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Investigation of Bioactive Functional Groups of Solanum tuberosum Peels Using FTIR Technique and Evaluation of Its Antifungal Activity

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Abstract:

In fact Solanum tuberosum peel contains a lot of nutrients. In the disc diffusion method, the effectiveness of the potato peel waste extract on the antibacterial activity against fungal infections was determined. Specificity of the antifungal activity for the phylogenetic group was again confirmed by the fact that media containing active rhizospheric bacteria inhibited the growth of different species of the pathogenic fungus. The specific aim of the study was, therefore, to determine if the crude methanolic extract of the peelings of Solanum tuberosum L. (White potatoes) possesses antifungal activities against . Indeed, when it comes to analysing various substrates, there is no single method that could be regarded as more important than Fourier transform infrared spectroscopy (FTIR). It is also a strength of this technique that the analyst is able to perform analysis at nearly any state of the sample. For example, if proper sample preparation is used than liquids, solutions, pastes, powders, films, fibres, gases and surfaces can be tested. Many IR sampling techniques including diffuse reflectance and ATR sampling has been made easier by FTIR. This type of analysis was done using Fourier transform infrared (DRIFT) spectrometer. Evaluation of the antifungal properties of Solanum tuberosum peel bioactive metabolites of methanol, ethyl acetate, and ethanolic extract in comparison to three common antibiotics (Fluconazole (FCZ), Itraconazole (ICZ), and Posaconazole (PCZ)). Recorded (15.00±0.58, 13.74±0.25 and 17.00±0.30) for Trichophyton rubrum while (16.09 ± 0.29, 14.45 ± 0.28 and 18.90 ± 0.35) for Fusarium oxyporum and recorded (10.17 ± 0.20, 09.05 ± 0.18 and 13.00 ± 0.22) for Cladosporium herbarum in the same time antifungal activity of Candida albicans was (12.50 ± 0.24, 11.00 ± 0.19, and 15.47 ± 0.26). According to the current study's findings, Solanum tuberosum peels may be a valuable plant source of active chemicals with therapeutic value that can be used to treat certain fungal diseases.

Keywords: Antimicrobial, *Solanum tuberosum* Peels, Bioactive Functional Groups

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INTRODUCTION

Peel waste from Solanum tuberosum is an intriguing, inexpensive adsorbent that effectively removes methylene blue (MB) dye from aqueous solutions. Methylene blue dye could be successfully removed from an aqueous solution using potato peels as an environmentally friendly adsorption material. Therefore, using the coagulation-flocculation process, potato peel leftovers can be valorised to provide a flocculant agent for wastewater treatment [1–3]. Utilising and exploiting byproducts from human endeavours like fishing, farming, industry, and others, this environmentally friendly strategy incorporates sustainability and biodegradability. Examples of bioflocculants that are safe, effective, and affordable alternatives to synthetic flocculants include alginate, cellulosic materials, starch, chitosan, xanthan gum, and tannins. It should be noted that certain food wastes, such as potato peels, contain vital organic substance. In order to support environmentally friendly food sectors, potato peel residues may be utilised as a food preservative, pharmaceutical ingredient, or animal feed. They also stated that potato peels may be utilised in renewable energy. Traditional medicine practitioners have highlighted the therapeutic usefulness of numerous indigenous plants for a variety of diseases. Patients with dermatophytes are increasingly seeking treatment based on Indian medicinal herbs, and doctors are searching for alternative therapies because to the negative effects of current medicines [4]. The current study was conducted to examine the antifungal activity against the clinical isolates of fungi after these facts were revealed. Five distinct fungal isolates were obtained for this investigation: Candida albicans, Fusarium oxyporum, Cladosporium herbarum, and Trichophyton rubrum. The isolates that were chosen were cultivated on sabouraud dextrose agar (SDA). Twenty percent those treated with dermatophytic fungi using a sterile scalpel scrapped and macerated a 21-day-old culture of dermatophytic fungi with sterile distilled water. Spectrophotometric studies were performed on the suspension which was brought to have an A450 of 0.600. Fungal inoculum was prepared in this way: A known quantity of this inoculum was used for further study. Reference broth micro dilution method was employed in performing the susceptibility test as supported by previous studies [5, 6]. MIC and MFC were determined 21 days after incubation at 35°C. Thin layer chromatography and high performance thin layer chromatography were employed for identification of macromolecules and secondary metabolites of A. marmelos to assess phytoconstituents.

