



MANAGEMENT OF POST-HARVEST FUNGI IN PAPAYA BY PLANT EXTRACTS AND ESSENTIAL OILS

Suchita V. More*, Gulab M. Rathod, Arun S. Kharat, and Jeetendra A. Kulkarni

¹Dept. Of Biotechnology, Dr. BAMU sub-campus, Osmanabad.

²Department of Botany, Shrikrishna Mahavidhyalay, Gunjoti, Osmanabad

³Laboratory of Applied of Microbiology, School of Life Sciences

⁴Department of Biotechnology, Dr. Babasaheb Ambedkar Marathwada University, Sub-campus, Osmanabad

*Corresponding Author Email: suchu.more@gmail.com

ABSTRACT

Post-harvest fungal infections represent a major challenge to the storage and marketability of papaya (*Carica papaya* L.), often causing significant economic losses. This study evaluated the antifungal efficacy of selected aqueous leaf extracts and essential oils against major post-harvest fungal pathogens of papaya using the poisoned food technique. Infected fruits were collected from local markets in Chhatrapati Sambhajnagar and Dharashiv, and fungal isolates were identified based on morphological characteristics. A total of thirteen fungal species, including *Alternaria alternata*, *Aspergillus flavus*, *Aspergillus fumigatus*, *Aspergillus niger*, *Colletotrichum gloeosporioides*, *Curvularia lunata*, *Fusarium equiseti*, *Fusarium moniliforme*, *Fusarium oxysporum*, *Penicillium digitatum*, *Penicillium islandicum*, and *Rhizopus stolonifer*, were tested against seven plant extracts and six essential oils. Among the aqueous extracts, *Annona squamosa* showed the highest inhibition, particularly against *Fusarium oxysporum* (83.9 %), while *Vitex negundo* exhibited strong activity against *Colletotrichum gloeosporioides* (94.7 %). In contrast, *Azadirachta indica* and *Piper betel* extracts demonstrated relatively low efficacy. Essential oils exhibited broad-spectrum antifungal activity, with *Ricinus communis* (castor oil) being the most effective, showing over 80% inhibition against several fungi. Oils of *Brassica juncea*, *Ocimum sanctum*, and *Syzygium aromaticum* also showed promising results, while *Eucalyptus globulus* and *Azadirachta indica* oils were less effective. Statistical analysis confirmed significant differences among treatments ($p < 0.05$). The results supported the potential of *Annona squamosa* extract and castor oil as eco-friendly, cost-effective alternatives to synthetic fungicides for managing post-harvest papaya diseases.

Key words:

Carica papaya, Essential oils, Post-harvest, Poisoned food technique, Plant extract.

1. INTRODUCTION

Papaya (*Carica papaya* L.) is a tropical fruit of significant economic importance, widely cultivated for its nutritional and medicinal value. However, post-harvest fungal diseases, particularly anthracnose caused by *Colletotrichum gloeosporioides*, pose a major challenge, leading to substantial losses during storage and transportation. In Mexico, post-harvest diseases are directly responsible for up to 40% losses in papaya production (Prasad & Paul, 2021). These losses not only

affect the economic returns for farmers but also limit the fruit's shelf life and marketability.

Traditional management of post-harvest fungal diseases relies heavily on synthetic fungicides. While effective, their extensive use raises concerns about environmental pollution, human health risks, and the development of resistant fungal strains (Pathak *et al.*, 2022). Moreover, consumer demand is shifting towards organically produced fruits, necessitating the exploration of alternative, eco-friendly disease management strategies.

In recent years, plant-derived substances, such as aqueous leaf extracts and essential oils, have garnered attention for their antifungal properties. Studies have demonstrated that certain plant extracts can inhibit the growth of post-harvest pathogens. For instance, leaf extracts of *C. papaya* have been shown to completely inhibit post-harvest rots of papaya (Kabir & Hossain, 2024). Similarly, essential oils from various plants, including clove basil and cinnamon bark, have exhibited high antifungal activity against papaya pathogens (Sarkhosh *et al.*, 2018).

Among these, essential oils stand out due to their broad-spectrum antifungal activity and potential for integration into post-harvest treatment protocols. For example, essential oils of oregano, cinnamon bark, clove basil, and rosemary pepper have been effective in controlling *P. caricae-papayae*, *A. alternata*, *L. theobromae*, *F. solani*, and *C. gloeosporioides* (Silva *et al.*, 2025). These findings suggest that essential oils could serve as viable alternatives to synthetic fungicides.

