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# *In vitro* antimicrobial activities of vegetables (Potato, Cucumber, Sweet Potato and Ginger) peel wastes for ecofriendly microbial management

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**Abstract**
Vegetable processing generates tremendous amount of peel waste, which is dumped in the environment. The vegetables peels are generally considered as waste product and are normally thrown away. These wastes have potential microcidal activities. These can be used as natural and economic source of antimicrobial agent against many pathogenic microbes. In the present study antimicrobial potential of four copiously available vegetable peel wastes (e.g., potato, cucumber, sweet potato and ginger) was evaluated on selected bacterial and fungal strains. The *in vitro* antimicrobial activities were worked out using diffusion assay expressed in terms of zone of inhibition and substantiated by advanced numerical tools. The highest antibacterial activity was found with cucumber against *Escherichia coli* followed by *Staphylococcus aureus*, *Lactobacillus* and *Proteus vulgaris* the highest antifungal activity was found with sweet potato followed by ginger and potato against *Saccharomyces cerevisiae* in terms of zone of inhibition. Hence it confirms the potential of above vegetable peel waste to be used for therapeutic purpose to combat the pathogenic microbes. The studies conducted on peels revealed the presence of important pharmacologically active antimicrobial constituents and suggests future scope of vegetable peel wastes for therapeutic purpose. Thus the ecofriendly approach of microbial management will be helpful in lowering of organic wastes and sustainability of the environment.

**Keywords:** vegetable peels, *escherichia coli*, *staphylococcus aureus*, *lactobacillus*, *proteus vulgaris*, *saccharomyces cerevisiae*, antimicrobial, microbial management

## Introduction

The scientific investigations revealed the uninterrupted rich sources of antimicrobials among vegetables seeds and peels. Usually vegetables skins are thrown in the garbage or fed to livestock. These parts are very rich source of many bioactive components and considered to have antimicrobial potential (Singh *et al.*, 2017) [23]. Therefore, it can be used for pharmacological or pharmaceutical purposes. Various components having antimicrobial, antioxidant and anti-inflammatory activities are extracted from different peels (Sehrawat *et al.*, 2020; Yadav *et al.*, 2020) [20, 39]. This prospect will make available an alternative to solve the problems in areas of antibiotic application as an economical and ecofriendly approach in reducing the pollution due to disposal of such agro wastes (Saleem and Saeed, 2020) [18]. It was reported that vegetable wastes of potato, brinjal, pumpkin, cauliflower and cabbage, produced proteases during by solid state fermentation used *in vitro* management of *Aspergillus niger* (Madhumithah *et al.*, 2011) [11]. The antimicrobial activity of wax gourd (*Benincasa hispida*) extracts was tested against six Gram positive (*Bacillus subtilis, Staphylococcus aureus, Micrococcus species, Staphylococcus epidermidis, Staphylococcus xylosus* and *Bacillus circulans*) and seven Gram-negative bacteria (*Salmonella typhimurium, Pseudomonas aeruginosa, Proteus vulgaris, Serratia liquefaciens, Cronobacter muytjens, Shigella boydii* and *Serratia marcescens*), one yeast and two molds using the disc diffusion method and revealed significant antimicrobial potential (Abdullah *et al.*, 2012; Doharey *et al.*, 2021) [1, 9]. In another report the peel extracts of *Citrus limon* showed maximum antimicrobial activity followed by *Manilkara zapota* and *Carica papaya*, indicating its effectiveness as a promising source of natural antimicrobics (Rakholiya *et al.*, 2014) [17]. There were various fruits (peel, flesh or seed) have been used in traditional medicine for stomachache, sore eyes, fever, diabetes, cardioprotective, hepatoprotective and renoprotective purposes (Singh *et al.*, 2018a; Singh *et al.*, 2019; Singh *et al.*, 2020a; Singh *et al.*, 2020b; Singh *et al.*, 2020c) [26, 28, 29, 30, 31]. Papaya has been shown to contain sulphydroxyl protease which can inhibit viralsor microbial infection. These compounds are playing an important role in fruits protection against pathogenic agents responsible for fruit lysis (Rajashekhara *et al.*, 1990) [16]. Phenolic compounds from spices such as zingerone and capsaicin have been found to inhibit the germination of bacterial spores, and many known to be potential anticancer agent as well (Burt, 2004; Tuli *et al.*, 2021) [7, 35].