Fungal disease occurrence is a major issue in the modern world. This is due to the pathogens' development of resistance to antifungal treatments and the adverse effects of medications used to treat fungal disorders. Therefore, the need for safer, more effective, and alternative chemotherapeutic treatments is high. Triterpenoids, phenols, flavanoids, quinines, tannins and their glycosides, alkaloids, and their essential oils are only a few of the diverse secondary metabolites found in plants. Several workers have stressed the significance of these compounds as antibacterial agents against infections. Synthetic and natural plant-based products are the main focus of scientific efforts to find new possible antifungal medications [7, 8]. It has also been proved that the extracts of many plants and herbs show the biological activity both in vitro and in vivo while in the current study the plants used are in line with the traditional medicine research which emphasis on the characterisation of antifungal activity of such plants. In many years, especially when current generation drugs were not easily available, crude medicine has been one of the cheapest therapeutic services that can be provided in the millennium primary care system. Actually, use of medical plants is one of the integral parts of folk remedies prevalent among individuals in the third world countries. [9-11]. Besides, thanks to the applied possibilities of contemporary technologies and the constant search for new scientific methods, information on the phyto-active compounds within the plants, their activities, and therapeutic characteristics become newer and newer. As postulated by pharmacopoeia, the active compounds in these plants are extracted and marketed in various pharmaceutical formulations, concentrations and packaging

materials [12, 13]. The aim of the study was to determine the level of effectiveness of an extract prepared from Solanum tuberosum L peelings using methanol solvent against a fungal pathogen.

Materials and Methods

The Solanum tuberosum preparation Peeled

The local Babylonian marketplaces were the source of dried plant components. They were crushed using an electrical grinder, and the resulting powder was gathered in nylon bags and stored at room temperature in the laboratory until it was needed. Before being allowed to dry in the open for a few days, the potato peels that were going to be tested were cleaned with tap water. Following that, they were chopped into tiny bits and ground into a fine powder. After that, the samples were put in bottles and kept at room temperature.

Characteristics

Using potassium bromide pellets and Fourier-transform infrared spectroscopy investigations, the surface functional groups of the potato peels were investigated in order to characterise them for usage as a bioflocculant. An FT-IR Spectrometer made by PerkinElmer Spectrum One was used to conduct the infrared analysis.

Culture Media and Compound Extract Preparation

The culture media was produced in accordance with the Manufacturing Company's instructions and autoclaved for 15 minutes at 121°C in 15 pi³. The fungus have been isolated and grown using this technique.

Investigation of Methanolic Compound Extracts' Antifungal Effectiveness

The potentiation antifungal activity of extracts has been assessed using the mixing method on Sabouraud dextrose agar (SDA) medium by dilution of concentration by 1:100, 1:200, 1:400, 1:800, 1:1600 and 1:3200 where after 0.1 mL of each concentration was pipeted aseptically onto appropriate Petry dishes. Consistent with this, the sterile cork borer took a 5 mL disc from each fungus and placed it on the surface of the culture media after the SDA medium had been poured on its and the dishes allowed to solidify. For seven days the petry dishes are kept inside incubator maintained at 25°C ± 2. Diameter of the inhibitory zone in millimetres (mm) is used to compute antifungal efficiency of the methanolic extracts as described earlier [14, 15]. Calculating the percentage of diameter growth inhibition (PIDG) The percentage inhibition of diameter growth (PIDG) values were calculated using the following formula after the MFC observation:

Percentage inhibition of diameter growth PIDG (%)=

Diameter of sample – Diameter of control / diameter of the control × 100 …. (11)

Statistical Analysis

The analysed data is presented using Tukey's Honestly Significant Differences test and by applying the statistical analysis program SPSS 19.0 (IBM, New York, NY, USA) for the assessment of the mean values of the ANOVA analysis of variance, at the 95% or 99% probability level. Statistical significance with its measure, the p-value, was arbitrarily selected at a value of less than 0.05.