Despite their promise, the application of plant extracts and essential oils in post-harvest disease management faces challenges. Variability in efficacy due to differences in plant species, extraction methods, and concentrations used can limit their practical application (Mugao, 2004). Moreover, the potential phytotoxic effects on the fruit and the cost of large-scale production of these natural products need to be considered.

The current study aimed to evaluate the antifungal efficacy of selected aqueous leaf extracts and essential oils against common post-harvest fungal pathogens of papaya. By identifying effective plant-based treatments, the research seeks to contribute to the development of sustainable and safe post-harvest disease management strategies for papaya, aligning with the growing demand for organic and environmentally friendly agricultural practices.

2. MATERIAL AND METHODS

2.1. Collection, isolation, and identification of post-harvest fungi

Infected *Carica papaya* fruits were collected from markets in Chhatrapati Sambhajnagar and Dharashiv during various seasons and ripening stages, focusing on visibly infected specimens at harvest and market stages. Small tissue sections (2 mm²) from infected areas were excised with sterile scalpels and cultured on potato dextrose agar (PDA) plates, which were incubated at 28 °C for seven days with daily observation for emerging fungal colonies. Pure isolates were obtained using the single spore isolation technique described by Leyronas *et al.* (2012) and maintained on PDA slants. The fungal isolates were identified based on morphological

characteristics, including colony appearance, spore formation, and mycelial and conidial structures according to standard identification keys.

2.2. Management of post-harvest fungi by plant extract and essential oils

The fungitoxicity of plant extracts and essential oils was evaluated using the poisoned food technique as described by Nene and Thapliyal (1979). Aqueous extracts were prepared by using the wet weight of fresh leaves at a final concentration of 10 mg/ml. Leaves of various plants including *Azadirachta indica*, *Vitex negundo*, *Jatropha curcas*, *Datura stramonium*, *Annona squamosa*, *Murraya koenigii*, and *Piper betel* were collected, thoroughly washed, and ground in distilled water to prepare the extracts. The glucose nitrate medium was prepared in sterilized flasks, and 100 ml of the medium was mixed with 10 ml of each plant extract to achieve a final concentration of 10%. The mixture was stirred thoroughly and autoclaved at 15 lbs pressure for 20 minutes. After the medium cooled, fungal inoculations were carried out under aseptic conditions. The cultures were incubated at room temperature for six days. Fungi grown in glucose nitrate medium without plant extracts served as controls. The dry weight of fungal mycelium (in mg) was recorded and used to determine fungitoxicity. Percent inhibition of mycelial growth was calculated using the formula:

$$\text{Percent mycelial inhibition} = \left(\frac{W_c - W_t}{W_c} \right) * 100$$

Where W_c is dry mycelial weight of control, W_t is dry mycelial weight of test.

The same poisoned food technique was used to assess the fungitoxicity of plant products/byproducts in the form of essential oils. Essential oils such as tulsi, mustard, castor, neem, clove, and eucalyptus were used at a concentration of 1%, dissolved in acetone. These were added to the glucose nitrate medium in a similar manner to the aqueous extracts. After mixing thoroughly, the medium was autoclaved, cooled, inoculated with fungal cultures under aseptic conditions, and incubated for six days at room temperature.

2.3. Statistical analysis

All the experiments were performed in triplicates. The standard error of the mean was calculated. The significance between the treatments was done by one way ANOVA by Tukey's HSD post hoc analysis at 0.05 level of significance.

3. RESULTS

3.1. Identification of post-harvest fungi

Pathogenic fungal isolates were initially identified through morphological characterization, focusing on features such as colony appearance, pigmentation, hyphal

structure, and spore morphology. Distinctive conidial and hyphal traits facilitated the preliminary identification of the isolates as *Alternaria alternata*, *Aspergillus flavus*, *Aspergillus fumigatus*, *Aspergillus niger*, *Colletotrichum gloeosporioides*, *Curvularia lunata*, *Fusarium equiseti*, *Fusarium moniliforme*, *Fusarium oxysporum*, *Penicillium digitatum*, *Penicillium islandicum*, and *Rhizopus stolonifer*.

