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Original Research Article

Antifungal Activity of Nutmeg (*Myristica fragrans*) Flesh Extract from South Aceh Against *Candida albicans* on Denture Base

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ABSTRACT

Nutmeg (*Myristica fragrans*) contains several antimicrobial and anticandidal metabolites, yet the bioactivity of its fruit flesh has received limited attention, particularly for managing denture-associated fungal infections. *Candida albicans* (*C. Albicans*) frequently colonizes acrylic denture materials and contributes to denture stomatitis, emphasizing the need for natural antifungal alternatives. This study investigated the chemical composition and antifungal potential of *M. fragrans* fruit flesh extract against *C. albicans* on acrylic denture surfaces. The extract was prepared and subjected to phytochemical screening and GC–MS profiling to identify its secondary metabolites. Antifungal activity was assessed using acrylic specimens inoculated with *C. albicans* for 24, 48, and 72 hours. Minimum fungicidal concentration (MFC) was determined via liquid and solid dilution assays at concentrations of 25%, 50%, 75%, and 100%. Biofilm inhibition was further evaluated using the crystal violet assay. GC–MS analysis revealed 9-octadecenoic acid E (25.9%) as the predominant compound. All extract concentrations (25–100%) resulted in weak biofilm formation, classified as Weak Biofilm Producer (WBP). Solid dilution tests showed complete absence of fungal colonies across all concentrations, indicating fungicidal activity with MFC ≤ 25%. At 24 hours, biofilm inhibition increased from 25.00±5.00% (25%) to 42.00±5.00% (100%), with significant differences between these concentrations (p = 0.007), while no differences were noted at later times. The 75% and 100% concentrations demonstrated inhibitory effects comparable to the positive control (p = 0.156 and p = 0.714). In conclusion, *M. fragrans* fruit flesh extract effectively suppresses *C. albicans* biofilm formation on acrylic denture surfaces.

Keywords: *Myristica fragrans*, 9-Octadecenoic, *Candida albicans*, Denture Base, Biofilm.

Introduction

Acrylic resin is widely used as denture bases due to its non-irritating, compatible, dimensionally stable, and easy-to-repair or clean nature.[1] However, the material's high water absorption facilitates biofilm formation, particularly by *C. albicans*.[2,3] As reported previously, *C. albicans* can readily grow on denture surfaces, especially in the presence of poor oral hygiene, systemic disease, or surface irregularities.[4] Although *C. albicans* can also be present on the oral mucosa, studies show that the denture surface serves as a major reservoir, as suggested in the previous findings.[5]

Persistent colonization by the *C. albicans* may lead to denture stomatitis, which presents with erythema, edema, and discomfort.[6] The condition is associated with factors such as low salivary flow, poorly fitting dentures, material irritation, and *Candida* presence on the mucosa.[6] To reduce *C. albicans* accumulation on dentures, cleaning solutions are commonly used, with sodium hypochlorite being the most frequent choice due to its disinfectant properties.[7,8]

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However, sodium hypochlorite can increase acrylic surface roughness, promoting microbial adhesion and biofilm formation.[8] It may also cause allergic reactions, metal corrosion, and denture discoloration, limiting its long-term use.[9]

Given the limitations of chemical cleansers, natural plant-derived antifungal agents are being explored as safer alternatives. Nutmeg (*Myristica fragrans*) has demonstrated anticandidal activity against *C. albicans*.[10] With Indonesia, particularly South Aceh, producing most of the world's nutmeg, the locally abundant fruit represents a feasible natural alternative for antifungal applications.[11] The fruit of *M. fragrans* comprises the pericarp (skin and flesh), the aril (mace), and the seed. While research typically centers on the seed, the flesh accounts for nearly 78% of the fruit and remains largely unexplored.[12]

According to a previous study, *M. fragrans* flesh extract has a total phenolic content of 50.09 µg/mL.[13] The *M. fragrans* flesh contains phenolic compounds, including both flavonoid and non-flavonoid constituents, which are known to contribute to antimicrobial activity.[14,15] The flesh extract also contains saponins, tannins, and alkaloids, which are known for their anticandidal properties.[16,17]A previous work showed that a 20% *M. fragrans* flesh extract inhibited *C. albicans*, although not specifically on denture acrylic.[18]

These compounds have anticandidal activity that can inhibit the development of *C. albicans* colonies and reduce biofilm formation.[16] Previously, 20% *M. fragrans* flesh extract inhibited *C. albicans*,[18] but this is not on denture material. However, despite evidence of its anticandidal properties, the activity of *M. fragrans* flesh extract on acrylic denture surfaces has not been examined. Thus, this study aimed to determine the effect of *M. fragrans* flesh extract on the growth of *C. albicans* on acrylic denture material.