Results and Discussion

Solanum tuberosum is a desirable protein source for the food industry because of its well-known nutritive, emulsifying, foaming, gel-forming, and antioxidant qualities. The review's description of potato proteins' antifungal, antimicrobial, and antiviral qualities expands the potential applications for potato proteins. Protease inhibitors, patatin, and a subset of other proteins—which included, among other things, proteins involved in the physiology of potato defense—were separated from potato proteins. All of these protein classes contain proteins and peptides with antifungal & or antimicrobial properties. Explants established from Phytophthora infestans resistant cultivars were successful in inhibiting the germination of spores of the pathogen. The large structural group of compounds effective against fungi and microbes in general is the group of protease inhibitors. Potato protease inhibitors I and II had an inhibitory effect on the growth of Phytophthora infestans, Rhizoctonia solani, and Botrytis cinerea or on the fungi of the Fusarium genus. Other proteins including the Kunitz family of proteins such as Potide-G, AFP-J, Potamin-1, or PG-2 can inhibit the risky microorganisms like Candida albicans, Escherichia coli, Listeria monocytogenes, and Staphylococcus aureus [16, 17]. The capacity of potato snakins, defensins, and pseudothionins to suppress harmful bacterial infections and potato fungus is examined. To improve crops, pathogen-resistant transgenic plants were created using potato proteins that might stop the growth of infections. There are new opportunities for using potato protein when antifungal and antibacterial proteins are added to feed, food items, or food packaging to get rid of hygiene risk microorganisms. Determining the physical and chemical makeup of potato peels is necessary to comprehend their physicochemical characteristics. It was discovered that potato peels include fatty acids and lipids, which have intriguing antimicrobial properties, as well as a variety of polyphenols and phenolic acids, which give them their antioxidant properties. Peak (Wave number cm^{-1}), Intensity, Type of Intensity, Bond, Type of Vibration, and Functional group assignment (675.09, 67.825, Strong, C-Cl, Stretch, and alkyl halides), (692.44, 69.075, Strong, C-Cl, Stretch, and alkyl halides), (738.74, 72.075, Strong, =C–H, Bending and Alkenes), (813.96, 76.441, Strong, =C–H, Bending, and Alkenes), (974.05, 65.287, Strong, =C–H, Bending, and Alkenes), (1008.77, 54.765, Strong, C-F, Stretch and alkyl halides), (1049.28, 58.347, Strong, C-F, Stretch and alkyl halides), (1093.64, 64.409, Strong, C-F, Stretch and alkyl halides), (1232.51, 80.641, Strong, C-F, Stretch and alkyl halides), (1276.88, 80.140, Strong, C-F, Stretch and alkyl halides), (1606.70, 79.503, Bending, N-H, Stretch, and Amide), (1647.21, 79.220, Variable, C=C, Stretch and Alkene).

