

Enhanced Antimicrobial effects of Disinfectant prepared from Fruits and Vegetable Peels Extracts

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Abstract- Background: Fruits and vegetables are important components with a crucial role in supplying invaluable nutrients for maintaining human health. Interestingly, the seed and rind of some have higher vitamins, fibers, minerals, and other essential nutrients activity. A large amount of peel waste is generated from fruit and vegetable waste industries and household kitchen and has led to a big nutritional and economic loss and environmental problems. The peel is discarded as waste, even though they contain a diverse range of bioactive compounds with significant antioxidant activity compared to other edible contents. It is therefore necessary to evaluate the nutritional and antioxidant contents of the fruits and vegetables waste materials and highlight their potential to encourage adequate consumption of the waste and re-utilization of the components and rind in possible values of their activities.

Objectives: The present study involved the inedible part of eight different fruits and vegetable waste; Orange peel, Sweet lime peel, Apple peel, Pineapple peel, Banana peel, Bitter gourd peel, Fenugreek stem and Coriander stem phytochemical analysis followed by the formulation of the natural disinfectant. To check the efficacy of prepared disinfectant, antimicrobial tests were performed with selected reference strains.

Methods: The extracts were prepared by drying the collected fruits and vegetable wastes in shade and grinding into a fine powder. Qualitative test for the presence of phytochemicals-carbohydrates, protein, alkaloids, glycoside, steroids, flavonoids, saponin and phenolic compounds were analyzed with suitable methods for all the samples. The aqueous extract was prepared of each powder and mixed with the formulated composition and disinfectant was prepared of eight various types. Further all prepared disinfectants were tested for antibacterial activity against reference strains of *S. aureus* (ATCC25923), *E. coli* (ATCC25922) and *K. pneumoniae* (ATCC700603) by agar cup method.

Key findings: The inedible part of fruits and vegetable wastes contain bioactive compounds due to which significant antibacterial activity was observed with the

test organisms. Hence it is used for the preparation of natural disinfectant with a proper formulation. The prepared disinfectant is ecofriendly and a cost-effective product.

Conclusion: The results revealed very strong inhibition of natural disinfectants as compared with the tested antibiotic (Ampicillin) which was more than double for *E. coli* (15 mm) and for *S. aureus* and *K. pneumoniae* the zone of inhibition was ranked significant. Therefore, the study revealed that utilization of the fruits and vegetables waste as a cost effective and sustainable method for the preparation of natural disinfectants. This method also proved in minimizing the organic bulk wastes of inedible part of fruits and vegetable generated from the industries and household and thereby reducing the environmental pollution and achieved sustainable utilization of waste materials.

Keywords: Antibacterial, Disinfectant, Peel waste, Phytochemical

1. INTRODUCTION

Plant materials are a rich source of biologically active metabolites. Some of these plants have potential bioactive compounds of interest in the pharmaceutical industry. Plant-derived substances have great interest due to their applications as drugs (Ncube et.al., 2008). According to WHO plant and plant materials are used for the medicinal drug and therapeutic use. Fruits and vegetables contain phenol, amino acids, essential oils, pectin, carotenoids, flavonoids, vitamin C all of which have been known as potentially beneficial compounds and are classified as phytochemicals. This ingredient shows the antimicrobial, antioxidant and anti-inflammatory effect which requires for the purpose to reduce the chances of microbial infection (WHO, 2001). Antimicrobial effects of *Citrus sinensis* peel extracts against dental caries bacteria has been studied

(Shetty *et.al.*, 2016). Phytochemicals are diverse range of biologically active compounds found in plants, which provide color, flavor, and natural protection against pests to the plants along with reduction of the risk of developing many forms of cancer (lung, prostate, pancreas, bladder, and breast) and risk of cardiovascular diseases). Treutter (2006) also reported significance of flavonoids in plant resistance. Mervat *et.al.*, 2009 studied antioxidant activities, total anthocyanins, phenolics and flavonoids contents of some sweet potato under stress of different concentrations of sucrose and sorbitol. Ahmad and Aqil (2007) reported in vitro efficacy of bioactive extracts of fifteen medicinal plants against ES betaL-producing multidrug-resistant enteric bacteria. Antimicrobial activity of various plants extracts was also reported by Iwu *et.al.*, (1999). The problem of waste management in India is increasing day by day. Fruits and vegetable waste is classified as organic solid waste, which can decompose easily and produce carbon dioxide and methane. Common disposal in landfills causes environmental pollution. The inedible part of fruits and vegetables waste generated from various food industries and from domestic waste contains potential bioactive compounds. Due to rising infectious diseases use of disinfectants among individuals has also increased. Mostly chemical based disinfectants are manufactured with higher ration of alcohol and hydrogen peroxide. This had harmful effect on the skin or applied area. Recently Adeeyoa *et. al.*, (2023) also studied on the disinfectants of plant origin and its emerging application.