Materials and Methods

Plant Material Preparation

Nutmeg samples were collected between 1 - 5 September 2023 from Batu Itam Village, Tapaktuan Subdistrict, South Aceh District, Aceh, Indonesia (3°26′90.44″ N, 97°17′91.26″ E). A total of 10 kg of *M. fragrans* flesh was washed with running deionized water and oven-dried at 40 °C for 72 h. The dried material was subsequently ground into a fine powder and stored in an airtight container at 4 °C until further use. The preparation steps followed procedures previously described in published work.[19]

Determination of Nutmeg Plants

The plant specimen was taxonomically identified by Dr. Budi Irawan, M.Si, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Padjadjaran. A voucher specimen (Voucher No. 233/LBM/IT/X/2023) was prepared and deposited at the Jatinangor Herbarium, Laboratory of Biosystematics and Molecular Biology, Universitas Padjadjaran, Bandung, Indonesia, for future reference.

Preparation of M. fragrans Flesh Extract

The complete extraction procedure followed the method described by a previous study.[20] Approximately 200 g of powdered *M. fragrans* flesh was sequentially extracted using solvents of increasing polarity (n-hexane, ethyl acetate, and methanol) using a Soxhlet apparatus. Extraction was performed for 24 h with n-hexane, 15 h with ethyl acetate, and 14 h with methanol at a controlled temperature of 70 °C. Each solvent extract was then concentrated to approximately 100 mL and further reduced under vacuum using a rotary evaporator at 50 °C.

Gas Chromatography–Mass Spectrometry (GC-MS) Analysis

GC–MS analysis was performed according to the operating conditions described previously.[21] The system was equipped with an AOC-20I autosampler and an Elite-1 fused silica capillary column (30 m × 0.25 mm internal diameter, 1 µm film thickness; 100% dimethylpolysiloxane). Helium (99.999%) was used as the carrier gas at a flow rate of 1 mL/min, and 0.5 µL of sample was injected in split mode (10:1). The injector and ion source temperatures were set at 250 °C and 280 °C, respectively. The oven temperature program was initiated at 110 °C for 2 min, increased to 200 °C at 10 °C/min, and then to 280 °C at 5 °C/min with a final hold of 9 min. Mass spectra were acquired in electron impact mode (70 eV) over a scan range of 45–450 Da. Compound identification was performed by comparing the obtained mass spectra with entries in the NIST library.

Preparation of Acrylic Resin Specimens

Acrylic resin specimens measuring 5 × 5 × 1 mm were fabricated using a standard flasking technique. Baseplate wax patterns were invested in type III dental stone within a cuvette coated with Vaseline. After 15 min, the wax was eliminated by immersing the mold in boiling water for 5 min, and the mold cavity was coated with CMS. Heat-cured acrylic resin was packed at the dough stage, pressed, and polymerized in boiling water at 100 °C for 30 min. The cured specimens were retrieved and immersed in 30 mL of distilled water at room temperature for 24 h to remove residual monomers. This fabrication procedure followed a previously published standard protocol.[22]

Adhesion and Biofilm Formation of C. albicans on Acrylic Specimens

Each acrylic specimen was vertically positioned in a 96-well flat-bottom microplate and inoculated with 200 µL of *C. albicans* suspension. The plates were incubated at 37 °C for 90 min to allow the adhesion phase. Non-adherent cells were removed by rinsing with phosphate-buffered saline (PBS), after which the specimens were transferred to fresh wells containing 200 µL of peptone water. Biofilm formation was induced by incubation at 37 °C for 24, 48, and 72 h, with the culture medium replaced every 24 h.[23]

Determination of Minimum Fungicidal Concentration (MFC)

A total of six acrylic specimens were immersed in a *C. albicans* suspension adjusted to the McFarland standard (1.5×10^8 CFU/mL) and incubated at 37 °C for 48 h. Following incubation, each specimen was transferred into test tubes containing the respective extract concentrations, along with positive and negative controls, for 20 min. The specimens were then rinsed twice with PBS, placed in 1 mL of 0.9% NaCl solution, and vortexed for 30 s. From each suspension, 0.1 mL was plated onto Sabouraud dextrose agar using a bent rod and incubated at 37 °C for 48 h. Colony counts were determined using a colony counter and expressed as CFU/mL, as previously recommended.[24,25]

Biofilm Inhibition Assay

The Soxhlet extract was diluted with distilled water to concentrations of 25%, 50%, 75%, and 100%. Acrylic specimens pre-exposed to *C. albicans* biofilms were rinsed with PBS and vertically positioned in 96-well plates containing 135 µL of the extract.[24] PBS served as the negative control, while 0.5% sodium hypochlorite served as the positive control (K+). After a 20-min immersion, the specimens were washed with PBS, transferred to vials containing 1 mL of 0.9% NaCl, and vortexed for 30 s to detach adherent cells.[26-28] A 100 µL aliquot was inoculated into 96-well plates containing 100 µL of Sabouraud dextrose broth and incubated at 37 °C for 24, 48, and 72 h. Subsequently, the media were discarded, and the wells were washed with PBS, air-dried, stained with 200 µL of crystal violet for 15 min, rinsed, and decolorized with 200 µL of 96% ethanol. Biofilm quantification was performed spectrophotometrically at 625 nm, following previously published recommendations.[29]

