



EFFICACY OF MEDICINAL PLANTS IN THE *IN VITRO* CONTROL OF *CANDIDA ALBICANS*

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ABSTRACT

Objective: The aim of this study was to evaluate *in vitro* the effect of medicinal plants on *Candida albicans*.

Theoretical Framework: *Candida albicans* is a yeast present in the human microbiota considered as an opportunistic pathogen, which in times of low resistance can invade tissues, organs and even cause systemic diseases. The resistance of *C. albicans* to antifungals has caused recurrences, requiring the search for therapeutic alternatives, such as the use of herbal medicines.

Method: Infusions of *Cymbopogon citratus*, *Citrus limon*, *Eucalyptus citriodora*, *Caryophyllus aromaticus* and *Origanum vulgare* on *Candida albicans* strain were used. Minimum inhibitory and fungicidal concentrations were used in the study. Descriptive statistics was used with the Kruskal-Wallis non-parametric test approach with Dunn's post-hoc multiple comparison test, with 0.05 significance.

Results and Discussion: All infusions demonstrated antifungal efficacy against *C. albicans*, though effectiveness varied significantly by plant species and exposure time. While *Citrus limon* (lowest MIC: 5%) required extended exposure for complete eradication, *Eucalyptus citriodora* exhibited rapid initial action. These findings align with prior studies on essential oils but uniquely highlight infusions as accessible alternatives. Synergy studies are warranted to optimize therapeutic potential.

Research Implications: Infusions of these plants could serve as low-cost, low-toxicity therapies for candidiasis, especially in resource-limited settings. Future work should validate efficacy *in vivo* and explore synergistic combinations. Supports Brazil's policy promoting sustainable use of biodiversity in public health.

Originality/Value: First comparative study of infusions (traditional preparation) against *C. albicans*, revealing time-dependent fungicidal kinetics. Demonstrates that infusions, not just essential oils, have clinical relevance, bridging traditional medicine with evidence-based practice.

Keywords: *Candida albicans*, Candidiasis, Treatment Failure, Medicinal Plants, Phytotherapy.

EFICÁCIA DE PLANTAS MEDICINAIS NO CONTROLE *IN VITRO* DE *CANDIDA ALBICANS*

RESUMO

Objetivo: Avaliar *in vitro* o efeito de plantas medicinais sobre *Candida albicans*.

Referencial Teórico: *Candida albicans* é uma levedura comensal da microbiota humana, considerada patógeno oportunista que, em condições de baixa resistência, pode invadir tecidos, órgãos e causar doenças sistêmicas. A resistência a antifúngicos tem gerado recorrências, demandando alternativas terapêuticas como fitoterápicos.

Método: Foram utilizadas infusões de *Cymbopogon citratus*, *Citrus limon*, *Eucalyptus citriodora*, *Caryophyllus aromaticus* e *Origanum vulgare* sobre linhagem de *C. albicans*. Determinaram-se Concentração Inibitória Mínima (CIM) e Concentração Fungicida Mínima (CFM). A análise estatística empregou teste não paramétrico de Kruskal-Wallis com pós-teste de Dunn (significância: 0,05).

Resultados e Discussão: Todas as infusões demonstraram eficácia antifúngica contra *C. albicans*, com variação temporal significativa. *Citrus limon* (menor CIM: 5%) exigiu exposição prolongada para erradicação total, enquanto *Eucalyptus citriodora* apresentou ação inicial rápida. Os achados alinham-se a estudos com óleos essenciais, mas destacam infusões como alternativas acessíveis. Estudos de sinergismo são necessários para otimizar o potencial terapêutico.

Implicações da Pesquisa: As infusões podem constituir terapias de baixo custo e toxicidade para candidíase, especialmente em locais com recursos limitados. Estudos futuros devem validar a eficácia *in vivo* e explorar combinações sinérgicas, apoiando políticas brasileiras de uso sustentável da biodiversidade na saúde pública.