The antimicrobial food disinfectant market size has grown strongly in recent years. It has grown from \$1.89 billion in 2024 to \$2.04 billion in 2025 at a compound annual growth rate (CAGR) of 8.2% and it will grow to \$2.77 billion in 2029 at a compound annual growth rate (CAGR) of 7.9%. The growth in the forecast period can be attributed to the rising demand for organic food disinfectants, growing consumer preference for natural antimicrobial agents and increasing focus on sustainability (Antimicrobial Food Disinfectant Global Market Report 2025). Therefore, there is a need for a cost-effective ecofriendly natural formulation of disinfectant as per the increasing demand. There is likely any study conducted on the use of natural components from inedible part of fruits and vegetables waste for the preparation of disinfectant. Hence our study is based

on the utilization of the inedible part of the fruits and vegetables waste containing the potential bioactive components with biological characteristics like antibacterial activity, antifungal activity and antiviral activity. This study revealed dual purpose, utilization of the fruits and vegetable waste in the preparation of disinfectants and secondly this also reduces the bulk waste generated and environmental pollution to some extent. By utilizing the inedible part of fruits and vegetable wastes the international goal of “zero waste” can be achieved by sustainable utilization of these waste materials as a rich source of bioactive compounds and it also fulfils in the category of sustainable development goals 12 (SDG12) for responsible production and consumption. The natural disinfectants are projected to be better alternative to commercial disinfectant since they are cost effective and safe for skin.

2. MATERIALS AND METHODS

2.1 Sample collection and extract preparation

The sample of fruits and vegetables waste were collected; Orange peel, Sweet lime peel, Apple peel, Pineapple peel, Banana peel, Bitter gourd peel, Fenugreek stem and Coriander stem. They were carefully washed under the tap water followed by the distilled water and then air dried for 2-3 days. Dried samples were ground in mixer in powdered form and their aqueous extracts were prepared by adding 20 gram each in 50 ml of distilled water. Sterilized and filtered through the Whatman filter paper and stored in air-tight sterile container at 4°C in refrigerator for further use.

2.2 Disinfectant preparation

20 ml of each sample extracts were taken in different sterile beaker to make disinfectants. Following reagents were added, Tween 80 – 0.5%, Hydrogen peroxide – 0.2%, Ethanol 0.5%, Sodium benzoate – 0.5%, Glycerin – 2.3% and Olive oil – 2 to 3 drops are mixed respectively in each beaker. The efficacy of the prepared disinfectants was further tested for its antimicrobial activity

2.3 Test microorganisms

The reference bacterial species of American type cell culture (ATCC) was used for testing. Overnight grown

cultures of *Klebsiella pneumoniae* (ATCC700603), *Staphylococcus aureus* (ATCC25923) and *Escherichia coli* (ATCC25922) were used for antimicrobial testing. All laboratory works were performed according to CLSI guidelines (Wayne 2014).

2.4 Inoculum's preparation

Each strain was sub-cultured on Muller-Hinton agar slants at 37°C for 24 hours. The cell harvest was used for testing the antimicrobial activity with viable cell count of 10⁷ colony forming units (CFU/ml) by MacFarland. Freshly prepared inoculum density was adjusted and was used for the antimicrobial activity testing.

2.5 Antimicrobial Test

Agar cup method was used on sterile Muller Hinton agar (Himedia, India) plates. Wells were prepared of 5mm diameter with sterile cork borer and samples were added 30 µl of each prepared disinfectants and 30 µl of its extracts were added in respective wells and antibiotics discs of Gentamycin 10µg/disc and Ampicillin 10µg/disc (Himedia, India) were used for reference as standards. All plated were incubated at 37°C for 24 hours. Zone of inhibition was measured in mm and using Kirby Bauer chart it was compared (Barbour *et.al.*, 2004)

2.6 Qualitative analysis of phytochemicals

Standard preliminary phytochemical qualitative analysis of the extracts was carried out for the selected fruits and vegetable waste and screened for the presence or absence of bioactive compounds or secondary metabolites using standard procedures. (Agrawal *et.al.*, 2012)

2.6.1 Carbohydrates – DNSA test was performed with all extracted samples in different test tubes and boiled for 10 minutes after cooling distilled water is added. Color difference was compared with blank tube (yellow), orange color showed the presence of carbohydrate.