3.2. Management of post-harvest fungi by plant extracts

The antifungal activity of aqueous leaf extracts from *Azadirachta indica*, *Vitex negundo*, *Jatropha curcas*, *Datura stramonium*, *Annona squamosa*, *Murraya koenigii*, and *Piper betel* was evaluated against ten phytopathogenic fungi (Table 1). The inhibitory effects varied across fungal species, with *Annona squamosa* demonstrating strong activity against seven isolates, showing the highest inhibition ($83.9 \pm 0\%$) against *Fusarium oxysporum* and the lowest ($-47.0 \pm 0.1\%$) against *Colletotrichum gloeosporioides*. *Vitex negundo* exhibited high inhibition against *Colletotrichum gloeosporioides* ($94.7 \pm 0\%$) and *Alternaria alternata* ($72.5 \pm 0\%$), though effective against only four fungi. *Jatropha curcas* showed moderate activity against six fungi, with maximum inhibition against *Colletotrichum gloeosporioides* ($48.5 \pm 0\%$) and least against *Curvularia lunata* ($18.8 \pm 0.1\%$). *Datura stramonium* exhibited notable inhibition against *Alternaria alternata* ($52.1 \pm 0\%$), with relatively lower efficacy than others.

Azadirachta indica inhibited five fungal strains, with the highest inhibition against *Fusarium oxysporum* ($63.6 \pm 0\%$) but showed negative inhibition against *Aspergillus niger* ($-105.1 \pm 0.1\%$). *Murraya koenigii* displayed activity against seven strains, most effectively against *Penicillium digitatum* ($40.8 \pm 0.1\%$). *Piper betel* demonstrated strong antifungal potential, inhibiting *Colletotrichum gloeosporioides* ($53.8 \pm 0\%$) and *Fusarium oxysporum* ($50.3 \pm 0\%$). Overall, the degree of fungal inhibition varied significantly among the different plant extracts and fungal species. Negative inhibition in the data means that growth of fungal mycelia in the test was higher than the control means poorer inhibition. Post Hoc analysis using Tukey's HSD test confirmed that the mean percent inhibition values across all treatments were statistically significant, indicating distinct antifungal potential among the tested plant species.

3.3. Management of post-harvest fungi by essential oils

The antifungal potential of six essential oils—*Ocimum sanctum* (tulsi), *Brassica juncea* (mustard), *Ricinus communis* (castor), *Azadirachta indica* (neem), *Syzygium aromaticum* (clove), and *Eucalyptus globulus*

(eucalyptus)—was assessed against ten phytopathogenic fungi (Table 2). All essential oils showed inhibitory activity, though with varying degrees of effectiveness. *Ricinus communis* oil exhibited the highest antifungal activity, with inhibition values ranging from $83.3 \pm 0\%$ against *Fusarium moniliforme* to $44.9 \pm 0.01\%$ against *Aspergillus niger*. *Brassica juncea* oil followed closely, showing inhibition between $78.9 \pm 0.01\%$ (*Alternaria alternata*) and $61.0 \pm 0.01\%$ (*Aspergillus niger*). *Ocimum sanctum* oil demonstrated a consistent inhibitory profile, with activity ranging from $77.8 \pm 0.01\%$ (*Aspergillus flavus*) to $67.1 \pm 0.01\%$ (*Rhizopus stolonifer*).

Syzygium aromaticum oil showed broad-spectrum antifungal effects with inhibition ranging from $83.8 \pm 0\%$ (*Alternaria alternata*) to $39 \pm 0.01\%$ (*Aspergillus niger*), while moderate effects were observed against *Colletotrichum gloeosporioides*, *Aspergillus flavus*, and *Curvularia lunata*. *Azadirachta indica* oil demonstrated moderate efficacy, with highest inhibition against *Alternaria alternata* ($79.6 \pm 0.01\%$) and lowest against *Aspergillus niger* ($29.7 \pm 0.01\%$). In contrast, *Eucalyptus globulus* oil was the least effective overall, showing its highest inhibition against *Alternaria alternata* ($76.8 \pm 0.01\%$) and the lowest against *Aspergillus niger* ($34.7 \pm 0.01\%$). Despite differences in effectiveness, all essential oils demonstrated measurable inhibitory activity. Post Hoc analysis using Tukey's HSD test confirmed statistically significant differences in the mean percent growth inhibition values among the oils and fungal isolates.