Originalidade/Valor: Primeiro estudo comparativo de infusões (preparo tradicional) contra *C. albicans*, revelando cinética fungicida tempo-dependente. Demonstra que infusões – não apenas óleos essenciais – têm relevância clínica, conectando medicina tradicional à prática baseada em evidências.



Palavras-chave: *Candida albicans*, Candidíase, Falha Terapêutica, Plantas Medicinais, Fitoterapia.

EFICACIA DE LAS PLANTAS MEDICINALES EN EL CONTROL *IN VITRO* DE *CANDIDA ALBICANS*

RESUMEN

Objetivo: Evaluar el efecto *in vitro* de plantas medicinales sobre *Candida albicans*.

Marco teórico: *Candida albicans* es una levadura comensal de la microbiota humana, considerada un patógeno oportunista que, en condiciones de baja resistencia, puede invadir tejidos y órganos y causar enfermedades sistémicas. La resistencia a los antifúngicos ha provocado recurrencias, requiriendo alternativas terapéuticas como las hierbas medicinales.

Método: Se utilizaron infusiones de *Cymbopogon citratus*, *Citrus limon*, *Eucalyptus citriodora*, *Caryophyllus aromaticus* y *Origanum vulgare* sobre cepas de *C. albicans*. Se determinó la concentración mínima inhibitoria (CMI) y la concentración mínima fungicida (CMF). El análisis estadístico utilizó la prueba no paramétrica de Kruskal-Wallis con la prueba posterior de Dunn (significancia: 0,05).

Resultados y Discusión: Todas las infusiones demostraron eficacia antifúngica contra *C. albicans*, con una variación temporal significativa. *Citrus limon* (concentración mínima inhibitoria: 5%) requirió una exposición prolongada para su erradicación completa, mientras que *Eucalyptus citriodora* mostró una acción inicial rápida. Estos hallazgos concuerdan con los estudios con aceites esenciales, pero destacan las infusiones como alternativas asequibles. Se necesitan estudios sinérgicos para optimizar su potencial terapéutico.

Implicaciones de la Investigación: Las infusiones pueden constituir terapias de bajo costo y baja toxicidad para la candidiasis, especialmente en entornos con recursos limitados. Estudios futuros deberían validar la eficacia *in vivo* y explorar combinaciones sinérgicas, apoyando las políticas brasileñas para el uso sostenible de la biodiversidad en salud pública.

Originalidad/Valor: Este es el primer estudio comparativo de infusiones (preparación tradicional) contra *C. albicans*, que revela una cinética fungicida dependiente del tiempo. Demuestra que las infusiones, no solo los aceites esenciales, tienen relevancia clínica, conectando la medicina tradicional con la práctica basada en la evidencia.

Palabras clave: *Candida albicans*, Candidiasis, Fracaso Terapêutico, Plantas Medicinales, Fitoterapia.

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1 INTRODUCTION

Candida albicans is a commensal fungus that lives asymptotically in several areas of the body, such as skin, mucosa of the gastrointestinal tract and the genitourinary of healthy individuals. Changes in immunity, stress or when different factors cause a reduction in the number of bacteria in the normal microbiota of the skin and mucosa, predispose to the excessive increase of *C. albicans*, causing infections in various regions or organs of the body (Harriott *et al.* 2010; Ganguly *et al.* 2011; Nobile, 2015).

This fungal agent presents its oval morphology with a single bud, however, cell



dimorphism can happen, a transition from budding yeast to elongated filament (pseudo-hyphae) (Giolo and Svidzinski 2010). The transition from yeast to filament is associated with the expression of genes specifically important for filamentation, as well as changes in pH and temperature are related to virulence, and is controlled, in part, by the main transcriptional regulators Nrg1 and Ume6 (Childers and Kadosh 2015). Other species (*Candida non albicans*) such as *C. tropicalis*, *C. parapsilosis*, *C. krusei* and *C. glabrata* have observed a significant increase and are increasingly implicated in human infectious processes. Rörig *et al.* (2009) report that *C. albicans* has greater hemolytic capacity than *Candida non albicans* and is still considered one of the most prevalent species in human infections and the main cause of candidiasis.