2.6.2 Alkaloids – Mayer's test was performed, few drops of Mayer's reagent was added to 1ml of extract. A yellowish or white precipitate, indicated the presence of alkaloids.

2.6.3 Glycoside –0.5 mg of extracted sample was dissolved in 1 ml of water and then aqueous NaOH solution was added. Formation of yellow color indicated the presence of glycosides.

2.6.4 Protein – Folin-Lowry method was done where CuSO₄ reacts with NaOH and gave faint green color, showed the presence of protein.

2.6.5 Steroids – 1 ml of the extract was dissolved in 10 ml of the chloroform and equal volume of sulphuric acid was added by the sides of the test tube. Upper layer turning red and sulphuric acid layer showed yellow with green fluorescence indicated presence of steroids.

2.6.6 Phenolic – To neutral FeCl₃ solution, added diluted NaOH until a permanent brown precipitate is formed.

2.6.7 Flavonoids – Two to three drops of NaOH were added to 2 ml of extract. Initially, a deep yellow color appeared but it gradually became colorless by adding few drops of dilute HCl, indicating the presence of flavonoids.

2.6.8 Saponin – Frothing test, 2.5 mg of extract was allowed to react with 5 ml of water formation of foam indicates presence of saponin.

2.7 Quantitative estimation of sugar content of extracts
Quantitative estimation of sugar was performed by the DNSA method. The extracted samples with addition of DNSA were mixed and boiled, color changed (red) was observed. After the cooling and the addition of distilled water, absorbance at 540 nm on colorimeter was recorded (Lubaina *et.al.*, 2019). Standard concentration of glucose was used to determine the sugar concentration in extracts by plotting the graph and unknown were extrapolated.

2.8 Statistical analysis

For antimicrobial study, three replicates of each set of plates with test strains were performed. The diameter of inhibition zone was analyzed by taking its mean value followed by standard deviation was determined and one way ANOVA was performed by Microsoft excel. The results were expressed as mean (± SD). The data at p < 0.05 were considered significant.

3. RESULT AND DISCUSSION

3.1 Antimicrobial effect of extracts on reference strains

Antimicrobial activity of prepared disinfectants against *Klebsiella pneumoniae* (ATCC700603), *Staphylococcus aureus* (ATCC25923) and *Escherichia coli* (ATCC25922) were performed. All fruits and vegetables peel extracts showed the antimicrobial activity with the *Klebsiella pneumoniae* (ATCC700603) except coriander stem extract (Fig.1A and Fig.3). Antimicrobial activity against *Klebsiella pneumoniae* (ATCC700603) was in the order of; Banana peel > Bitter gourd peel > Pineapple peel > Apple peel > Sweet lime peel > Orange peel > Fenugreek stem > Coriander stem disinfectant respectively. The zone of inhibition was larger than the reference antibiotic gentamicin 10 µg. Banana peel disinfectant showed maximum zone of inhibition against the *K. pneumoniae* (ATCC700603) and Fenugreek stem disinfectant showed least zone of inhibition. Antimicrobial activity against *Staphylococcus aureus* (ATCC25923) was in the order of Banana peel > Bitter gourd peel > Pineapple peel > Apple peel > Sweet lime peel > Orange peel > Fenugreek stem > Coriander stem disinfectant respectively. Antimicrobial activity of sample extracts against the *Staphylococcus aureus* showed least zone of inhibition whereas gentamicin showed maximum zone of inhibition in Fig.1C and Fig.5. This study corroborated with the study of Tomoko *et.al.*, 2002. Antimicrobial activity against *Escherichia coli* (ATCC25922) was observed to be in the order of Pineapple peel > Fenugreek stem > Apple peel > Bitter gourd peel > Orange peel > Sweet lime peel > Banana peel > Coriander stem disinfectant respectively (Fig.1B and Fig.4). All the zone of inhibition was ranked to be almost doubled than the reference antibiotic tested ampicillin 10 µg (Ali *et. al.*, 2017)

