018). Toxicidade dos óleos essenciais de endro (Anethum graveolens) e nim (Azadirachta indica A. Juss) através do ensaio de bioletalidade utilizando Artemia salina. *Seminário de Iniciação Científica e Seminário Integrado de Ensino, Pesquisa e Extensão (SIEPE)*. https://periodicos.unoesc.edu.br/siepe/article/view/17928

Osanloo, M., Ghanbariasad, A., Taghinezhad, A. (2021). Antioxidant and anticancer activities of Anethum graveolens L., Citrus limon (L.) Osbeck and Zingiber officinale Roscoe essential oils. *Traditional and Integrative Medicine*, 333-347. doi: https://doi.org/10.18502/tim.v6i4.8266

Padmanabhan, P., & Jangle, S. N. (2012). Evaluation of in-vitro anti-inflammatory activity of herbal preparation, a combination of four medicinal plants. *International journal of basic and applied medical sciences*, 2(1), 109-116. https://api.semanticscholar.org/CorpusID:111380163

Perfecto, R. (2020). Um produto natural de possível suporte para o tratamento da periodontite: revisão bibliográfica. *Av Odontoestomatol*, *36*(3). doi: https://dx.doi.org/10.4321/s0213-12852020000300003

Penido, A. B., De Morais, S. M., Ribeiro, A. B., Alves, D. R., Rodrigues, A. L. M., Dos Santos, L. H., & de Menezes, J. E. S. A. (2017). Medicinal plants from northeastern Brazil against Alzheimer's disease. *Evidence-Based Complementary and Alternative Medicine*, *2017*(1), 1753673.

Ramadan, M. F. (2013). Healthy blends of high linoleic sunflower oil with selected cold pressed oils: Functionality, stability and antioxidative characteristics. *Industrial Crops and Products*, 43, 65-72. doi: https://doi.org/10.1016/j.indcrop.2012.07.013

Rodrigues, R., & Souza, J. (2017). Utilização do óleo de copaíba no tratamento e cicatrização de lesões. *Revista Interdisciplinar de Ciências Médicas–Anais*, 1(4), 168.

Sankomkai, W., Suttisunsanee, U., Somsong, P., & Srichamnong, W. (2018, August). Effect of storage temperature on antioxidant activities of Citrus medica L. var. limetta. In 4th Asia Symposium on Quality Management in Postharvest Systems (pp. 257-262). *International Society for Horticultural Science*. doi: 10.17660/ActaHortic.2018.1210.36

Santana, S., Bianchini-Pontuschka, R., Bay Hurtado, F., de Oliveira, C. A., Rodrigues Melo, L. P., & dos Santos, G. J. (2014). Uso medicinal do óleo de copaíba (Copaifera sp.) por pessoas da melhor idade no município de Presidente Médici, Rondônia, Brasil. *Acta Agronómica*, 63(4), 361-366. doi: https://doi.org/10.15446/acag.v63n4.39111

Selles, S. M. A., Kouidri, M., Belhamiti, B. T., & Ait Amrane, A. (2020). Chemical composition, in-vitro antibacterial and antioxidant activities of Syzygium aromaticum essential oil. *Journal of Food Measurement and Characterization,* 14(4), 2352-2358. doi: https://doi.org/10.1007/s11694-020-00482-5

Smirnoff, N., & Cumbes, Q. J. (1989). Hydroxyl radical scavenging activity of compatible solutes. *Phytochemistry*, 28(4), 1057-1060. doi: https://doi.org/10.1016/0031-9422(89)80182-7

Sousa, M. S. B., Vieira, L. M., & Lima, A. D. (2011). Fenólicos totais e capacidade antioxidante in vitro de resíduos de polpas de frutas tropicais. *Brazilian Journal of Food Technology*, *14*, 202-210. doi: https://doi.org/10.4260/BJFT2011140300024

Spiassa, V. Aromaterapia: Uma abordagem sistêmica e multidisciplinar na estética e bemestar. Óleos essenciais. 2017. https://pt.scribd.com/document/426136045/Aromaterapia-Uma-Abordagem-Sistematica-e-Multidisciplinar-Na-Estetica-e-Bem-Estar-Vanessa-Spiassa

