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Deciphering the Antimicrobial Potential of *Cinnamon zeylanicum* Bark

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Abstract: One of the prime reasons for spoilage of fruit juice is microorganisms. To counteract this, many preservation techniques are utilized by food processing industries of which the use of artificial additives and antimicrobials is inevitable, which has vividly raised eyebrows among many consumers. This negative impact has prompted food processing industries to be on the outlook for alternative sources such as the utilization of natural antimicrobials. In this context, spices serve as an ideal resource for increasing the shelf life of foods. Spices not only possess good flavor but significantly contribute to medicinal, antimicrobial and antioxidant properties. We evaluated the antimicrobial potential of one of the most commonly used Indian spices viz. Cinnamon bark in various solvents (ethyl acetate, n-hexane, acetone, ethanol, methanol), aqueous extracts and tested them on four gram positive bacteria (*Staphylococcus aureus, Bacillus subtilis, Alicyclobacillus acidocaldarius, Lactobacillus fermentum*), four gram negative bacteria (*E.coli, Pseudomonas putida, Pseudomonas aeruginosa, Klebsiella pneumonia*), one species of mold (*Aspergillus niger*), three species of yeast (*Candida tropicalis, Candida albicans* and *Saccharomyces cerevisiae*). Our results indicated that the antimicrobial response differed with different solvent extracts.

It is found that *S.aureus* is most sensitive bacteria with ethyl acetate and ethanol extracts; *L.fermentum* with n-hexane extract; *B.subtilis* with acetone and methanol extracts; and *A. acidocaldarius* with cool and warm water extracts respectively. Among the gram –ve bacteria, most sensitive bacteria is *E.coli* with n-hexane, acetone ,ethanol and methanol extracts; *K. pneumonia* with ethyl acetate extract and *P. aeruginosa* with cool and warm water extracts. It was observed that *A.niger* was most sensitive with ethyl acetate and acetone extracts; *C.tropicalis* with n-hexane and methanol extracts; *S. cerevisiae* with ethanol extract and *C.albicans* with cool water and warm water extracts of *Cinnamon.*

Key words: Cinnamon bark, antimicrobial activity, preservative.

Introduction

The contents of fruit juices serve as an invaluable substrate for the growth of microorganisms which in turn contributes to its spoilage. The most commonly existing bacteria that contribute to the spoilage of fruit juices are *Acetobacter, Alicyclobacillus, Bacillus, Clostridium, Glucanobacter, Lactobacillus, Leuconostioc, Saccharobaacter, Zymomonas* and *Zymobacter* etc. In addition to it, yeasts also predominantly contribute to spoilage of juices as they thrive in highly acidic environment and also grow anaerobically. Various research groups have shown that *Pichia, Candida, Saccaharomyces* and *Rhodotorula* are the most commonly reported strains of yeasts that contribute to spoilage of juices[1]. It has also been reported [2] that many pathogenic microorganisms such as *Listeria onocytogenes, Staphylococcus aureus, Klebsiella pneumoniae, Escherichia coli* and *Campylobacter jejuni* serve as the casual agents of food borne diseases and also might contribute to food spoilage.

The food industry is heavily relying on novel methodologies of food preservation for long term storage of fruit juices to increase their shelf life. Although a wide array of artificial preservatives along with antimicrobials[3] are utilized by food processing industries for preservation, consumers major concern regarding their unsafe use coupled with their growing knowledge about the adverse impact on human health is gaining momentum. This key concern prompted food industries towards the use of natural plant antimicrobials.

Indian flora serves as a land of spices and spices are being used in food preparations since ancient times. It has been well established that spices not only impart good flavor and pungent stimuli but also contribute to medicinal, antimicrobial[4] and antioxidant properties [5]. Due to these multiple potential properties, spices serve as an ideal food preservative[6] and will aid in prolonging the shelf life of foods by preventing rancidity through their antioxidant activity[5]. Another interesting facet is that the natural potential of spices contribute to a safe intake for food products as well as improve the shelf life of food products [7].