Optical density (OD) measurements were used to determine biofilm strength, following the previous work.[30] The OD_{test} value for each sample was compared with the optical density cut-off (OD_{cut}) to classify the biofilm. The OD_{cut} value was determined using the formula:

$$OD_{cut} = OD_c + (3 \times SDOD_c)$$

where OD_c represents the mean optical density of the negative control and SD_{ODc} denotes the standard deviation of the control OD. Samples with OD_{test} values relative to OD_{cut} were then classified according to standard biofilm strength criteria. Biofilm inhibition was further calculated using:

$$\text{Inhibition (\%)} = \frac{\text{OD}_{\text{ negative control}} - \text{OD}_{\text{ test}}}{\text{OD}_{\text{ negative control}}} x100\%$$

The classification criteria for bacterial biofilm strength were shown in Table 1

Table 1: Biofilm Strength Classification

Cut-off value calculation	Mean of OD value results	Biofilm producing power
ODtest ≤ ODcut	OD ≤ 0.05	Non-biofilm producers
ODcut < ODtest ≤ 2 x ODcut	0.05 < OD ≤ 0.1	Weak biofilm producer
2 x ODcut < Odtest ≤ 4 x ODcut	0.1< OD ≤ 0.2	Moderate biofilm producer
4 x ODcut < ODtest	OD > 0.2	Strong biofilm producer

Data analysis

All experiments were performed in triplicate, and results are expressed as mean ± standard deviation (SD). Statistical analysis was conducted using the Kruskal–Wallis test to evaluate differences among treatment and control groups, using IBM SPSS Statistics version 26 (IBM Corp., Armonk, NY, USA). A significance level of $p < 0.05$ was applied for all statistical tests, including Dunn's post hoc analysis.

Results and Discussion

Phytochemical Profile of Myristica fragrans Flesh Extract

Phytochemical screening of the methanolic extract of *M. fragrans* flesh collected from the Tapaktuan area, South Aceh, confirmed the presence of several bioactive secondary metabolites, including terpenoids, saponins, flavonoids, phenolics, and tannins (Table 2). Stronger color

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intensities observed in the qualitative assays indicated higher concentrations of these metabolite groups compared with reactions showing only slight color changes. The presence of these compounds supports the antifungal potential of the extract, as they are widely reported to possess antimicrobial and antibiofilm activities.

Table 2: Results of Phytochemical Analysis of Methanol Extract of *M. fragrans* flesh

Compound name	RT	Molecular Formula	Pharmacological Effects	Content (%) of compounds in the sample
4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	6.428	$C_6H_8O_4$	Antimicrobial, antioxidant, insecticide.[40]	1.45
5-Hydroxymethylfurfural	9.559	$C_6H_6O_3$	Antioxidant, anti-inflammatory, anti-hyperuricemic effects.[41]	6.02
Trans-Isoeugenol	12.979	$C_{10}H_{12}O_2$	Antibacterial, antifungal, and analgesic.[42]	1.76
Myristicine	18.909	$C_{11}H_{12}O_3$	Antioxidants.[43]	1.44
Phenol, 2,6-dimethoxy-4-(2-propenyl)-	22.129	$C_{11}H_{14}O_3$	Antioxidant, anti-inflammatory, antimicrobial, and anticancer.[44]	4.66
6-Pentadecenoic acid, 13-methyl-, (6Z)-, O-methyl	30.114	$C_{16}H_{30}O_2$	*Antiangiogenic*, antibacterial.[45]	6.22
Hexadecanoic acid, methyl ester	30.355	$C_{17}H_{34}O_2$	Antimicrobial, antioxidant, Analgesi.[46]	3.82
n-Hexadecanoic acid	30.920	$C_{16}H_{32}O_2$	Antimicrobial, antioxidant, Analgesic.[46]	9.25
Methyl 9-cis,11-trans-octadecadienoate	31.679	$C_{19}H_{34}O_2$	*Antiangiogenic*, antibacterial.[37]	4.52
cis-13-Octadecenoic acid, methyl ester	31.879	$C_{19}H_{36}O_2$	*Antiangiogenic*, antioxidant, antibacterial.[47]	6.31
9-Octadecenoic acid, (E)-	32.196	$C_{18}H_{34}O_2$	*Antiangiogenic*, antioxidant, antibacterial.[48]	25.23

Table 3: Secondary metabolites found in *M. fragrans* flesh

Metabolite Content	Result
	-
Alkaloid	-
	-
Steroid	-
Terpenoid	+
Saponins	+
Flavonoid	+
Phenolic	+
Tannin	+

Note: (+) Presence of secondary metabolite, (-) Absence of secondary metabolite

GC–MS analysis further revealed a diverse secondary metabolite profile in the *M. fragrans* flesh extract (Table 3).