4. DISCUSSION

The present study explored the efficacy of various botanicals, including aqueous leaf extracts and essential oils, in controlling post-harvest fungal pathogens of papaya. Among the seven tested leaf extracts, *Annona squamosa* demonstrated the highest antifungal activity, effectively inhibiting multiple fungal strains such as *Alternaria alternata*, *Aspergillus niger*, *Curvularia lunata*, *Fusarium equiseti*, *Fusarium moniliforme*, *Fusarium oxysporum*, and *Penicillium digitatum*. These results aligned with those reported by Kalidindi *et al.* (2015), who noted strong antifungal effects of plant extracts against *Aspergillus* and *Fusarium* species. The variability in efficacy among the other leaf extracts could be attributed to dose dependency, as higher concentrations (above 10%), though potentially more effective were considered commercially unfeasible.

Piper betel showed the lowest inhibitory effect in this study, despite previous reports of its antifungal potential Sivareddy *et al.* (2019). This discrepancy might indicate the development of fungal resistance to bioactive

compounds in the extracts or variability in fungal strain susceptibility. *Azadirachta indica*, widely recognized for its antifungal properties, exhibited limited effectiveness, consistent with findings by Mahmoud *et al.* (2011), who reported low antifungal activity even at higher concentrations (20%). Notably, *Rhizopus stolonifer* appeared the most resistant fungus in this study, possibly utilizing certain plant metabolites for growth, a phenomenon also observed by Makarenkov *et al.* (2010) and Atolani *et al.* (2020).

All tested essential oils showed inhibitory effects against the fungal isolates, with *Ricinus communis* (castor oil) displaying the most potent activity, particularly against *Fusarium moniliforme*. Remarkably, the current study demonstrated this efficacy at just 1% concentration, contrasting with previous findings such as Siqueira Júnior *et al.* (2012), who required higher concentrations for similar effects. *Syzygium aromaticum* (clove oil) showed moderate inhibition, which supports earlier research by Davy *et al.* (2020), although the current study observed slightly lower inhibition at reduced concentrations, likely due to differences in application method (*in vitro* vs. on fruit surface).

Brassica juncea (mustard oil) also showed broad-spectrum activity, including effective inhibition of *Fusarium oxysporum*, differing from Sitara *et al.* (2008), who reported limited control. In contrast, *Azadirachta*

indica (neem oil) was the least effective essential oil in this study, despite previously reported moderate activity. These variations highlight the strain-specific responses and environmental factors influencing the antifungal efficacy of plant-based treatments. Overall, the results suggested that castor oil and *Annona squamosa* extract hold the greatest promise for the development of sustainable, low-cost post-harvest treatments for papaya fungal pathogens.

5. CONCLUSION

The study demonstrated that both plant extracts and essential oils exhibited varying degrees of effectiveness in managing post-harvest fungal pathogens of papaya. Among the leaf extracts, *Annona squamosa* showed the highest antifungal activity, effectively inhibiting multiple fungal strains. In contrast, *Piper betel* and *Azadirachta indica* extracts displayed comparatively lower efficacy. Essential oils tested at 1% concentration were effective against all fungal isolates, with *Ricinus communis* oil showing the strongest inhibition. *Eucalyptus globulus* and *Azadirachta indica* oils were the least effective. The findings suggested that *Annona squamosa* extract and castor oil could serve as promising, eco-friendly alternatives for post-harvest fungal management in papaya.

Table 1 Percent mycelial growth inhibition of post-harvest fungi by leaf extracts of plants