Candidiasis or candidose is an opportunistic infection caused by yeasts of the genus *Candida*, especially *C. albicans*. The manifestations of the disease vary according to the affected anatomical site, such as the mucocutaneous, in which it affects the oral and vaginal mucosa, cutaneous and systemic, where there is involvement of several organs and/or systems (Avrella and Goulart 2008). It is noteworthy that *C. albicans* is responsible for most cases of vulvovaginal candidiasis, common in women in the reproductive phase, due to the higher glycogen production, which is one of the predisposing factors to infection by this species (Makanjuola *et al.* 2018).

High antibiotic consumption is a risk condition that deserves special attention. The intake of multiple antibiotics are factors that have resulted in the resistance of microbial populations (Kim *et al.* 2017), causing a serious public health problem and also a high cost to the Brazilian Unified Health System (SUS). However, the search for alternative therapies, such as the use of herbal and medicinal plants, has been increasing due to low cost, low toxicity and easy access. As a result, several researchers are studying the inhibition of *C. albicans* by extracts of essential oils and substances isolated from plants with results that prove the antimicrobial activity of plants (Mandras *et al.* 2016; Ouknin *et al.* 2019; Potente *et al.* 2020; Pissolato *et al.* 2023; Miranda *et al.* 2024). It is important to show approval for the use of medicinal plants and herbal medicines in Brazil. The approval was published in the Official Gazette by Decree nº 5.813 of June 22, 2006, approving the National Policy of Medicinal and Phytotherapeutic Plants, with the general objective of ensuring the Brazilian population safe access and rational use of medicinal and phytotherapeutic plants, promoting the sustainable use of biodiversity (Brasil 2006). Another point to be highlighted is that phytotherapy and the use of medicinal plants are part of the practice of folk medicine, which complements the treatment used for the lower-income (Bruning *et al.* 2012) population or for people dissatisfied with adverse drug



reactions.

It is in this context that the objective of this study was to evaluate the efficacy of medicinal plants in the form of infusion in the *in vitro* control of *C. albicans*.

2 MATERIAL AND METHODS

2.1 STUDY DESIGN

The experimental research was conducted at the Microbiology Laboratory of Universidade Brasil, Sao Paulo, Brazil. The *Candida albicans* strain has been studied in the laboratory under the infusion of five types of medicinal plants (*Cymbopogon citratus* (DC) Stapf, *Eucalyptus citriodora* Hook, *Citrus limon* L., *Caryophyllus aromaticus* L. and *Origanum vulgare* L.), with evaluation of antifungal activity of these plants on the microbial agent.

2.2 LINEAGE AND INOCULUM PREPARATION

The strain of *Candida albicans* ATCC (American Type Culture Collection) 25923 was used. The strain was cultivated in Sabouraud-dextrose Agar (ASD) culture medium, incubated at 28°C for 48 hours. A colony of *C. albicans* was removed and cultivated in Sabouraud broth (BSD) for 24 hours. Then, centrifugation (4000 rpm) was performed for five minutes, after which the supernatant was discarded and the cell material was resuspended in a sterile NaCl solution (0.5%) and centrifuged again. This procedure was repeated five times in order to remove the components existing in the culture (Ramos *et al.* 2016) medium that could interfere in the evaluation of the minimum inhibitory concentration. Then, the obtained inoculum was diluted in 0.5% NaCl solution on the 0.5 scale of MacFarland, equivalent to a concentration of 1.5x10⁶ CFU mL⁻¹.

2.3 BOTANICAL MATERIAL

The plants used were *Cymbopogon citratus* (DC) Stapf, *Eucalyptus citriodora* and *Citrus limon*, leaves were collected from each plant for the development of the research. The collection was carried out at Santa Rita Farm, in the city of Fernandopolis, Sao Paulo, Brazil. The dried flower buds of *Caryophyllus aromaticus* and the dried leaves of *Origanum vulgare* were used in industrialized form. The place of sampling with availability of supplies and medicinal plants



for phytotherapeutic purposes were adopted as inclusion criteria. Diseased medicinal plants were excluded from the study.