3.2. Phytochemical screening from the vegetable and fruit peel extract

Preliminary phytochemical analysis of all extracts revealed the presence of following compounds: alkaloids, glycoside, steroids, phenolic compounds, flavonoids and saponin. Absence of alkaloids in Fenugreek stem and Coriander stem. Glycoside was present in Orange peel, Sweet lime peel, Apple peel, Banana peel and Bitter gourd peel. Except Pineapple peel and Coriander stem all sample extracts showed the steroids containing compound. Orange peel, Apple peel, Pineapple peel and Banana peel showed the presence of phenolic compound. Flavonoids were present in all extracts. Fenugreek stem and Coriander stem showed the absence of saponin components (Table I). Similarly, Edeoga *et. al.*, (2005) also studied the phytochemical components of plants extracts.

3.3 Sugar content of the vegetable and fruit peel extracts

Fenugreek stem showed minimum sugar content (450 µg ml⁻¹) as compared to the other analyzed sample extracts, whereas the Orange peel showed maximum sugar content as 960 µg ml⁻¹ (Fig.2).

4. CONCLUSION

The formulation of each sample extracts disinfectant showed perfect enhanced antimicrobial activity with the tested microorganisms. Further combination of the extracts could be studied to check if any enhanced antimicrobial activity is expressed or not. Thus, improving the methods for qualitative and quantitative determination of plants is very important for quality assessment in medicinal plant industry. In addition, phytochemical analysis gives a good monitoring method of the seasonal changes of the active constituents and during cultivations and harvesting which assists in collecting the largest amounts of the active constituents. To increase the use of plants as the cheapest source of raw material in medicinal industry, phytochemical analysis needs more research efforts

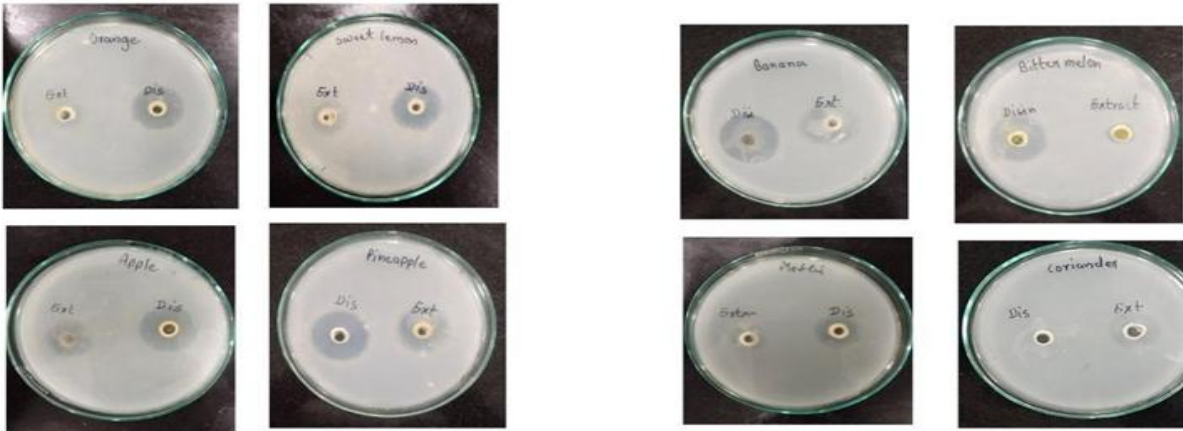


Fig.1(A): Antimicrobial test of the sample (peel/stem) extracts with the *K. pneumoniae* (a) Orange peel (b) Sweet lime (c) Apple peel (d) Pineapple peel (e) Banana peel (f) Bitter melon (g) Fenugreek stem and (h) Coriander stem.