Sr No.	Leaf extracts (10 % v/v)	<i>Alternaria alternata</i>	<i>Aspergillus flavus</i>	<i>Aspergillus niger</i>	<i>Colletotrichum gloeosporioides</i>	<i>Curvularia lunata</i>	<i>Fusarium equiseti</i>	<i>Fusarium moniliforme</i>	<i>Fusarium oxysporum</i>	<i>Penicillium digitatum</i>	<i>Rhizopus stolonifer</i>
1	<i>Annona squamosa</i>	71.1 ± 0	-14.2 ± 0.1	27.1 ± 0.1	-47 ± 0.1	62.5 ± 0	37.3 ± 0.1	16 ± 0.1	83.9 ± 0	42.8 ± 0.1	-45.2 ± 0.1
2	<i>Azadirachta indica</i>	47.9 ± 0	29.6 ± 0.1	-105.1 ± 0.1	25 ± 0.1	48.4 ± 0	-6.8 ± 0.1	-17.3 ± 0.1	63.6 ± 0	-32.2 ± 0.1	-58.9 ± 0.1
3	<i>Datura stramonium</i>	52.1 ± 0	-16.7 ± 0.1	1.7 ± 0.1	48.5 ± 0	32 ± 0.1	-13.7 ± 0.1	-24.4 ± 0.1	12.6 ± 0.1	-31.6 ± 0.1	-35.6 ± 0.1
4	<i>Jatropha curcas</i>	38 ± 0.1	-40.7 ± 0.1	19.5 ± 0.1	48.5 ± 0	18.8 ± 0.1	-40.4 ± 0.1	34.6 ± 0.1	-5.6 ± 0.1	38.2 ± 0.1	-35.6 ± 0.1
5	<i>Murraya koenigii</i>	-10.6 ± 0.1	-32.1 ± 0.1	10.2 ± 0.1	34.1 ± 0.1	37.5 ± 0.1	14.9 ± 0.1	1.9 ± 0.1	18.9 ± 0.1	40.8 ± 0.1	-44.5 ± 0.1
6	<i>Piper betel</i>	-3.5 ± 0.1	17.9 ± 0.1	-49.2 ± 0.1	53.8 ± 0	32 ± 0.1	21.7 ± 0.1	-14.1 ± 0.1	50.3 ± 0	-15.8 ± 0.1	-114.4 ± 0.2
7	<i>Vitex negundo</i>	72.5 ± 0	-18.5 ± 0.1	-63.6 ± 0.1	94.7 ± 0	26.6 ± 0.1	-8.1 ± 0.1	-7.7 ± 0.1	-2.1 ± 0.1	15.8 ± 0.1	-53.4 ± 0.1

All means are the percent inhibition of the mycelial growth. Any mean followed by '±' is the standard error of the mean. The percent inhibition is relative to the growth observed in control flask. All the means are significantly different from each other at p<0.05 level of significance.

Table 2 Percent mycelial growth inhibition of post-harvest fungi by different essential oils of plants

Sr. No.	Essential oils (1 % v/v)	<i>Alternaria alternata</i>	<i>Aspergillus flavus</i>	<i>Aspergillus niger</i>	<i>Colletotrichum gloeosporioides</i>	<i>Curvularia lunata</i>	<i>Fusarium equiseti</i>	<i>Fusarium moniliforme</i>	<i>Fusarium oxysporum</i>	<i>Penicillium digitatum</i>	<i>Rhizopus stolonifer</i>
1	Castor	79.6 ± 0.01 ^a	58.0 ± 0.01	44.9 ± 0.01	75.8 ± 0.01 ^d	78.1 ± 0	82.0 ± 0.01	83.3 ± 0	80.4 ± 0	77.6 ± 0.01	75.3 ± 0.01 ^g
2	Eucalyptus	76.8 ± 0.01 ^b	51.2 ± 0.01	34.7 ± 0.01	44.7 ± 0.01	57.8 ± 0.01	64.0 ± 0.01	57.1 ± 0.01	55.2 ± 0.01 ^f	57.7 ± 0.01	52.1 ± 0.01
3	Mustard	78.9 ± 0.01	66.7 ± 0.01	61.0 ± 0.01	72.7 ± 0.01	75.0 ± 0.01	75.8 ± 0.01 ^e	76.9 ± 0.01	76.2 ± 0.01	74.4 ± 0.01	75.3 ± 0.01 ^g
4	Neem	79.6 ± 0.01 ^a	77.8 ± 0.01 ^c	29.7 ± 0.01	50.8 ± 0.01	71.9 ± 0.01	60.9 ± 0.01	51.9 ± 0.01	53.8 ± 0.01	55.1 ± 0.01	56.2 ± 0.01
5	Tulsi	76.1 ± 0.01 ^b	77.8 ± 0.01 ^c	67.8 ± 0.01	75.0 ± 0.01 ^d	72.7 ± 0.01	75.8 ± 0.01 ^e	71.2 ± 0.01	73.4 ± 0.01	71.8 ± 0.01	67.1 ± 0.01
6	Clove	83.8 ± 0	71.6 ± 0.01	39.0 ± 0.01	74.2 ± 0.01	70.3 ± 0.01	67.7 ± 0.01	60.3 ± 0.01	55.2 ± 0.01 ^f	56.4 ± 0.01	57.5 ± 0.01

All means are the percent inhibition of the mycelial growth. Any mean followed by '±' is the standard error of the mean. The percent inhibition is relative to the growth observed in control flask. All the means are significantly different from each other at p<0.05 level of significance. The means with common superscripts denote similar means.