2.4 PREPARATION OF INFUSIONS

100 mL of boiling distilled water was used for each 1g of the glass-graded Becker plant leaving in infusion for 5 minutes, after being filtered on sterile filter paper, the filtered material was conserved in amber bottle and under refrigeration (8° C).

2.5 DETERMINATION OF MINIMUM INHIBITORY CONCENTRATION (MIC) AND MINIMUM FUNGICIDAL CONCENTRATION (MFC)

MIC were evaluated according to the procedure recommended by the Clinical and Laboratory Standards Institute (CLSI 2012). MIC was determined by a microdilution method in ninety-six well plates. After incubation at 28°C for 24h, MIC was evaluated, and the presence of viable cells at non-inhibitory concentrations was determined by adding, in each sample, the dye 2,3,5-Triphenyltetrazolium Chloride, in a volume of 50 µL. This made it possible to distinguish the live samples, colored red, from the dead ones that retained their color. The minimum inhibitory concentration was considered as the lowest concentration of the prepared infusion capable of inhibiting bacterial development.

MFC, on the other hand, was determined based on the methodology of Favre *et al.* (2003). After the MIC results, 100µL were removed from each sample, inoculated in ASD medium, incubated for 24 hours at 37°C. Fungal growth was evaluated, and MFC was considered to be the one with negative or average culture of 0.1 CFU. The MIC and MFC experiments were performed in triplicate.

2.6 BACTERICIDAL KINETICS OF INFUSIONS

The methodology described by Allahghadri *et al.* (2010) was used. 40 mL of each infusion were added in tubes at the dilution determined by CBM to every 5 mL of BSD containing a bacterial suspension of 10⁶ CFU mL⁻¹ and then incubated at 28°C. Aliquots of 0.1 mL were removed every 15 minutes for a period of 105 minutes. The samples were immediately washed with sterile phosphate buffer, pH 7.0, centrifuged at 10000 rpm, resuspended in the



buffer and then spread in ASD, incubated for 24h to 28°C. All evaluations were performed in triplicate. Colonies were counted after the incubation period.

From the data obtained, the percentage of reduction of the *C. albicans* count was quantified in relation to the previous time evaluated. This was necessary due to the fact that the initial count differed between the evaluated extracts, being necessary to evaluate the relative reduction between the evaluated times. For this purpose, the following expression was used:

$$\% \text{ reduction} = \frac{MO_{before} - MO_{after}}{MO_{before}} \quad (1)$$

To calculate the percentage of reduction in microbial count between the exposure times of 15 and 30 minutes, the expression was as follows:

$$\% \text{ reduction}_{15-30min} = \frac{MO_{15min} - MO_{30min}}{MO_{15min}} \quad (2)$$

And, always, the percentage of reduction related to the value of the microbial count of the exposure time before the evaluated one.

2.7 STATISTICAL ANALYSIS

Descriptive statistics were used with a non-parametric Kruskal-Wallis test approach with a post-hoc Dunn multiple comparison test at a significance level of 0.05.

3 RESULTS

The MIC and CFM results show that all infusions showed antifungal activity, however greater efficacy was observed in the infusions of *Origanum vulgare* L., *Cymbopogon citratus* (DC) Stapf and *Citrus limon* L., with MIC of 10%, 8% and 5% (Table 1).

**Table 1**

Minimum Inhibitory Concentration and Minimum Fungicide Concentration of infusions on Candida albicans.

Medicinal plants		Concentration of infusions (%)	
Scientific name	Popular name	MIC	MFC
<i>Eucaliptus citriodora</i>	Eucalyptus	40	50
<i>Caryophyllus aromaticus</i>	Clove	20	30
<i>Origanum vulgare</i>	Oregano	10	10
<i>Cymbopogon citratus</i>	Lemon balm	8	10
<i>Citrus limon</i>	Lemon	5	8

Source: Own author (2025).