Cinnamon bark is one among the commonly used Indian spices in food preparations. It has been reported[8] that when *Cinnamon* bark is used as natural preservative, it prevents decomposition of the products. Research investigation by Mandal *et. al.*,[9] reported that Cinnamon bark is rich in cinnamaldehyde which has been proven to be active against many pathogenic gram positive and gram negative bacteria. Chandarana *et. al.*,[10] suggested that spices can serve as the excellent alternatives to chemical food additives due to their antimicrobial properties. The antioxidant and antimicrobial properties are very important to preserve the quality of food material which provides safety to the consumers [11].

In view of this, the present study was aimed at determining the antimicrobial activity of different solvents (ethyl acetate, n-hexane, acetone, ethanol, methanol) and aqueous extracts (cool water and warm water) of *Cinnamon bark* against four gram +ve bacteria, four gram -ve bacteria, one mold species and three species of yeast that causes fruit juice spoilage.

Materials and Methods

Materials:

Cinnamon bark (*Cinnamomum zeylanicum*) was purchased from local vendor market, Guntur and it was authenticated by the department of phamacology, Vignan's College of Pharmacy, Vadlamudi or Department of Botany, ANU, Guntur. The bark was repeatedly rinsed with tap water followed by several washing with distilled water to remove the presence of dirt and other contaminants, if any. After washing with water, bark was dried under sun light/ at room temperature followed by drying in the oven at 40 ^{0}C for 24 h. After drying, the bark was homogenized into fine powder by using mortar and pestle or grinder. The fine powder was transferred into dark bottles and stored at room temperature until use.

Microbial Cultures:

Bacterial strains, yeast and mold species that cause fruit juice poisoning or spoilage were selected for the study. Four gram positive bacteria i.e., *Staphylococcus aureus* (MTCC 3103), *Bacillus subtilis* (MTCC1305), *Alicyclobacillus acidocaldarius* (MTCC 1309), *Lactobacillus fermentum* (MTCC 9748); four gram negative bacteria i.e., *E.coli* (MTCC 9537), *Pseudomonas putida* (MTCC 1194), *Pseudomonas aeruginosa* (MTCC 10636), *Klebsiella pneumonia* (MTCC 10309); and one mold species i.e., *Aspergillus niger* (MTCC 872) and three yeast species i.e., *Candida tropicalis* (MTCC 4370), *Candida albicans* and *Saccharomyces cerevisiae* (MTCC 36) were obtained from MTCC (Microbial Type Culture Collection and Gene Bank), Chandigarh.

Preparation of microbial culture:

Pure cultures of microbial strains were always maintained on nutrient agar slants on regular basis. Prior to experimental use, the cultures were streaked on sterile nutrient agar plates and incubated overnight at 37 ^{0}C and then stored at 4 ^{0}C. Inoculum was prepared by growing the pure bacterial culture in nutrient broth overnight at 37 ^{0}C. For culturing of microbes, mold and yeast species, media like NAM (Nutrient Agar Media), MRS (*Lactobacillus fermentum*), YPD (Yeast Peptone Agar Media) and Czapak (*Asperigillus niger*) were used. All chemicals were purchased from sd fine chemicals and were of analytical grade / all the selective media are obtained from Hi-Media.

Preparation of *Cinnamon* bark extracts:

To prepare *Cinnamon* bark extracts, five different solvents like ethyl acetate, n-hexane, acetone, ethanol and methanol were used in the present study. Similarly, distilled water was also used. To prepare the solvent extracts, four grams each of *Cinnamon* fine powder was added to 20 ml of ethyl acetate, n-hexane, acetone, ethanol and methanol respectively and kept on orbital shaker at 37 ^{0}C for 2 h. After 2 h of shaking, they were filtered through Whatmann No.1 filter paper and the filtrates were used as extracts. To prepare cool water extract, four grams of *Cinnamon* fine powder was added to 20 ml of distilled water and kept on orbital shaker at 37 ^{0} C for 12 h. After 12 h of shaking, it was filtered through Whatmann No.1 filter paper and the filtrate was used as cool water extract. The warm water extract was prepared by adding 4 gm of *Cinnamon* fine powder to 20 ml of distilled water and heated on water bath until boiling. Then, it was cooled at room temperature. After cooling, it was filtered through Whatmann No.1 filter paper and the filtrate was used as warm water extract. All the solvent extracts as well as cool and warm water extracts were used to test the antimicrobial activity against selected bacteria, mold and yeast species. The extracts were stored at 4 ^{0}C until the use.