The wastes from fruits and vegetable processing industries being rich in polysaccharides (cellulose, hemicellulose and lignin) can be subjected to solid state fermentation (SSF) for the production of ethanol which has several uses (Abu Yazid *et al.*, 2017; Mahato *et al.*, 2021) [2, 12]. It can be used as a liquid fuel or liquid fuel supplement and as a solvent in many industries. Citric, succinic, malic, acetic, and tartaric acids are commonly found in fruits and fresh-cut byproducts (Yadav *et al.*, 2021) [40]. They have been traditionally used in the food industry as preservative agents, attributing their antimicrobial efficacy to the pH changes of the treated media. In general, bacteria grow at a pH close to 6.5 to 7.5, but tolerate a pH range from 4 to 9. Yeasts are more tolerant to low pH values than bacteria, whereas molds can grow in the widest pH range. One effective way of limiting microbial growth is increasing the acidity of a particular food by adding an acidic substance (Massilia *et al.*, 2009) [13]. Acids attack cell walls, cell membranes, metabolic enzymes, protein synthesis systems, and the genetic material of microorganisms (Tripathi and Dubey, 2004) [33]. Flavonoids have been reported to enhance the antibacterial, antiviral, or anticancer activities of compounds such as naringenin, acycloguanosine, and tamoxifen (Bracke *et al.*, 1999, Singh *et al.*, 2021a; Tuli *et al.*, 2021) [6, 25, 35]. The mixture of phytochemical constituents in plant extracts can be an advantage due to the synergistic effect that the constituents may have (Bakkali *et al.*, 2008; Singh *et al.*, 2018b; Sheokand *et al.*, 2019; Devi *et al.*, 2020; Singh *et al.*, 2021b) [5, 27, 2, 8, 32]. Present study designed to investigates the antimicrobial activity of potato, cucumber, sweet potato and ginger peel extracts against selected microorganisms. Furthermore, this study also aimed to suggest a solution for agro waste minimization. The results obtained in this study will help to explore the possibility for future use of selected fruit peel wastes as antimicrobial agents.

## Materials and Methods

a. **Collection and preparation of peel extracts:** This study had carried out in the Department of Biotechnology, Maharishi Markandeshwar (Deemed to be University), Mullana-Ambala (Haryana). The vegetable *viz.* potato, cucumber, sweet potato and ginger peel were obtained from local market and some from home waste peel material as well. The vegetables were washed and cleaned very well. Thereafter peeled extraneous matters were dried at room temperature in a shaded region for 7 to 10 days. The dried peels were grinded in mortar and pestle followed by preparation of aqueous extract using sterile distilled water (10 g of each powdered sample in 100 ml of aqueous solvent). The solutions were kept in shaking incubator for 24hrs and filtrate was collected using Whatman No.1 filter paper. The collected filtrate was stored at 4°C for further application.

b. ***In vitro* antimicrobial activity:** Pure culture *viz. Escherichia coli, Staphylococcus aureus, Proteus vulgaris, Lactobacillus* and *Saccharomyces cerevisiae* were collected from the Microbiology Laboratory, Department of Biotechnology, MMDU-Mullana. The minimum inhibitory concentration of crude plant extracts against pathogenic strains was determined by dilution method (Sathyabama *et al.*, 2011) [19]. The nutrient agar medium was used for mass culture of microorganisms. Nutrient broth and potato dextrose media was used for the inoculation and standardisation of the microorganisms. The crude plant extract prepared were tested for the antibacterial activity through well diffusion method (Upadhyay, 2016a) [36]. In each well 100μl of crude peel extract was added (Upadhyay, 2016b) [37]. Simultaneously the positive control streptomycin (1mg/ml) applied for gram positive and gram negative bacteria; however, fluconazole (1mg/ml) used against fungi.

c. **Incubation and inhibition analysis:** The microbial growth inhibition zone for bacteria was measured after incubation at 37°C. While in case of fungi it was measured after incubation at 30°C. The appearance of the clear and microbes free inhibitor zones begin within 24 hrs in bacteria culture plates and after 48-72 hrs in fungi. The antibacterial activity of each extract expressed in terms of diameter of zone of inhibition (mm) produced by respective extract (Upadhyay, 2016c) [38]. The findings were substantiated using advanced numerical tools and illustrated.

**Table 1:** Antibacterial and Antifungal activities of vegetable peel and positive control antimicrobial agents (Zone of inhibition in mm).

| S. No. | Name of vegetable peel control positive antimicrobial agents | Antibacterial activities | | | | Antifungal activities |
|---|---|---|---|---|---|---|
| | | *E. coli* | *S. aureus* | *Proteus vulgaris* | *Lactobacillus* | *Saccharomyces cerevisiae* |
| 1. | Potato (*Solanum tuberosum* L.) | 18 | 17 | 18 | 19 | 18 |
| 2. | Cucumber (*Cucumis sativus* L.) | 22 | 21 | 19 | 20 | 14 |
| 3. | Sweet potato (*Ipomoea batatas* L.) | 14 | 16 | 12 | 13 | 23 |
| 4. | Ginger (*Zingiber officinale* R.) | 10 | 12 | 10 | 11 | 20 |
| 5. | Streptomycin (+ve control) | 22 | 20 | 21 | 21 | - |
| 6. | Fluconazole (+ve control) | - | - | - | - | 25 |