If one type of functional group is formed or another is eliminated, the look of distinct bands associated with a variety of functional groups in the products formed is used to analyze FTIR spectra in the case of chemical or biochemical reactions and the end products created. On the other hand humification phases FTIR spectra provide information both on the functional groups of products formed and on starting reagents bands which are not fully involved in the fragmentation and transformation processes as in composts. Most of the chemical structural features of the plant material, including lignin, carbohydrates and long chain aliphatic structural units were found to be incorporated into the humic acid fraction of peat soil, agricultural soil and lake sediment. To differentiate the bands of the HS produced, one must be aware of the nature [18, 19], composition, and initial raw material structure. Bioactive metabolites of methanol, ethyl acetate, and ethanolic extract of Solanum tuberosum exhibit antifungal action. Comparing peels to three common antibiotics (Fluconazole (FCZ), Itraconazole (ICZ), Posaconazole (PCZ)). Recorded (15.00±0.58, 13.74±0.25 and 17.00±0.30) for Trichophyton rubrum while (16.09 ± 0.29, 14.45 ± 0.28 and 18.90 ± 0.35) for Fusarium oxyporum and recorded (10.17 ± 0.20, 09.05 ± 0.18 and 13.00 ± 0.22) for Cladosporium herbarum in the same time antifungal activity of Candida albicans was (12.50 ± 0.24, 11.00 ± 0.19, and 15.47 ± 0.26).

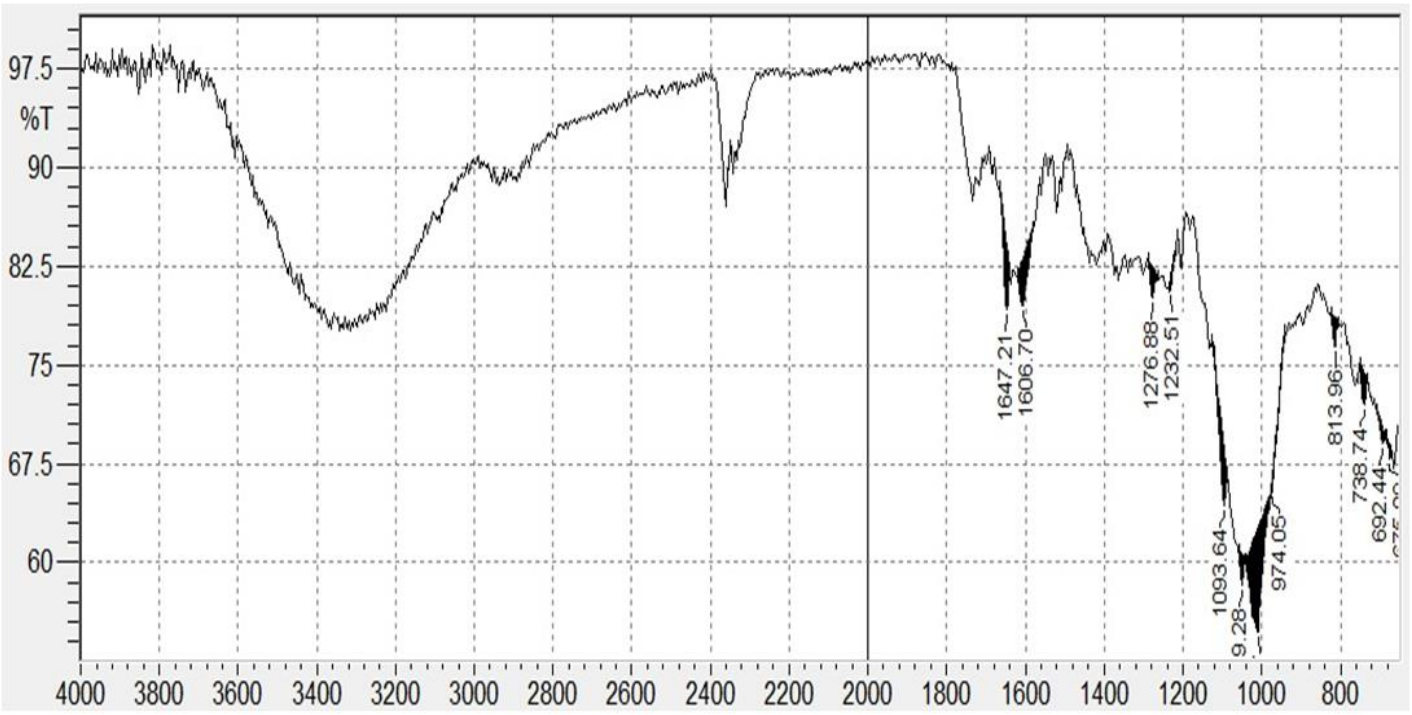

Figure 1. Fourier-Transform Infrared Spectroscopic peak values of solid analysis of *Solanum tuberosum* Peels.