The predominant compound was 9-octadecenoic acid (E) (25.23%), followed by n-hexadecanoic acid (9.25%), cis-13-octadecenoic acid methyl ester (6.31%), 6-pentadecenoic acid, 13-methyl-, (6Z)-, O-methyl (6.22%), and 5-hydroxymethylfurfural (6.02%). Myristicin was detected at the lowest relative abundance (1.44%).

The predominance of the monounsaturated trans-fatty acid 9-octadecenoic acid (E) is noteworthy, as this compound has been reported to modify microbial membrane permeability by reducing surface hydrophobicity and interfering with metabolic or signaling pathways involved in microbial growth and biofilm development.[31,32]

The phytochemical profile observed in this study is generally consistent with previous reports on *M. fragrans* flesh, although slight differences in GC–MS composition have been documented. These variations may be attributed to geographical factors such as altitude, temperature, and soil chemistry, as well as differences in extraction methods.[33,34]

Anticandidal Effect of M. fragrans Flesh Extract

The anticandidal evaluation demonstrated that *M. fragrans* flesh extract exhibited potent fungicidal activity against *C. albicans*. The minimum fungicidal concentration (MFC) was determined to be ≤ 25%, as no fungal growth was observed at this concentration in the liquid dilution assay (Table 4). Turbidity and fungal growth, with an average of 34 CFU/mL, were observed only in the negative control. Subsequent subculturing onto agar media confirmed the absence of viable fungal colonies in all extract-treated groups (25–100%) as well as in the positive control, indicating a fungicidal rather than fungistatic effect. These findings are consistent with previous studies reporting the antifungal activity of nutmeg extracts against *C. albicans*.[35,36]

Inhibition of C. albicans Biofilm

Biofilm assessment showed that *C. albicans* exhibited weak biofilm-producing capacity across all treatment groups and incubation periods (24, 48, and 72 h), as indicated by optical density measurements (Table 5). Despite this classification, treatment with *M. fragrans* flesh extract resulted in a measurable reduction in biofilm biomass. The percentage of biofilm inhibition increased with increasing extract concentration (Table 6), indicating a concentration-dependent effect.

Statistical analysis revealed no significant differences in inhibition among incubation times (Kruskal–Wallis, $p = 0.826$), whereas significant differences were observed among extract concentrations ($p = 0.011$). At 24 h, biofilm inhibition increased from 25.00 ± 5.00% at 25% concentration to 42.00 ± 5.00% at 100%, with a statistically significant difference between these concentrations ($p = 0.007$). At higher concentrations (75% and 100%), the inhibitory activity of the extract was comparable to that of the positive control, as indicated by non-significant p-values of 0.156 and 0.714, respectively (Table 7; Figure 1). These results are in agreement with previous reports demonstrating concentration-dependent anticandidal activity of *M. fragrans* extracts.[37]

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Table 4: Minimum inhibitory concentration of *C. albicans* from *M. fragrans* flesh extract with liquid and solid dilution tests

Concentration	Dilution	
	Liquid	Solids (CFU/ml)
25%	Clear	0
50%	Clear	0
75%	Clear	0
100%	Clear	0
K+	Clear	0
K-	Cloudy	34

Note: K+: Positive Control (Sodium Hypochlorite); K-: Negative Control (PBS)

Table 5: Classification of Biofilm Formation (OD) in *M. fragrans* Flesh Extract

Concentration	Biofilm Formation Activity *of C. Albicans*		
	24 hours	48 hours	72 hours
25%	WBP	WBP	WBP
50%	WBP	WBP	WBP
75%	WBP	WBP	WBP
100%	WBP	WBP	WBP
K+	WBP	WBP	WBP
K-	WBP	WBP	WBP

Note: WBP = Weak Biofilm Producer. All groups consistently demonstrated weak biofilm formation across concentrations and incubation times.

Table 6: Inhibition of *C. albicans* Biofilm

Concentration	Time ± SD						*pValue*
	24 hours		48 hours		72 hours		
25%	25.00 5.00	±	27.00 4.00	±	26.00 0.04	±	
50%	31.00 3.00	±	30.00 5.00	±	29.00 4.00	±	
75%	35.00 4.00	±	36.00 ±5.00		34.00 2.00	±	0.011 *
100%	42.00 5.00	±	41.00 2.00	±	38.00 1.00	±	
K+	45.00 4.00	±	48.00 1.00	±	39.00 2.00	±	
p time	0.826						

Note: Kruskal Wallis test (*p*<0,000*), with confidence interval 95% (95% CI)*

Table 7: Post hoc *C. albicans* Biofilm

Concentration	25%	50%	75%	100%	K+
25%		0.41	0.099	0.007 *	0.002*
50%	0.41		0.41	0.061	0.025*
75%	0.099	0.41		0.293	0.156
100%	0.007*	0.061	0.293		0.714
K+	0.002*	0.025*	0.156	0.714	

Note: Post Hoc Dunn's Test. Significant difference at p < 0.05.