Table 2 shows the descriptive statistics of the count of *C. albicans* in relation to the times of exposure of the micro-organism to the medicinal plants evaluated. The results show that, for all medicinal plants, the median microbial count of *C. albicans* showed significant differences, since all P values were lower than the adopted significance level ($p < 0.05$). For all cases, except for C. Lemon, the median time 0 minutes differed significantly from the medians of the final time (90 minutes and 105 minutes), the time that reset the microbial count. However, for C. Lemon, the zero-time count differed significantly from the 90-minute and 105-minute times, and the 15-minute time count also differed from the 105-minute time count.

This result shows that the exposure time, in the inhibitory concentrations used, it is a determining factor for the decrease of the microbial count of *C. albicans*, however, in most cases, except for C. lemon, the difference in the count of this microorganism is only significant when the count is reset.

Table 2

Descriptive statistics of the count of C. albicans in relation to the times of exposure of the microorganism to infusion.

Medicinal plant	Count of <i>Candida albicans</i>			Value P ¹
	Time (min)	$\bar{x} \pm s$	Md ²	
<i>Cymbopogon citratus</i>	0	$1,50.10^6 \pm 0,00$	$1,50.10^6$ a	0,005
	15	$6,96.10^5 \pm 5,77.10^3$	$7,00.10^5$ ab	
	30	$5,13.10^4 \pm 1,15.10^3$	$5,20.10^4$ ab	
	45	$2,95.10^4 \pm 3,85.10^4$	$7,30.10^3$ ab	
	60	$7,36.10^2 \pm 5,77$	$7,40.10^2$ ab	
	75	$2,63.10^1 \pm 0,57$	$2,60.10^1$ ab	
	90	$0,00 \pm 0,00$	$0,00$ b	
<i>Caryophyllus aromaticus</i>	0	$1,06.10^6 \pm 1,15.10^5$	$1,00.10^6$ a	0,003
	15	$7,76.10^4 \pm 5,77.10^2$	$7,80.10^4$ ab	
	30	$7,23.10^3 \pm 5,77.10^1$	$7,20.10^3$ ab	
	45	$3,46.10^2 \pm 5,77$	$3,50.10^2$ ab	
	60	$5,93.10^1 \pm 0,57$	$5,90.10^1$ ab	
	75	$6,00.10^0 \pm 0,00$	$6,00.10^0$ ab	
	90	$0,00 \pm 0,00$	$0,00$ b	



<i>Eucalyptus citriodora</i>	0	$8,33.10^6 \pm 3,05.10^5$	$8,40.10^6$ ^a	0,003
	15	$6,16.10^4 \pm 5,77.10^2$	$6,20.10^4$ ^{ab}	
	30	$6,23.10^3 \pm 5,77.10^1$	$6,20.10^3$ ^{ab}	
	45	$4,33.10^2 \pm 5,77$	$4,30.10^2$ ^{ab}	
	60	$3,20.10^1 \pm 1,00$	$3,20.10^1$ ^{ab}	
	75	$7,66.10^0 \pm 1,52$	$8,00.10^0$ ^{ab}	
	90	$0,00 \pm 0,00$	$0,00$ ^b	
<i>Citrus limon</i>	0	$1,00.10^6 \pm 0,00$	$1,00.10^6$ ^a	0,001
	15	$5,50.10^4 \pm 2,51.10^4$	$4,10.10^4$ ^{ab}	
	30	$3,86.10^3 \pm 8,08.10^3$	$3,40.10^3$ ^{abc}	
	45	$4,06.10^2 \pm 6,35.10^1$	$3,70.10^2$ ^{abc}	
	60	$2,13.10^2 \pm 5,77$	$2,10.10^2$ ^{abc}	
	75	$6,83.10^1 \pm 0,57$	$6,80.10^1$ ^{abc}	
	90	$6,00 \pm 1,73$	$5,00$ ^{bc}	
	105	$0,00 \pm 0,00$	$0,00$ ^c	
<i>Origanum vulgare</i>	0	$3,12.10^7 \pm 4,04.10^7$	$7,90.10^6$ ^a	0,002
	15	$5,23.10^5 \pm 5,77.10^3$	$5,20.10^5$ ^{ab}	
	30	$5,60.10^3 \pm 0,00$	$5,60.10^3$ ^{ab}	
	45	$7,30.10^2 \pm 1,00.10^1$	$7,30.10^2$ ^{ab}	
	60	$3,03.10^2 \pm 5,77$	$3,00.10^2$ ^{ab}	
	75	$5,30.10^1 \pm 1,00$	$5,30.10^1$ ^{ab}	
	90	$2,00 \pm 1,00$	$2,00$ ^{ab}	
	105	$0,00 \pm 0,00$	$0,00$ ^b	