Table 1. Fourier-Transform Infrared Spectroscopic peak values of solid analysis of *Solanum tuberosum* Peels.

No.	Peak (Wave number cm-1)	Intensity	Corr. Intensity	Base (H)	Base (L)	Area	Corr. Area	Type of Intensity	Bond	Type of Vibration	Functional group assignment	Group frequency
1.	675.09	67.825	1.011	684.73	671.23	2.209	0.033	Strong	C-Cl	Stretch	alkyl halides	600–800
2.	692.44	69.075	1.098	705.95	686.66	3.008	0.076	Strong	C-Cl	Stretch	alkyl halides	600–800
3.	738.74	72.075	2.274	750.31	732.95	2.372	0.151	Strong	=C–H	Bending	Alkenes	650-1000
4.	813.96	76.441	2.172	823.60	804.32	2.118	0.099	Strong	=C–H	Bending	Alkenes	650-1000
5.	974.05	65.287	0.687	975.98	941.26	5.103	0.077	Strong	=C–H	Bending	Alkenes	650-1000
6.	1008.77	54.765	7.948	1039.63	977.91	14.254	1.759	Strong	C-F	Stretch	alkyl halides	1000-1400
7.	1049.28	58.347	2.245	1056.99	1041.56	3.494	0.131	Strong	C-F	Stretch	alkyl halides	1000-1400
8.	1093.64	64.409	3.812	1126.43	1087.85	6.008	0.401	Strong	C-F	Stretch	alkyl halides	1000-1400
9.	1232.51	80.641	0.860	1236.37	1213.23	1.937	0.064	Strong	C-F	Stretch	alkyl halides	1000-1400
10.	1276.88	80.140	2.278	1288.45	1263.37	2.246	0.127	Strong	C-F	Stretch	alkyl halides	1000-1400
11.	1606.70	79.503	3.556	1618.28	1581.63	3.219	0.402	Bending	N-H	Stretch	Amide	1550-1640
12.	1647.21	79.220	4.828	1664.57	1639.49	2.059	0.286	Variable	C=C	Stretch	Alkene	1620–1680