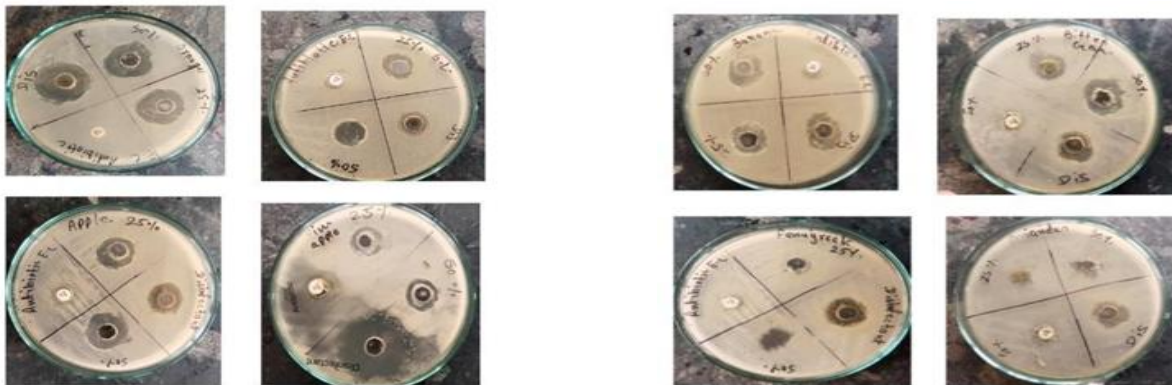


Fig.1(B): Antimicrobial test of the sample (peel/stem) extracts with the *E. coli* (a) Orange peel (b) Sweet lime (c) Apple peel (d) Pineapple peel (e) Banana peel (f) Bitter melon (g) Fenugreek stem and (h) Coriander stem.

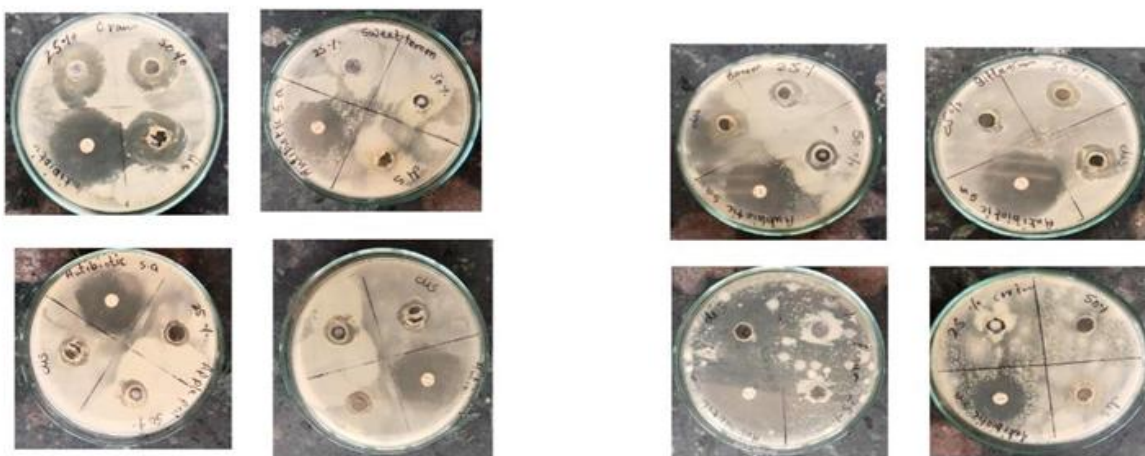


Fig.1(C): Antimicrobial test of the sample (peel/stem) extracts with the *S. aureus* (a) Orange peel (b) Sweet lime (c) Apple peel (d) Pineapple peel (e) Banana peel (f) Bitter melon (g) Fenugreek stem and (h) Coriander stem.

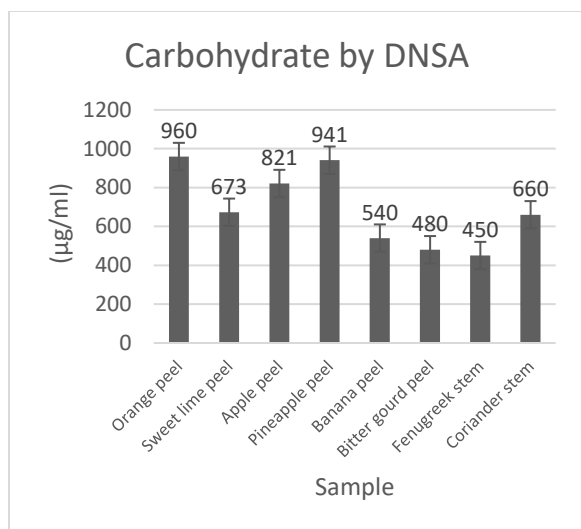


Fig.2: Quantitative estimation of Carbohydrate contents of the fruit and vegetable peel waste samples.