## Results and Discussion

Antimicrobial activity was observed with different peels of vegetable against gram negative bacteria, gram positive bacteria and fungi. Zone of inhibitions marked the clear difference between the activities of different peels during the study (Table 1). As the bacteria and fungi belong to different groups and have structural and metabolic differences, therefore these vegetable peels differed in the activity accordingly. Amongst the selected fruits peels the highest antibacterial activity was found with cucumber against *Escherichia coli* (22 mm) followed by *Staphylococcus aureus* (21 mm), *Lactobacillus* (20 mm) and *Proteus vulgaris* (19 mm). The peak antifungal activity was recorded with sweet potato (23 mm) followed by ginger (20 mm), potato (18 mm) and cucumber (14 mm) against *Saccharomyces cerevisiae* in terms of zone of inhibition (Fig. 1).

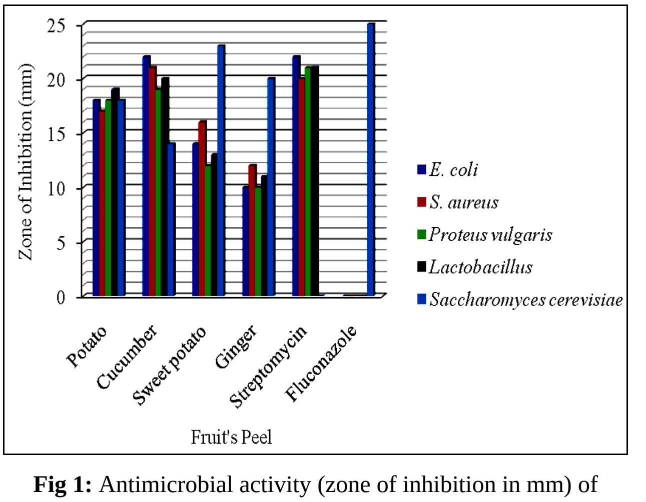


**Fig 1:** Antimicrobial activity (zone of inhibition in mm) of different fruits peel extracts against the selected microbes.

The differences in values of total phenolic compounds (TPC) were probably due to the color and variety of the potato tested (Al-Saikhan *et al.*, 1995) [4]. A report on the presence of anthocyanins in the skin of colored potato varieties was found to be 2.5 fold higher than in the tuber pulp (Jansen and Flamme, 2006) [10]. Bracke *et al.*, (1999) [6] reported that, flavonoids (naringenin, acycloguanosine, and tamoxifen compounds) from some plant extracts increased the antibacterial activity (Aggarwal *et al.*, 2020; Yadav *et al.*, 2020) [3, 39]. Some organic acids *viz.* citric, succinic, malic, acetic, and tartaric acids are commonly found in the fruit and vegetable peels having antimicrobial activity including *Staphylococcus aureus* (Prajapati *et al.*, 2020) [15]. These attack cell walls, cell membranes, metabolic enzymes, protein synthesis systems, and the genetic material of microorganisms (Tripathi and Dubey, 2004) [33]. Numerous studies have provided evidences for decreased risk of some chronic diseases e.g., some types of cancer, cardiovascular and neurodegenerative disorders with increased dietary intake of vegetables, fruits, teas, spices and other plant-based foods and supplements (Sehrawat *et al.*, 2020; Singh *et al.*, 2020d; Tuli *et al*., 2021; Yadav *et al.*, 2021) [20, 24, 35, 39]. The most abundant byproducts of minimal processing of fresh-cut fruit and vegetable were peel and seed that contain high amounts of phenolic compounds with antioxidant and antimicrobial properties (Shrikhande, 2000; Muthuswamy *et al*., 2008; Tuchila *et al*., 2008) [22, 14, 34]. Hence these studies confirmed that vegetable peel extracts consists of potential antimicrobial active compounds such as phenolic compounds, flavonoids and organic acids corroborated to the current findings. Thus these play a very significant role to control bacterial and fungal pathogens in ecofriendly and sustainable manner.

## Conclusion

The vegetable peel is common household and industrial wastes which causes pollution problem if not utilized or disposed-off properly. This study is aimed to explore the new dimension applicability of vegetable peel wastes as potential source of low cost natural antimicrobial agent. The antimicrobial activities of potato, cucumber, sweet potato and ginger vegetable peel showed noticeable significant antimicrobial activities against the selected microbes. This investigation has open up the opportunity to these vegetable peels in drug development for the treatment and management of various pathogenic microbes. Therefore, the current findings will definitely unlock scope for utilization of the vegetable peel as sustainable and ecofriendly antimicrobial agents.

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