¹P-value for the Kruskal-Wallis test at 0.05 significance. ²Different letters in the same column indicate significantly different medians at 0.05 significance. **Source:** Own author (2025).

Table 3 shows the means of the percentages of reduction of the count of *C. albicans* for each of the medicinal extracts used. The results indicate the presence of significant differences in percentages of microbial load reduction for each of the intervals evaluated, and for the first 15 minutes of exposure, *E. citriodora* stood out as the most efficient plant in reducing the count of *C. albicans*. In contrast, *C. citratus* was the least effective in the first 15 minutes. For the subsequent fifteen minutes, *O. vulgare* was more effective, reducing about 98.9% of the microbial count in relation to the previous interval. Between 30 and 45 minutes, the clove was more effective reducing 95.2% of the microbial count. Between 45 and 60 minutes, *E. citriodora* again becomes the most effective in reducing the count, reducing 92.7% of the microbial count in relation to the previous interval. For times above 60 minutes, *C. citratus* stands out, drastically decreasing the count of *Candida albicans*.

Given this context, it is possible to assume that *E. citriodora* and *O. vulgare* exert greater antimicrobial activity in the first intervals of exposure of the microorganism to the herb, whereas *C. citratus* herb exerts greater antimicrobial function in longer periods of exposure of the microorganism.

**Table 3***Median percentages of reduction of microbial count of C. albicans for each medicinal herb.*

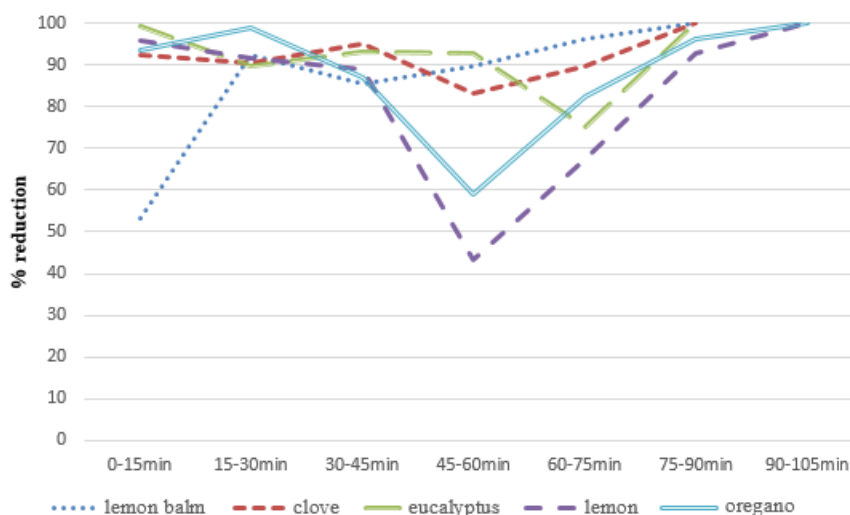
Time (min)	% reduction in microbial count				
	<i>Cymbopogon citratus</i>	<i>Caryophyllus aromaticus</i>	<i>Eucaliptus citriodora</i>	<i>Citrus limon</i>	<i>Origanum vulgare</i>
0 - 15	53,3 ^b	92,2 ^{ab}	99,2 ^a	95,9 ^{ab}	93,4 ^{ab}
15 - 30	92,5 ^{ab}	90,6 ^{ab}	89,8 ^b	91,7 ^{ab}	98,9 ^a
30 - 45	85,6 ^b	95,2 ^a	93,0 ^{ab}	89,1 ^{ab}	86,9 ^{ab}
45 - 60	89,8 ^{ab}	83,1 ^{ab}	92,7 ^a	43,2 ^b	58,9 ^{ab}
60 - 75	96,4 ^a	89,8 ^{ab}	75,0 ^{ab}	67,6 ^b	82,6 ^{ab}
75 - 90	100	100	100	92,6	96,1
90 - 105	-	-	-	100	100