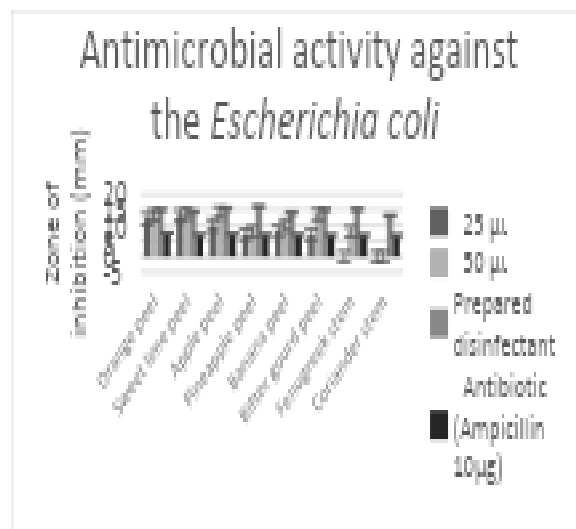


Fig.4: Zone of inhibition (diameter in mm) of extracts on *Escherichia coli*, Mean $\pm$ Standard Deviation.

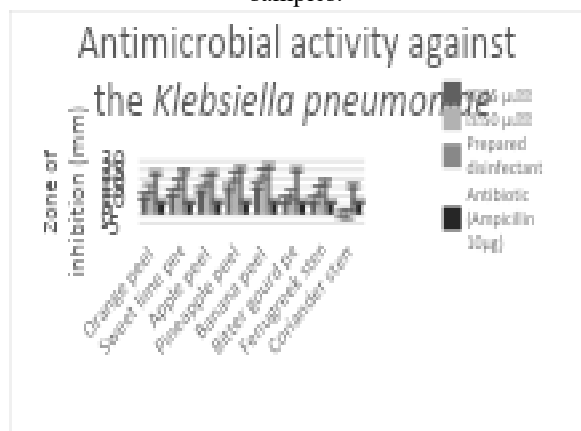


Fig.3: Zone of inhibition (diameter in mm) of extracts on *Klebsiella pneumoniae*, Mean $\pm$ Standard Deviation

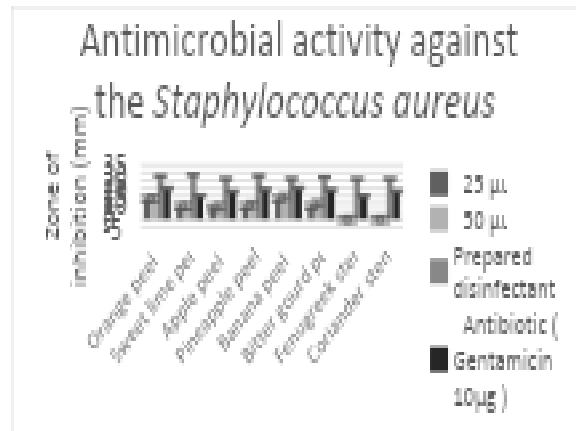


Fig. 5: Zone of inhibition (diameter in mm) of extracts on *S. aureus*, Mean $\pm$ Standard Deviation

Sr. no.	Sample	Carbohydrates	Alkaloids	Glycosides	Protein	Steroids	Phenolics	Flavonoids	Saponine
1	Orange peel	+	+	+	+	+	+	+	+
2	Sweet lime peel	+	+	+	+	+	-	+	-
3	Apple peel	+	+	+	+	+	+	+	+
4	Pineapple peel	+	+	+	+	+	+	+	+
5	Banana peel	+	+	+	+	+	+	+	+
6	Bitter gourd peel	+	+	+	+	+	-	+	+
7	Fenugreek stem	+	-	-	+	+	-	+	-
8	Coriander stem	+	-	-	+	-	-	+	-

Note: '+' presence and '-' absence

Table I: Phytochemical screening of the aqueous extracts and the active constituents of samples used