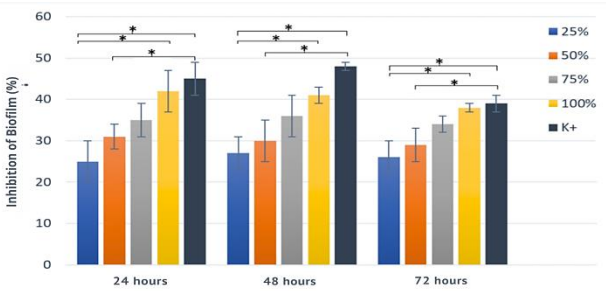

Figure 1: Percentage of *C. albicans* biofilm inhibition at different concentrations of *M. fragrans* flesh extract (25%, 50%, 75%, 100%) compared with positive control. Error bars represent mean ± SD. Asterisks (*) indicate statistically significant differences ($p < 0.05$).

The observed anticandidal and antibiofilm activities can be attributed to the synergistic effects of multiple secondary metabolites present in the extract. Terpenoids have been reported to disrupt fungal membrane integrity and interfere with cell cycle progression, thereby inhibiting biofilm formation.[38] Flavonoids may damage the plasma membrane and mitochondria of *Candida*, disrupting membrane permeability and nutrient transport, ultimately leading to cellular toxicity. Saponins exert antifungal effects by forming pores in lipid bilayers, resulting in membrane destabilization,[39] while tannins inhibit extracellular enzymes and degrade substrates required for fungal growth and biofilm maturation.[37] The combined action of these compounds likely underlies the potent fungicidal and antibiofilm effects observed in this study.

Despite these promising results, the present study is limited by its in vitro design, which cannot fully replicate the complex biological interactions occurring in vivo. Factors such as metabolism, bioavailability, salivary flow, and host immune responses may influence the antifungal efficacy of *M. fragrans* flesh extract under physiological conditions. Therefore, these results should be interpreted with caution, and further in vivo studies are recommended to validate the efficacy and safety of nutmeg flesh extract for potential oral health applications, particularly on acrylic denture materials.

Conclusion

The methanolic extract of *M. fragrans* flesh contained bioactive compounds, including terpenoids, flavonoids, phenolics, and fatty acids, which may contribute to its inhibitory effects on the growth and biofilm formation of *C. albicans*. At concentrations of 75% and 100%, the extract exhibited biofilm inhibition comparable to that of the positive control. The minimum fungicidal concentration (MFC) was estimated to be below 25%. These results indicate the potential of *M. fragrans* flesh extract as a natural anticandidal agent, particularly for the development of herbal denture cleansers; however, further in vivo and clinical studies are required to confirm its efficacy and safety.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Declaration

The authors hereby declare that the work presented in this article is original and that any liability for claims relating to the content of this article will be borne by them.

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References

1. Nejatian T, Pezeshki S, Yaqin Syed AU. 5 - Acrylic denture base materials, in Advanced Dental Biomaterials, Khurshid, Z,