Sundararajan, B., Mahendran, G., Thamaraiselvi, R., & Ranjitha Kumari, B. D. (2016). Biological activities of synthesized silver nanoparticles from Cardiospermum halicacabum L*. Bulletin of Materials Science*, 39, 423-431. doi: https://doi.org/10.1007/s12034-016-1174-2

Teles, A. M., Silva-Silva, J. V., Fernandes, J. M. P., Calabrese, K. D. S., Abreu-Silva, A. L., Marinho, S. C., ... & Almeida-Souza, F. (2020). Aniba rosaeodora (Var. amazonica Ducke) essential oil: Chemical composition, antibacterial, antioxidant and antitrypanosomal activity. *Antibiotics*, 10(1), 24. doi: https://doi.org/10.3390/antibiotics10010024

Turgay, O., & Esen, Y. (2015). Antioxidant, total phenolic and antimicrobial characteristics of some species. *Bulgarian Journal of Agricultural Science*, 21(3), 498-503. https://www.agrojournal.org/21/03-05.pdf

Veiga Junior, V., Rosas, E. C., Carvalho, M. V. D., Henriques, M. G. M. O., & Pinto, A. C. (2007). Chemical composition and anti-inflammatory activity of copaiba oils from Copaifera cearensis Huber ex Ducke, Copaifera reticulata Ducke and Copaifera multijuga Hayne—A comparative study. *Journal of ethnopharmacology*, *112*(2), 248-254. doi: https://doi.org/10.1016/j.jep.2007.03.005

Vigo, S. L. (2019). *Compuestos bioactivos y capacidad antioxidante de extractos de hoja de sacha culantro (Erynguim foetidum L.) y de aceite de copaiba (Copaifera paupera) procedentes de la provincia de Coronel Portillo, Ucayal*i. https://hdl.handle.net/20.500.12805/741

Waterhouse, A. L. (2002). Determination of total phenolics. *Current protocols in food analytical chemistry*, 6(1), I1-1. doi: https://doi.org/10.1002/0471142913.fai0101s06

Zieniuk, B., & Bętkowska, A. (2021, October). Mixture design as a tool for optimization of antimicrobial activity of selected essential oils. *In Biology and Life Sciences Forum* (Vol. 6, No. 1, p. 98). MDPI. doi: https://doi.org/10.3390/Foods2021-11018

Authorship contributions

1 – Alisson Louzeiro Barros

Bachelor's degree in Chemistry from UFMA.
https://orcid.org/0000-0002-0457-914X • alisson.barros@discente.ufma.br
Contribution: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Visualization, Writing– original draft, Writing– review editing.

2 – Thamires de Jesus Teles Ribeiro

Bachelor’s degree in Chemistry from UFMA.
https://orcid.org/0000-0003-1495-9282 • thamiresbelle@gmail.com
Contribution: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Visualization, Writing– original draft, Writing– review editing.

3 – Américo Pinheiro Neto

Bachelor’s degree in Industrial Chemistry from UFMA.
https://orcid.org/0009-0005-6095-0336 • americo.pn@discente.ufma.br
Contribution: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Resources, Software, Visualization, Writing– original draft, Writing– review editing.

4 – Victor Elias Mouchrek Filho

Full Professor at UFMA.
https://orcid.org/0000-0003-2855-7292 • gustavo.oliveira@discente.ufma.br
Contribution: Funding acquisition, Project administration.

5 – Gustavo Oliveira Everton

PhD in Chemistry from UFMA.
https://orcid.org/0000-0002-0457-914X • gustavooliveiraeverton@gmail.com
Contribution: Conceptualization, Data, Curation, Formal Analysis, Funding, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing – original draft, Writing – review editing.

How to quote this article

Barros, A. L., Ribeiro, T. de J. T., Pinheiro Neto, A., Mouchrek Filho, V. E. & Everton, G. O. Synergistic effect of *Copaifera langsdorfii* oil with essential oils for anti-inflammatory activity. (2026). *Ciência e Natura*, Santa Maria, 48, e88048. DOI: https://doi.org/10.5902/2179460x88048.