REFERENCE

- [1] Adeeyoa A.O., Ojeladeb B.S., Alabic M.A., and Makungo R. (2023). Disinfectants of plant origin: emerging application, standardization and meta-analysis. *Desali. Wat. Treat.*, 313: 125–129
- [2] Agarwal Y., Ltankar P., Patil A., Vyas J., and Ketkar A. (2012). Phytochemical & HPTLC Studies of Various extracts of *Annona squamosa* (Annonaceae), *Int. Pharm. Tech. Res.* 4(1): 364-368.
- [3] Ahmad I., and Aqil F. (2007). In vitro efficacy of bioactive extracts of 15 medicinal plants against ESbetaL-producing multidrug-resistant enteric bacteria. *Microbiol. Res.* 162(3):264-75.
- [4] Ali J., Das B., and Saikia T. (2017). Antimicrobial activity of lemon peel (*Citrus limon*) extract. *Int. J. Curr. Pharm. Res.* 9(4):79-82.
- [5] Antimicrobial Food Disinfectant Global Market Report, April 23, 2025, Publisher: The Business Research Company.
- [6] Barbour E.K., Al Sharif M., Sagherian V.K., Habre A.N., Talhouk R.S., and Talhouk S.N. (2004). Screening of selected indigenous plants of Lebanon for antimicrobial activity. *J. Ethnopharmacol.* 93(1):1-7.
- [7] Behboud J., and Amirreza K. (2013). Antibacterial activities methanol of extract and lemongrass essence on pathogenic bacteria. *World Appl. Sci. J.* 28:1796-801.
- [8] Edeoga, H.O., Okwu, D.E., and Mbaebie, B.O. (2005). Phytochemical Constituents of Some Nigerian Medicinal Plants. *Afr. J. Biotechnol.* 4: 685-688.
- [9] Iwu, M.W., Duncan, A.R., and Okunji, C.O. (1999). New antimicrobials of plant origin *In: Perspectives on new Crops and new Uses*, eds. J. Janick, ASHS Press, Alexandria, VA, 457-462.
- [10] Lubaina A.S., Renjith P.R., and Dinesh Babu K.V. (2019). Phytochemical Analysis and FT-IR Fingerprinting of Pineapple Peel-A Natural Resource of Bioactive Compounds. *Int. J. Pharm. Biol. Sci.* 9 (3): 1229-1237
- [11] Mayr U., Treutter D., Santos-Buelga C., Bauer H., and Feucht W. (1995). Developmental changes in the phenol concentrations of 'golden delicious' apple fruits and leaves. *Phytochem.* 38(5):1151-5.
- [12] Mervat M.M., El Far, Hanan A., and Taie A. (2009). Antioxidant activities, total anthocyanins, phenolics and flavonoids contents of some sweet potato genotypes under stress of different concentrations of sucrose and sorbitol. *Aust. J. Basic Appl. Sci.* 3:3609-3616.
- [13] Ncube N.S., Afolayan A.J., and Okoh A.I. (2008). Assessment techniques of antimicrobial properties of natural compounds of plant origin: Current methods and future trends, *Afr. J. Biotechnol.* 7: 1797–1806.
- [14] Shetty S.B., Mahin-Syed-Ismail P., Varghese S., Thomas-George B., Kandathil-Thajuraj P., Baby D., Haleem S., Sreedhar S., and Devang-Divakar D. (2016). Antimicrobial effects of Citrus sinensis peel extracts against dental caries bacteria: An in-vitro study. *J. Clin. Exp. Dent.* 8(1): 1-7.
- [15] Thakur N., Chawla S., Pathak R., and Pathak A. (2012). Invitro antioxidant potential studies of plant extracts of Tinsopora cordifolia, *Inter. J. Appl. Microbiol. Sci.* 1:15-20.
- [16] Tomoko N., Takashi A., Hiromu T., Yuka I., Hiroko M., Munekazu I., Totshiyuki T., Tetsuro I., Fujio A., Iriya I., Tsutomu N. and Kazuhito W. (2002). Antibacterial activity of extracts prepared from tropical and subtropical plants on methicillin-resistant *Staphylococcus aureus*. *J. Health Sci.* 48: 273-276.
- [17] Treutter, D. (2006). Significance of Flavonoids in Plant Resistance: A Review. *Environ. Chem. Lett.*, 4: 147-157.
- [18] Wayne, P.A. (2014) Performance Standards for Antimicrobial Susceptibility Testing; Twenty-Fourth Informational Supplement. CLSI Document M100-S24.
- [19] WHO (2001). Legal Status of Traditional Medicine and Complementary/ Alternative medicine, A world-wide review, WHO Publishing, Geneva.