¹P-value for the Kruskal-Wallis test. ²Different letters on the same line indicate significant differences at P<0.05.

Source: Own author (2025).

Figure 1 represents the behavior of the microbial load reduction percentages over the evaluated intervals. It is noted that only *C. citratus* showed a low reduction at first, promoting a certain increase in the percentage of reduction in later times. In most of the evaluated extracts, there was a certain reduction in the effectiveness in decreasing the count after 45 minutes, increasing the effectiveness after that time. This may be linked to the saturation of the medium or the adaptability of the microorganism to the active compound of the plant. However, after that time, the microbial load decreases again, until it reaches the zero value.

It is worth mentioning that *C. citratus*, *C. aromaticus* and *E. citriodora* caused null count of microorganisms in 90 minutes, while *C. lemon* and *O. vulgare* reached null count at 105 minutes. Thus, the first three samples showed greater efficiency due to the fact that they reset the microbial count in a shorter time.

Figure 1*Behavior of the percentage of microbial reduction over the evaluated times.*

Source: Own author (2025).



In view of these results, it is valid to consider the punctual action of each medicinal extract, however, studies of synergy between the extracts are necessary, because as can be seen, some plants such as *C. citratus* have relevant antimicrobial activity after a considerable exposure time, which is not observed in the other extracts. Thus, the synergy of these herbs, that is, the combined action of these extracts, can lead to better results with regard to antimicrobial activity.

4 DISCUSSION

Currently, the Ministry of Health has encouraged practices related to the use of phytotherapy as a curative measure of popular use and knowledge, highlighting that a large part of the population, mainly those living in underdeveloped regions, use medicinal plants practically as the only resource available in their health recovery needs (Brasil 2006). The plants used in this study meet this theme for being of easy access and popular knowledge, and, it was used in the form of infusion, its future use in humans is accessible.

Researchers present in their studies the efficacy of medicinal plants with effective microbial action, which makes their use favorable, proving the importance of deepening scientific knowledge based on the popular use of these phytotherapeutics, making the use of these plants by the population increasingly safe.

C. citratus popularly known as lemon balm, grass-of-smell and road-tea, has therapeutic indications such as: bactericidal, antispasmodic, soothing, light analgesic, carminative, stomatal, diuretic, sudorific, hypotensive and anti-rheumatic (Martins *et al.* 2000). In the study in question, *C. citratus* stood out as to the effectiveness of the fungicidal action for *C. albicans*, when it acted at different times of exposure, reaching zero yeasts in 90 minutes.

Amornvit *et al.* (2014), studied *in vitro* the action of *Cymbopogon citratus* essential oil against *C. albicans*. The authors illustrate in their research only one zone of inhibition against the fungus by the agar disk-diffusion test. However, when Coe-Comfort tissue conditioner was added to *C. citratus* oil, the strain was completely inhibited, which demonstrated anti-Candida efficacy. The authors report that the addition of the medicinal plant to the tissue conditioner is to complement the material's action and thus help to reduce the risk of fungal infection at the injury site. But compared to the study, *Cymbopogon citratus* did not need to be exposed to any material to fight *C. albicans*, it demonstrated antifungal action by inhibiting the microbial agent.