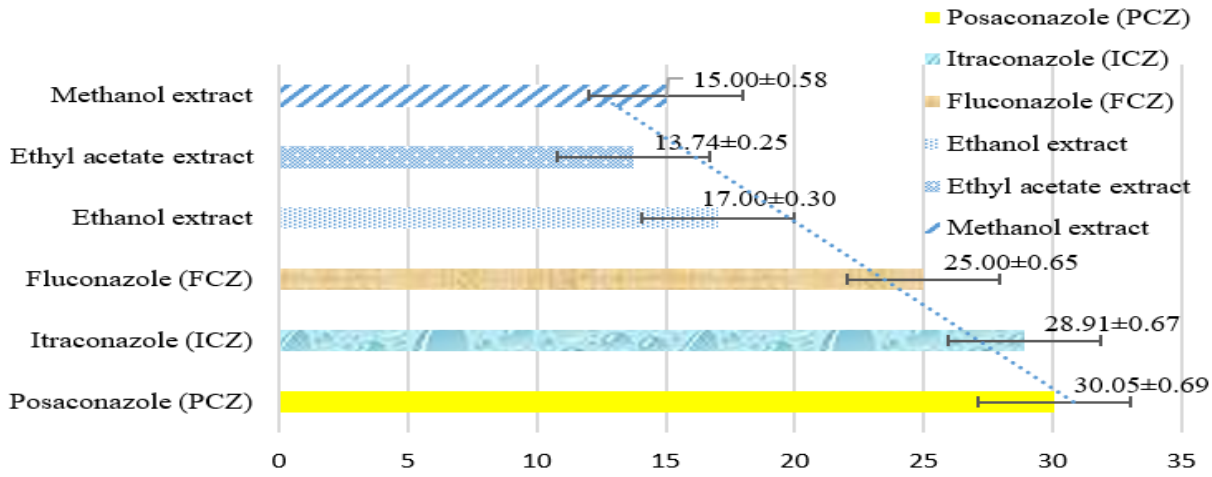

Figure 2. Antifungal activity of bioactive metabolites of methanol, ethyl acetate and ethanolic extract of *Solanum tuberosum* Peels against *Trichophyton rubrum*.

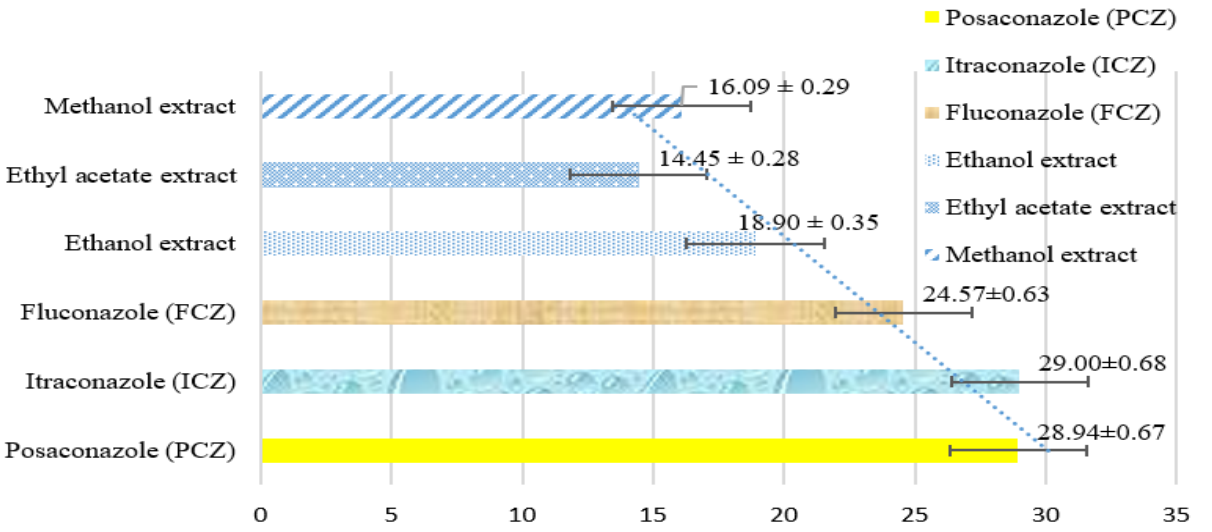

Figure 3. Antifungal activity of bioactive metabolites of methanol, ethyl acetate and ethanolic extract of *Solanum tuberosum* Peels against *Fusarium oxyporum*.