Determination of Antimicrobial Activity:

The antimicrobial activity of different solvent extracts, cool water and warm water extracts of *Cinnamon* against selected bacterial strains, mold and yeast species were determined by agar well diffusion assay technique of Chung *et. al.*,[12] with slight modifications. 100 µl of each microbial suspension from broth cultures (24 h) were inoculated on to the respective media and spread on the entire surface of the petri plate using a sterile spatula. After media were solidified, wells of 5 mm diameter were punched out of solid media by using 5 mm cork borer and each well was filled with 50 µl of respective solvent and water extracts. The inoculated agar plates were kept in the refrigerator for one hour for proper diffusion. Then, the plates were incubated at 37 ^{0}C for the bacteria and 30 ^{0}C for the yeast for 24 - 48 h. The solvents were also tested for their activity as a control at the same time. After 24 h, the plates were observed for the zone of inhibition (clear area around the well as suggested by WHO[13]), measured and expressed in millimeters. The experiments were repeated in duplicate for all of the test strains and average was calculated.

Results and Discussion

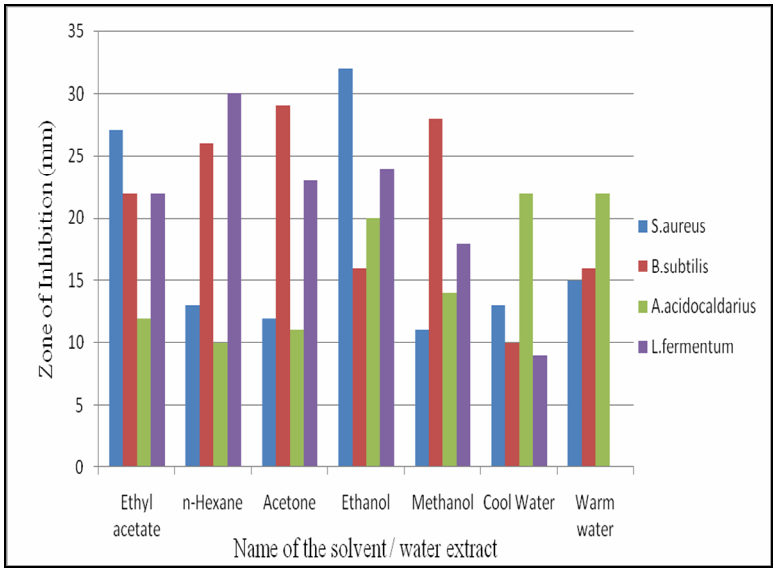
In the present study, antimicrobial activity of different solvents and water extracts of cinnamon bark like ethyl acetate, n-hexane, acetone, ethanol, methanol; cool water and warm water extracts were tested against four gram +ve bacteria viz., *Staphylococcus aureus, Bacillus subtilis, Alicyclobacillus acidocaldarius* and *Lactobacillus fermentum*; four gram -ve bacteria such as *E.coli, Pseudomonas putida, Pseudomonas aeruginosa* and *Klebsiella pneumonia*; one mold species, *Aspergillus niger* and three yeast species like *Candida tropicalis, Candida albicans* and *Saccharomyces cerevisiae* that causes fruit juice spoilage. The antimicrobial activity of different solvent extracts and cool and warm extracts against gram positive bacteria were expressed as diameter of zone of inhibition and <9 mm zone was considered as inactive; 9-12 mm zone as partially inactive; while 13-18 mm zone as active and >18mm zone as very active as suggested by Junior and Zanil[14].