Najeeb, S, Zafar, MS, Sefat, F, Editors.: Woodhead Publishing; 2019. 79-104 p. Doi: https://doi.org/10.1016/B978-0-08-102476-8.00005-0
2. Wigianto AYP, Ishida Y, Iwawaki Y, Goto T, Watanabe M, Sekine K, Hamada K, Murakami K, Fujii H, Ichikawa T. 2-methacryloyloxyethyl phosphorylcholine polymer treatment prevents *Candida albicans* biofilm formation on acrylic resin. J Prosthodont Res. 2022; 67(3):384-391. Doi: https://doi.org/10.2186/jpr.JPR_D_22_00102
3. Patel M. Oral cavity and *Candida albicans*: Colonisation to the development of infection. Pathogens. 2022; 11(3):335. Doi: https://doi.org/10.3390/pathogens11030335
4. Sartawi SY, Abu-Hammad S, A. Salim N, Al-Omoush S. Denture stomatitis revisited: A summary of systematic reviews in the past decade and two case reports of papillary hyperplasia of unusual locations. Int J Dent. 2021; 2021(1):7338143. Doi: https://doi.org/10.1155/2021/7338143
5. Balafif FF, Rafisa A, Kuswandani F, Najmi N. Oral *Candida albicans* colonization in denture wearer: A literature review. J Edu Health. 2024; 15(03):63-71. Doi: https://doi.org/10.54209/eduhealth.v15i03
6. Bajunaid SO. How effective are antimicrobial agents on preventing the adhesion of *Candida albicans* to denture base acrylic resin materials? A systematic review. Polymers. 2022; 14(5):908. Doi: https://doi.org/10.3390/polym14050908
7. Hayran Y, Sarikaya I, Aydin A, Tekin YH. Determination of the effective anticandidal concentration of denture cleanser tablets on some denture base resins. J Appl Oral Sci. 2018; 26:e20170077. Doi: https://doi.org/10.1590/1678-7757-2017-0077
8. Alqanas SS, Alfuhaid RA, Alghamdi SF, al-Qarni FD, Gad MM. Effect of denture cleansers on the surface properties and color stability of 3D printed denture base materials. J Dent. 2022; 120:104089. Doi: https://doi.org/10.1016/j.jdent.2022.104089
9. Badaró MM, Bueno FL, Makrakis LR, Araújo CB, Oliveira VdC, Macedo AP, Paranhos HdFO, Watanabe E, Silva-Lovato CH. Action of disinfectant solutions on adaptive capacity and virulence factors of the *Candida* spp. biofilms formed on acrylic resin. J Appl Oral Sci. 2021; 29:e20210024. Doi: https://doi.org/10.1590/1678-7757-2021-0024
10. Handayani RJ, Mahendra ICP, Forestrania RC, Gusmira A, Adawiyah R, Rozaliyani A, Makau JN, Raekiansyah M, Rahmasari R. *Myristica fragrans* oil as a potent inhibitor of *Candida albicans*: Phase development inhibition and synergistic effect. J Appl Pharm Sci. 2023; 13(1):212-220. Doi: https://dx.doi.org/10.7324/JAPS.2023.130106
11. Ulfah T, Hardjomidjodjo HH, Anggraeni E. Nutmeg determination as the main commodity in South Aceh; a literature review. IOP Conference Series: Earth and Environmental Science. 2020; 472(1):012040. Doi: https://doi.org/10.1088/1755-1315/472/1/012040
12. Rahardiyan D, Poluakan M, Moko EM. Physico-chemical properties of nutmeg (*Myristica fragrans* houtt) of North Sulawesi nutmeg. Fuller J Chem. 2020; 5(1):23-31. Doi: https://doi.org/10.37033/fjc.v5i1.146
13. Dareda CT, Suryanto E, Momuat LI. Characterization and antioxidant activity of dietary fiber from nutmeg (*Myristica fragrans* Houtt) pulp. Chem Prog. 2020; 13(1):48-55. Doi: https://doi.org/10.35799/cp.13.1.2020.29661
14. Simonetti G, Brasili E, Pasqua G. Antifungal activity of phenolic and polyphenolic compounds from different matrices of *Vitis vinifera* L. against human pathogens. Molecules. 2020; 25(16):3748. Doi: https://doi.org/10.3390/molecules25163748
15. Hasnat H, Shompa SA, Islam MM, Alam S, Richi FT, Emon NU, Ashrafi S, Ahmed NU, Chowdhury MNR, Fatema N, Hossain MS, Ghosh A, Ahmed F. Flavonoids: A treasure house of prospective pharmacological potentials. Heliyon. 2024; 10(6):e27533. Doi: https://doi.org/10.1016/j.heliyon.2024.e27533
16. Nguyen W, Grigori L, Just E, Santos C, Seleem D. The in vivo anti-*Candida albicans* activity of flavonoids. J Oral Biosci. 2021; 63(2):120-128. Doi: https://doi.org/10.1016/j.job.2021.03.004