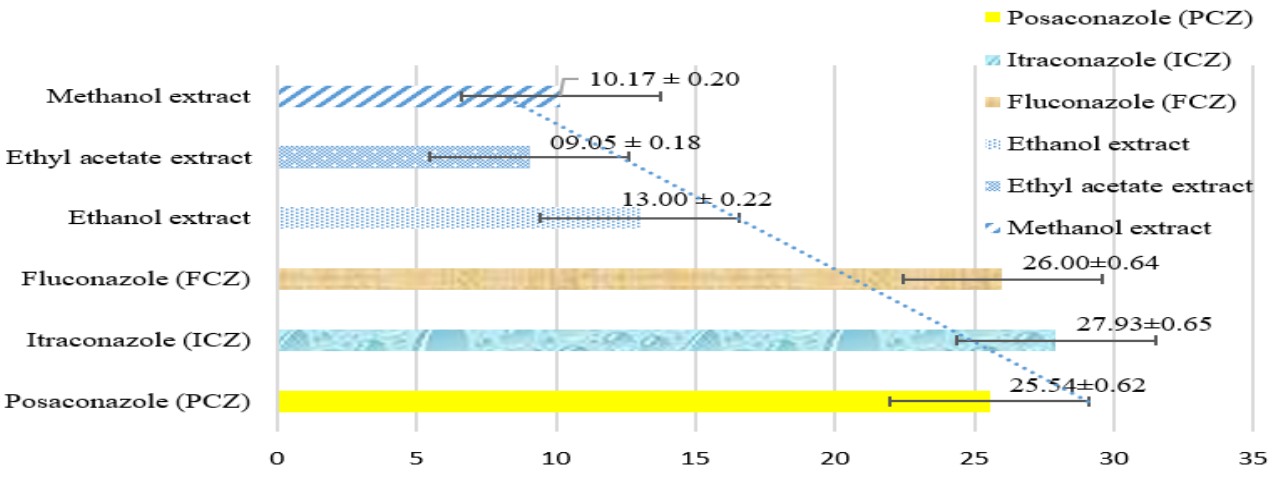

Figure 4. Antifungal activity of bioactive metabolites of methanol, ethyl acetate and ethanolic extract of *Solanum tuberosum* Peels against *Cladosporium herbarum*.

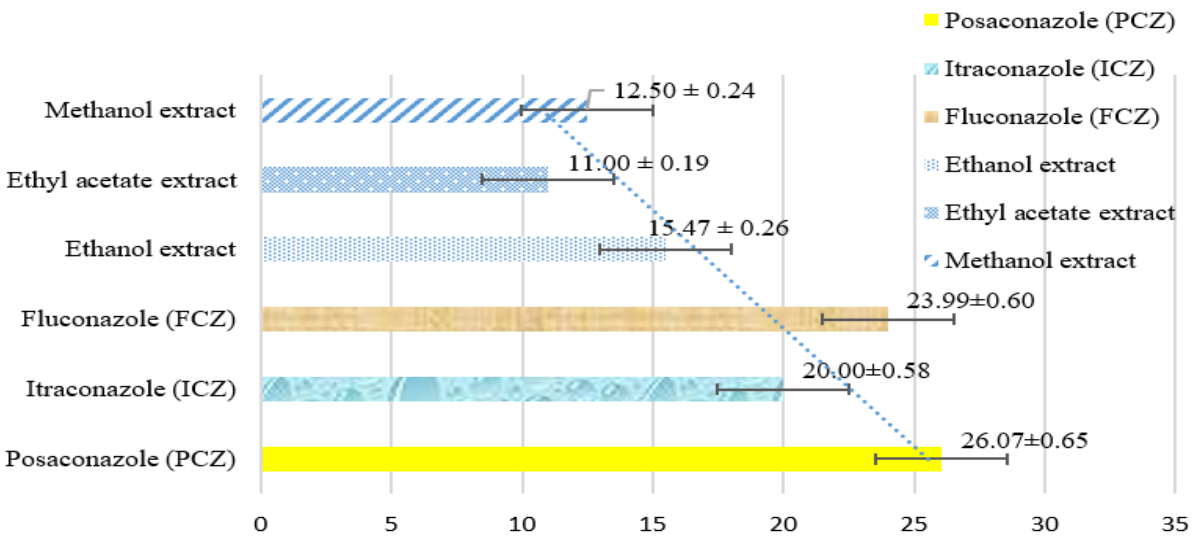

Figure 5. Antifungal activity of bioactive metabolites of methanol, ethyl acetate and ethanolic extract of *Solanum tuberosum* Peels against *Candida albicans*.