The results of gram +ve bacteria are represented in the Fig.1 which indicates that in the ethyl acetate extract of *Cinnamon*, the zone of inhibition is very active for *S. aureus, B.subtilis* and *L.fermentum*; and partially active for *A.acidocaldarius* (the inhibition in ascending order is *S.aureus* > *B.subtilis*> *L.fermentum* > *A.acidocaldarius*) which suggests that the most sensitive bacteria are *S.aureus*. The zone of inhibition ranged from 12-27 mm. The results are contradictory to the results obtained by Ayfer and Ozlem[15] who found no inhibition against *B.subtilis.*

In the n-hexane extract, highest zone of inhibition was observed for *L. fermentum* followed by *B.subtilis, S.aureus* and *A.acidocaldarius* which indicates that *L. fermentum* is most sensitive bacteria. The zone of inhibition was very active for *L. fermentum* and *B.subtilis*; active for *S.aureus* and partially active for *A.acidocaldarius*. The zone of inhibition ranged from 10-30 mm.

In the acetone extract of Cinnamon bark, the zone of inhibition was very active for *B.subtilis* and *L. fermentum*; and partially active for *S.aureus* and *A.acidocaldarius* (the ascending order of inhibition is *B.subtilis* > *L. fermentum*> *S.aureus* > *A. acidocaldarius*) which suggests that *B.subtilis* is more sensitive bacteria. The inhibition zones ranged from 11-29 mm. Similarly, Dinesh *et. al.*,[16] and Usha, Ragini and Naqui[17] found inhibition against *S.aureus* ; and *S.aureus* and *B.subtilis* respectively in their studies. However, Ayfer and Ozlem[15] didn't find any inhibition against *B.subtilis*.

Fig.1.Antimicrobial activities of different solvents and water extract of cinnamon bark powder against gram positive bacteria by agar well diffusion method



In the ethanol extract, the zone of inhibition was very active in *S. aureus, L.fermentum* and *A. acidocaldarius*; and active in *B.subtilis (*the ascending order of inhibition is *S. aureus, >L.fermentum> A. acidocaldarius > B.subtilis*) which indicates that the most sensitive bacteria is *S.aureus*. The inhibition zones ranged from 16-32 mm. Similarly Abdullah [18] found *S. aureus* as the most sensitive bacteria and Sana and Ifra [19] and Usha, Ragini and Naqui [17] found *B.subtilis* as the most sensitive bacteria.

The ascending order of inhibition in methanol extract is *B.subtilis>L.fermentum> A. acidocaldarius > S.aureus* which indicates that *B.subtilis* is most sensitive bacteria. The inhibition is very active in *B.subtilis*; active for *L.fermentum* and *A. acidocaldarius*; and partially active for *S.aureus*. The zone of inhibition ranged from 11-28 mm. However, Senhaji, Faid and Elyachioui [20] didn't find any inhibition of *Bacillus.* On the other hand, Senhaji, Faid and Elyachioui[20], Shan *et. al.*,[6] and Dinesh *et. al.*[16] reported that *S.aureus* is the most inhibited bacteria.

In the cool water extract, the zone of inhibition was very active for *A. acidocaldarius*; active for *S.aureus* and partially active for *B.subtilis* and *L.fermentum* which indicates that *A. acidocaldarius* is the most sensitive bacteria. The zone of inhibition ranged from 9-22 mm.