17. Suloi AF, Suloi ANF. Bioactivity of nutmeg (*Myristica fragrans* Houtt): Scientific review. J Agric Process Technol. 2021; 3(1):11-18. Doi: https://doi.org/10.35308/jtpp.v3i1.3702
18. Nasir M, Marwati E. Antimicrobial activity test of ethanol extracts from nutmeg fruit and leaves (*Myristica fragrans*) antimicrobial. J Sains Kes. 2022; 4(SE-1):67-76. Doi: https://jsk.ff.unmul.ac.id/index.php/JSK/article/view/516
19. Gupta AD, Bansal VK, Babu V, Maithil N. Chemistry, antioxidant and antimicrobial potential of nutmeg (*Myristica fragrans* Houtt). Journal of Genetic Engineering and Biotechnology. 2013; 11(1):25-31. Doi: https://doi.org/10.1016/j.jgeb.2012.12.001
20. Putra NR, Aziz AHA, Mamat H, Rizkiyah DN, Yunus MAC, Irianto I, Qomariyah L. Green extraction of nutmeg (*Myristica fragrans*) phytochemicals: Prospective strategies and roadblocks. Open Agric. 2024; 9(1):20220285. Doi: https://doi.org/10.1515/opag-2022-0285
21. Moirangthem S, Patra G, Biswas S, Das A, Nath S, Verma AK, Pal S, Chatterjee N, Bandyopadhyay S, Nanda PK, Sharma G, Das AK. Effect of nutmeg (*Myristica fragrans*) and tea tree (*Melaleuca alternifolia*) essential oils on the oxidative and microbial stability of chicken fillets during refrigerated storage. Foods. 2024; 13(24):4139. Doi: https://doi.org/10.3390/foods13244139
22. Diansari V, Subhaini S, Putri A. Surface microstructure study of self cured acrylic resin after immersion in arabica gayo coffee. J Biomim Biomater Biomed Eng. 2020; 48:62-69. Doi: https://doi.org/10.4028/www.scientific.net/jbbbe.48.62
23. Choonharuangdej S, Srithavaj T, Thummawanit S. Fungicidal and inhibitory efficacy of cinnamon and lemongrass essential oils on *Candida albicans* biofilm established on acrylic resin: An in vitro study. J Prosthet Dent. 2021; 125(4):707.e1-707.e6. Doi: https://doi.org/10.1016/j.prosdent.2020.12.017
24. Pintadi H, Aryandi UR. The comparison between black cumin extract and betel leaf extract as antifungal potential to *Candida albicans* on acrylic resin denture base. Insisiva Dent J. 2022; 11(1):1-6. Doi: https://doi.org/10.18196/di.v11i1.7535
25. d'Enfert C, Kaune A-K, Alaban L-R, Chakraborty S, Cole N, Delavy M, Kosmala D, Marsaux B, Fróis-Martins R, Morelli M, Rosati D, Valentine M, Xie Z, Emritloll Y, Warn PA, Bequet F, Bougnoux M-E, Bornes S, Gresnigt MS, Hube B, Jacobsen ID, Legrand M, Leibundgut-Landmann S, Manichanh C, Munro CA, Netea MG, Queiroz K, Roget K, Thomas V, Thoral C, Van den Abbeele P, Walker AW, Brown AJP. The impact of the Fungus-Host-Microbiota interplay upon *Candida albicans* infections: current knowledge and new perspectives. FEMS Microbiol Rev. 2020; 45(3): 1–55. Doi: https://doi.org/10.1093/femsre/fuaa060
26. Hutama MHT, Windriyatna W, Ngestiningsih D, Ariani RMD, Prihatiningsih T. Liquid smoke submersive effectiveness of acrylic plate to the growth of *Candida albicans*. Diponegoro Med J. 2021; 10(5):320-323. Doi: https://doi.org/10.14710/dmj.v10i5.30115
27. Albergaria LS, Scotti CK, Mondelli RFL, Vega HA, Faggion CM, Bombonatti JFS, Velo MMdAC. Effect of nanofibers as reinforcement on resin-based dental materials: A systematic review of in vitro studies. Jpn Dent Sci Rev. 2023; 59:239-252. Doi: https://doi.org/10.1016/j.jdsr.2023.07.002
28. Aprianto DS, Taftyanti Z. The effect of sodium hypochlorite on transverse strength of denture based material heat polymerized acrylic resin. Maj Sainstekes 2015; 2(1):001-011. Doi: https://doi.org/10.33476/ms.v2i1.1636
29. AlEraky DM, Abuohashish HM, Gad MM, Alshuyukh MH, Bugshan AS, Almulhim KS, Mahmoud MM. The antifungal and antibiofilm activities of caffeine against *Candida albicans* on polymethyl methacrylate denture base material. Biomedicines. 2022; 10(9):2078. Doi: https://doi.org/10.3390/biomedicines10092078
30. Cahyakirana TD, Susilowati A, Pangastuti A. Effectiveness of antibiofilm *Aspergillus niger* cell-free supernatant against