Almeida *et al.* (2008) evaluated the antimicrobial capacity of *C. citratus* in the form of hydroalcoholic extract, on *Candida* strains isolated in the human oral cavity, and the species of



C. albicans, *C. glabrata*, *C. tropicalis*, *C. parapsilosis*, and *C. krusei* were identified. In all strains, *C. citratus* showed antimicrobial activity similar to the present study. When analyzing the effects of the essential oil of *C. citratus* under the strains of *Candida*, Almeida (2013), report that *C. citratus* had bacteriostatic action for all strains of *Staphylococcus spp.*, And *Staphylococcus mutans* in different concentrations, also showed fungistatic activity for strains of *Candida ssp.*

Other authors show the activity of medicinal plants with satisfactory results in cultures of microorganisms. Nogueira *et al.* (2008), evaluated the antibacterial activity of extracts and / or essential oils from some plants, among them *C. aromaticus*, which showed activity on the growth of 2 isolated strains of *Candida*. In this study *C. aromaticus* showed fungicidal action at all exposure intervals, but with more effective punctual action in the 30 to 45 minutes of exposure reaching zero yeast count after 90 minutes of exposure, which shows the effectiveness of this plant also in the form of infusion. Lima *et al.* (2006), also evaluated essential oils from medicinal plants showing promising results, among them, *C. limon* and *E. citriodora*, which showed inhibition efficacy in at least one tested strain, the authors claim that the compounds of plant origin have significant significance due to its antibiotic potential.

The plants mentioned by the authors showed antifungal action, however in the form of infusion. It is important to point out *C. limon*, popularly known as lemon, showed efficacy in this study reaching zero yeast count after 105 minutes of exposure, in comparison with other plants *C. limon* was the least effective plant, but of great importance for presenting fungicidal action on *C. albicans*.

E. citriodora, known as eucalyptus, it presented significant efficacy in shorter exposure intervals compared to the other studied plants, and it can be pointed out as the most effective plant in relation to the time of action, reaching zero yeast count in 90 minutes of exposure. *O. vulgare*, known as oregano, Bahian marjoram and wild marjoram, it was tested in this study also showing a better efficacy in a shorter exposure time, resembles *C. limon* for having zero yeast count in a longer time, after 105 min of exposure.

O. vulgare belongs to the Labiatae family, it has an erect and square stem, pointed oval leaves (dark green or grayish, it has indications such as aperiente, expectorant, diuretic, carminative and tonic, without toxicological references (Di Stasi 2009). According to Cleff *et al.* (2010), the action of the essential oil of *O. vulgare* in isolates of human fungi (*C. albicans*) and clinical isolates of veterinary importance, it presented satisfactory results *in vitro*, the authors point out the need for *in vivo* research that confirms the relationship of these results.



It is important to highlight a similar experimental research with the medicinal plants used in the study. Contruccia *et al.* (2019) conducted *in vitro* research with *Cymbopogon citratus*, *Citrus limon*, *Caryophyllus aromaticus* and other agents under two strains "*Escherichia coli* and *Pseudomonas aeruginosa*". The medicinal plants showed antibacterial activity in both microorganisms. This result is similar to the current study, *Cymbopogon citratus*, *Citrus limon* and *Caryophyllus aromaticus* with antifungal activity.

With this similarity of data from medicinal plants under different microbial agents, the results indicate the possibility for the future, the development of antimicrobial agents phytotherapeutic and even the indication in the medical clinic for patients who are unable to buy medicines.

5 CONCLUSION

The present study revealed antifungal action of *C. citratus*, *C. aromaticus*, *O. vulgare*, *E. citriodora* and *C. limon*. The studied plants showed efficacy against *C. albicans*, highlighting that it was prepared in the form of infusion, it approximates the popularly prepared forms which makes its relevance even greater. The importance of the continuity of these studies may allow, in the future, their *in vivo* application for confirmation and comparison of results, allowing progress in the search for therapeutic alternatives that can offer low cost, easy applicability, low toxicity and promote the sustainable use of biodiversity.

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