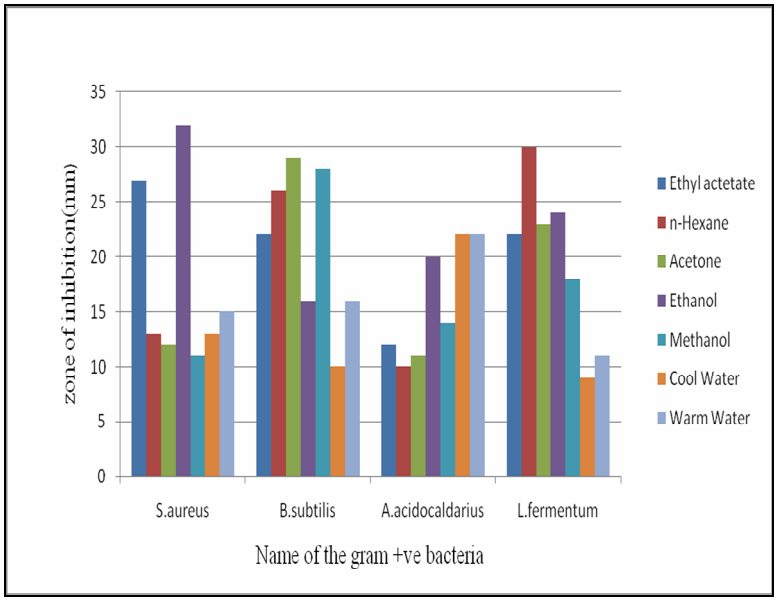
The ascending order of inhibition in warm water extract is *A. acidocaldarius> B.subtilis> S.aureus> L.fermentum* which suggests that *A. acidocaldarius* is the most sensitive bacteria. The inhibition zone is very active for *A. acidocaldarius*; active for *B.subtilis* and *S.aureus* and partially active for *L.fermentum*. The zone of inhibition ranged from 11-22 mm. Papachan *et. al.*,[21] also found strong antibacterial activity towards *B.cereus*. Several researchers like Maha *et. al.*,[22] and El-Kholie, Abdelreheem and Khader[23] have reported antimicrobial activity of aqueous extract of *Cinnamon* against *S.aureus.*

The results of the present findings demonstrate that antimicrobial activity of gram +ve bacteria varies with different solvent and water extracts as well as with different species of microorganisms. Similarly, Kaoutar *et. al.*,[24] reported varying magnitudes of antibacterial activity with *Cinnamon* extracts. Nanasombat *et. al.*,[25] also suggested that antibacterial activity may vary between different strains of same species and moreover depends on the form that is used such as dried, fresh or extracted. It is found that *S.aureus* is most sensitive bacteria with ethyl acetate and ethanol extracts; *L.fermentum* with n-hexane extract; *B.subtilis* with acetone and methanol extracts; and *A. acidocaldarius* with cool and warm water extracts respectively. This may be due to more sensitivity of gram positive bacteria to the extracts of herbs and spices as suggested by De-Boer *et. al.*,[26]. On the other hand Zottala and Smith [27] found that particularly *Bacillus* sp. was more sensitive among gram positives.

Among the different solvent and water extracts, maximum inhibition was exhibited by ethanol extract followed by ethyl acetate extracts for *S.aureus*; acetone and methanol extract for *B.subtilis*; n-hexane and ethanol extracts for *L.fermentum* and cool and warm water extracts for *A. acidocaldarius* (**Fig.2)** which may be explained by their more susceptible nature due to their structural features to phenolic compounds [28]. The

inhibitory effect of Cinnamon may be due to the presence of the principal active compounds of Cinnamon i.e., eugenol and cinnamaldehyde, which preferably dissolve in ethyl alcohol than in other solvents and water [29] and releases greater amount of active antimicrobial components[30]. The dominant antibacterial activity of ethanol against *S.aureus* and *L.fermentum* in the present study may be attributed to this factor. These phenolic compounds are capable of further cellular destruction and inhibition by establishing the hydrophobic and hydrogen bonding to membrane proteins and destructing the membranes, electron transport systems and cell wall[31]. Wendakoon and Sakaguchi[32] suggested that cinnamaldehyde may inhibit the amino acid decarboxylation activity in the cell that leads to energy deprivation and microbial cell death.