Such infrared analysis of co-composts of various organic matter types at different stages, with or without an HS extraction process, has shown that only five regions of the FTIR spectrum seem to contain information on the evolution and stability of the humification process. On attaining the humification process, a band appearing in the FTIR of composts at about 3430 cm–1 stabilizes at the lower wave numbers (3402 cm–1) during composting. A general increase of relative intensity of this band is resulted during composting, probably due to enhancement of cation exchange capacity of the compost. A relationship between the CEC, relating to the hydration properties of organic matter and clays, and water retention capacity is established. The hydrophobicity of the aliphatic organic material is observed in the 3000–2800-cm–1 region. As opposed to compost spectra, the bands in this region are better discerned [20]. At those stages of humification during the first eight weeks, these bands reduced, which supports microbial oxidation of carbon chains of aliphatic and peptidic chemicals. This is a clear indication that the co-composting process is now mature. In addition, after the humification process, the other intense peak of methyl groups is appeared at 2958 cm–1, while the peaks, which represent the methylene and methyl structure in compost and lignin, are exist at 2855 cm–1 and about 2920 cm–1, respectively. This change in the frequency shows that the aliphatic groups synthesized after composting are not the same as lignin and cellulose structures represented by the C-H bands at wave numbers less than 2930 cm–1.

Solanum tuberosum is a desirable protein source for the food industry because of its well-known nutritive, emulsifying, foaming, gel-forming, and antioxidant qualities. The review's description of potato proteins' antifungal, antimicrobial, and antiviral qualities expands the potential applications for potato proteins. Protease inhibitors, patatin, and a subset of other proteins—which included, among other things, proteins involved in the physiology of potato defense—were separated from potato proteins. Proteins and peptides with antifungal and/or antimicrobial properties are produced by all of these protein classes. Patatins derived from cultivars resistant to Phytophthora infestans were effective in preventing the pathogen's spores from germinating. The structurally diverse class of compounds with a wide variety of antifungal and antimicrobial properties is represented by protease inhibitors. The growth of Phytophthora infestans, Rhizoctonia solani, and Botrytis cinerea, or the fungi of the Fusarium genus, was inhibited by potato protease inhibitors I and II. Proteins belonging to the Kunitz family (Potide-G, AFP-J, Potamin-1, or PG-2) have the ability to inhibit dangerous infections like Candida albicans, Listeria monocytogenes, Escherichia coli, and Staphylococcus aureus. The capacity of potato snakins, defensins, and pseudothionins to prevent bacterial infections and dangerous potato fungus is explored. To improve crops, pathogen-resistant transgenic plants were created using potato proteins that might stop the growth of infections. Numerous studies have demonstrated that, in spite of the growing number of antifungal medications, drug resistance and cross-resistance among the isolated species have led to

a rise in the death rate from these fungi in recent decades. Fungal infections brought on by resistant fungi, including the most prevalent isolated species of Candida and Aspergillus, have altered their susceptibility patterns, frequently decreasing the efficacy of conventional medications and leading to chronic infection. [21]. It has been demonstrated that extracts of Solanum plants can effectively induce an antibacterial action against Staphylococcus aureus. Pectolite at 4.0mg/mL greatly enhanced this activity while the glycoalkaloid content of Solanum nigrum significantly mollified it at 20 microgram/mL. Fungicidal and pesticidal properties are demonstrated by solanine and chaconine and these compounds synergistically disrupt liposomes. Fungal growth of Ascobolus crenulatus and Rhizoctonia solani, spore germination and mycelial growth of Alternaria brassicicola and conidial germination of Phoma medicaginis were all affected more by α-chaconine than by α-solanine. In general it can be suggested that efficacy of the crude glycoalkaloid extract on A.flavus can be attributed to the surfactant effect of the compound based on the capability of affecting the sterol containing cell membranes of the fungus.

Conclusion:

In conclusion, the study's findings suggest that Solanum tuberosum is a useful plant source of chemicals with therapeutic promise for treating certain fungal infections. According to the current study's findings, Solanum tuberosum might be a beneficial plant source of active chemicals with therapeutic value that can be used to treat certain fungal infections. The experiment demonstrated the partial antifungal activity of the crude methanolic extract from S. tuberosum peels. To assess antifungal activity at higher concentrations, more research is advised.

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