BIBLIOGRAPHY

- Atolani, O., Adamu, N., Oguntoye, O., Zubair, M., Fabiyi, O., Oyegoke, R., Adeyemi, O., Areh, E., Tarigha, D., & Kambizi, L. (2020). Chemical characterization, antioxidant, cytotoxicity, Anti-Toxoplasma gondii and antimicrobial potentials of the Citrus sinensis seed oil for sustainable cosmeceutical production. *Heliyon*, 6(2).
- Davy, M., Sameza, M. L., Tchameni, S. N., Ayong, M. N. A., Bedine, M. A. B., Youassi, O. Y., Kamsu, P. N., & Jazet, P. M. D. (2020). Antifungal effects of clove (*Syzygium aromaticum*) essential oil against *Colletotrichum gloeosporioides*, the fungus associated with papaya (*Carica papaya* L.) fruit anthracnose. *International Journal of Applied Microbiology and Biotechnology Research*, 8, 51-57.
- Kabir, M. Y., & Hossain, S. K. (2024). Botanical extracts improve postharvest quality and extend the shelf life of papaya (*Carica papaya* L. cv. Shahi). *New Zealand Journal of Crop and Horticultural Science*, 1-17.
- Kalidindi, N., Thimmaiah, N. V., Jagadeesh, N. V., Nandee, R., Swetha, S., & Kalidindi, B. (2015). Antifungal and antioxidant activities of organic and aqueous extracts of *Annona squamosa* Linn. leaves. *Journal of food and drug analysis*, 23(4), 795-802.
- Leyronas, C., Duffaud, M., & Nicot, P. C. (2012). Compared efficiency of the isolation methods for *Botrytis cinerea*. *Mycology*, 3(4), 221-225.
- Mahmoud, D., Hassanein, N., Youssef, K., & Abou Zeid, M. (2011). Antifungal activity of different neem leaf extracts and the nimonol against some important human pathogens. *Brazilian Journal of Microbiology*, 42, 1007-1016.
- Makarenkov, V., Boc, A., Xie, J., Peres-Neto, P., Lapointe, F.-J., & Legendre, P. (2010). Weighted bootstrapping: a correction method for assessing the robustness of phylogenetic trees. *BMC evolutionary biology*, 10, 1-16.
- Mugao, L. (2004). Factors influencing yield, chemical composition and efficacy of essential oils. *Int. J. Multidiscip. Res. Growth Eval*, 5, 169-178.
- Nene, Y. L., & Thapliyal, P. N. (1979). Fungicides in plant disease control.
- Pathak, V. M., Verma, V. K., Rawat, B. S., Kaur, B., Babu, N., Sharma, A., Dewali, S., Yadav, M., Kumari, R., & Singh, S. (2022). Current status of pesticide effects on environment, human health and its eco-friendly management as bioremediation: A comprehensive review. *Frontiers in microbiology*, 13, 962619.
- Prasad, K., & Paul, J. R. (2021). Postharvest losses of papaya and practice for management. *Food Sci. Rep*, 2(7).
- Sarkhosh, A., Schaffer, B., Vargas, A., Palmateer, A., Lopez, P., Soleymani, A., & Farzaneh, M. (2018). Antifungal activity of five plant-extracted essential oils against anthracnose in papaya fruit. *Biological Agriculture & Horticulture*, 34(1), 18-26.
- Silva, A. M. D., Terao, D., Vilela, E. S., Queiroz, S. C. N. D., Maia, A. H., & Fracaroli, J. A. (2025). Essential oils on the control of postharvest diseases of papaya. *Anais da Academia Brasileira de Ciências*, 97(1), e20240770.
- Siqueira Júnior, C. L., Freire, M. d. G. M., Moreira, A. S. N., & Macedo, M. L. R. (2012). Control of papaya fruits anthracnose by essential oil of *Ricinus communis*. *Brazilian Archives of Biology and Technology*, 55, 75-80.
- Sitara, U., Niaz, I., Naseem, J., & Sultana, N. (2008). Antifungal effect of essential oils on in vitro growth of pathogenic fungi. *Pakistan Journal of Botany*, 40(1), 409.
- Sivareddy, B., Reginald, B. A., Sireesha, D., Samatha, M., Reddy, K. H., & Subrahmanyam, G. (2019). Antifungal activity of solvent extracts of *Piper betle* and *Ocimum sanctum* Linn on *Candida albicans*: An in vitro comparative study. *Journal of oral and Maxillofacial Pathology*, 23(3), 333-337.

*Corresponding author Email address:

suchu.more@gmail.com