Pseudomonas aeruginosa biofilm. Asian J Trop Biotechnol. 2024; 21(2):89-95. Doi: https://doi.org/10.13057/biotek/c210204
31. Guimarães A, Venâncio A. The potential of fatty acids and their derivatives as antifungal agents: A review. Toxins (Basel). 2022; 14(3):188. Doi: https://doi.org/10.3390/toxins14030188
32. Lee J-H, Kim Y-G, Khadke SK, Lee J. Antibiofilm and antifungal activities of medium-chain fatty acids against *Candida albicans* via mimicking of the quorum-sensing molecule farnesol. Microb biotechnol. 2021; 14(4):1353-1366. Doi: https://doi.org/10.1111/1751-7915.13710
33. Ashraf MA, Iqbal M, Rasheed R, Hussain I, Riaz M, Arif MS. Chapter 8 - Environmental Stress and Secondary Metabolites in Plants: An Overview, in Plant Metabolites and Regulation Under Environmental Stress, Ahmad, P, Ahanger, MA, Singh, VP, Tripathi, DK, Alam, P, Alyemeni, MN, Editors.: Academic Press; 2018. 153-167 p. Doi: https://doi.org/10.1016/B978-0-12-812689-9.00008-X
34. Sultan MT, Saeed F, Raza H, Ilyas A, Sadiq F, Musarrat A, Afzaal M, Hussain M, Raza MA, Al JBawi E. Nutritional and therapeutic potential of nutmeg (*Myristica fragrans*): A concurrent review. Cogent food agric. 2023; 9(2):2279701. Doi: https://doi.org/10.1080/23311932.2023.2279701
35. Nikolic V, Nikolic L, Dinic A, Gajic I, Urosevic M, Stanojevic L, Stanojevic J, Danilovic B. Chemical composition, antioxidant and antimicrobial activity of nutmeg (*Myristica fragrans* Houtt.) seed essential oil. J Essent Oil-Bear Plants. 2021; 24(2):218-227. Doi: https://doi.org/10.1080/0972060X.2021.1907230
36. Noviyandri PR, Nurhadisah N, Chismirina S. Effect of nutmeg flesh (*Myristica fragrans* Houtt) against *Streptococcus mutans* growth. J Syiah Kuala Dent Soc. 2020; 5(1):42-46. Doi: https://doi.org/10.24815/jds.v5i1.20010
37. Karmanah K, Susanto S, Widodo WD, Santosa E. The fruit characteristics of Ambon forest nutmeg (*Myristica fatua* Houtt) and Banda nutmeg (*Myristica fragrans* Houtt). Indones J Agric Sci. 2020; 25(2):291-298. Doi: https://doi.org/10.18343/jipi.25.2.292
38. Kumari I, Kaurav H, Chaudhary G. *Myristica fragrans* (Jaiphal): A significant medicinal herbal plant. Int j res appl sci biotechnol. 2021; 8(2):213-224. Doi: https://doi.org/10.31033/ijrasb.8.2.27
39. Wahyuni S, Susilowati M, Bakri A, Bermawie N. Fruit and seed variation of wild nutmeg (*Myristica schefferi* Warb.) in South Aceh, Indonesia. in IOP Conference Series: Earth and Environmental Science. IOP Publishing. 2022. Doi: https://doi.org/10.1088/1755-1315/974/1/012067
40. Rakotondraibe LH, Graupner PR, Xiong Q, Olson M, Wiley JD, Krai P, Brodie PJ, Callmander MW, Rakotobe E, Ratovoson F, Rasamison VE, Cassera MB, Hahn DR, Kingston DGI, Fotso S. Neolignans and other metabolites from *Ocotea cymosa* from the Madagascar rain forest and their biological activities. J Nat Prod. 2015; 78(3):431-440. Doi: https://doi.org/10.1021/np5008153
41. Shapla UM, Solayman M, Alam N, Khalil MI, Gan SH. 5-Hydroxymethylfurfural (HMF) levels in honey and other food products: Effects on bees and human health. Chem Cent J. 2018; 12(1):35. Doi: https://doi.org/10.1186/s13065-018-0408-3
42. Ogwuda UA, Adewumi CN, Anyip PJ, Ochi IO. Phytochemical screening and chemical analysis of cloves (*Syzygium aromaticum*) flower buds. Int Res J Mod Eng Technol Sci. 2022; 04(12):1139-1149. Doi: https://www.doi.org/10.56726/IRJMETS32302
43. Bhoopong P, Chareonviriyaphap T, Sukkanon C. Excito-repellency of *Myristica fragrans* Houtt. and *Curcuma longa* L. extracts from Southern Thailand against *Aedes aegypti* (L.). PeerJ. 2022; 10:e13357. Doi: https://doi.org/10.7717/peerj.13357
44. Kumar N, Goel N. Phenolic acids: Natural versatile molecules with promising therapeutic applications. Biotechnol Rep. 2019; 24:e00370. Doi: https://doi.org/10.1016/j.btre.2019.e00370
45. Piaru SP, Mahmud R, Abdul Majid AMS, Mahmoud Nassar ZD. Antioxidant and antiangiogenic activities of the essential oils of *Myristica fragrans* and *Morinda citrifolia*. Asian Pac J Trop Med. 2012; 5(4):294-298. Doi: https://doi.org/10.1016/S1995-7645(12)60042-X
46. Ashokkumar K, Simal-Gandara J, Murugan M, Dhanya MK, Pandian A. Nutmeg (*Myristica fragrans* Houtt.) essential oil: A review on its composition, biological, and pharmacological activities. Phytother Res. 2022; 36(7):2839-2851. Doi: https://doi.org/10.1002/ptr.7491
47. Anaduaka EG, Uchendu NO, Ezeanyika LUS. Mineral, amino acid and fatty acid evaluations of *Myristica fragrans* seeds extracts. Sci Afr. 2020; 10:e00567. Doi: https://doi.org/10.1016/j.sciaf.2020.e00567
48. Cruz A, Sánchez-Hernández E, Teixeira A, Oliveira R, Cunha A, Martín-Ramos P. Phytoconstituents and ergosterol biosynthesis-targeting antimicrobial activity of nutmeg (*Myristica fragans* Houtt.) against phytopathogens. Molecules. 2024; 29(471):1-16. Doi: https://doi.org/10.3390/molecules29020471