Fig.2. Inhibition of gram + ve bacteria with different solvents, cool and warm water extracts of cinnamon bark



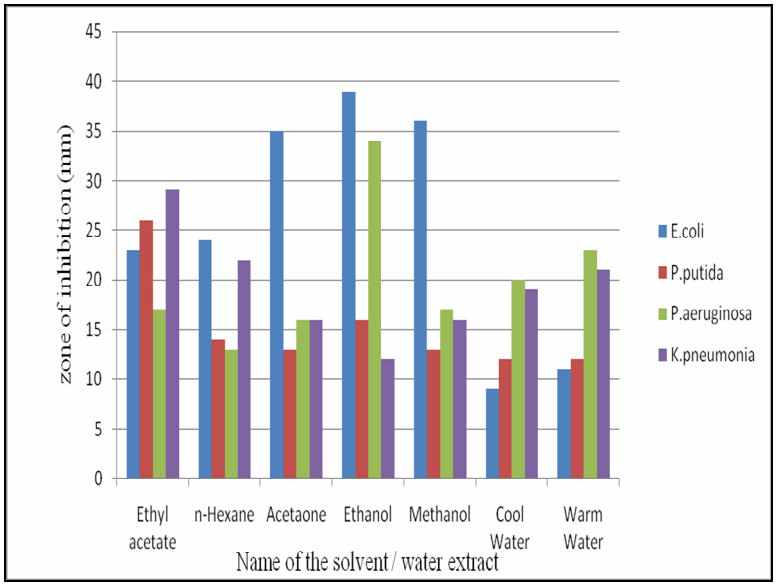
Among the cool and water extracts, the antimicrobial activity was more in warm water extract than in cool water extract for all the tested organisms except for *A. acidocaldarius* to which the activity is equal for both the extracts. The more inhibitory activity in warm water extract may be attributed to more solubilization of the active compounds than in cold water extract, which may require more time[18 & 20]. Darout *et. al.*, [33] suggested that the antimicrobial activity of aqueous extracts could be due to anionic components such as thiocyanate, nitrate, chlorides and sulphates in addition to many other compounds naturally present in plants.

The antimicrobial activity of different solvent extracts and cool and warm extracts against gram negative bacteria were indicated in Fig.3. It was observed that the zone of inhibition was very active for three bacteria i.e., *E.coli, Pseudomonas putida,* and *Klebsiella pneumonia;* and active for *Pseudomonas aeruginosa* in ethylacetate extract of *Cinnamon* bark (the ascending order of inhibition is *Klebsiella pneumonia> Pseudomonas putida> E.coli> Pseudomonas aeruginosa*) which infers that most sensitive bacteria is *K. pneumonia*. The zone of inhibition ranged from 17-29 mm. Similarly, Sarmauli, Adolf and Francisca[34] found inhibition of *E.coli* with ethyl acetate extract of Cinnamon in their studies. However, Ayfer and Ozlem[15] and Dilek and Sevil[35] didn't find inhibition against *P.aeruginosa* which are in contrast to the present findings.

The zone of inhibition was very active in *E.coli and Klebsiella pneumonia* and active in *Pseudomonas putida* and *Pseudomonas aeruginosa* with n-Hexane extract (the ascending order of inhibition is *E.coli > Klebsiella pneumonia> Pseudomonas putida > Pseudomonas aeruginosa*) which suggests that *E.coli* is most sensitive bacteria. The zone of inhibition ranged from 13-24 mm. The results are in agreement with the studies of Senhaji, Faid and Elyachioui[20] who also reported more inhibition of *E.coli* and *K.pneumoniae.*

The acetone extract showed very active inhibition with *E.coli* and active inhibition with rest of the bacteria. The ascending order of inhibition is *E.coli > Klebsiella pneumonia> Pseudomonas aeruginosa> Pseudomonas putida*. The zone of inhibition ranged from 13-35 mm. The results of the present study are in agreement with the studies of Dinesh et al.,[16] who reported inhibition against *E. coli* and *K.pneumoniae* and Usha, Ragini and Naqui[17] against *E.coli* and *Pseudomonas sp.*,

Fig.3.Antimicrobial activities of different solvents and water extract of cinnamon bark powder against gram negative bacteria by agar well diffusion method



Similarly, ethanol extract also showed highest inhibition towards *E.coli* followed by *Pseudomonas aeruginosa, Pseudomonas putida* and *Klebsiella pneumonia*. The inhibition zone ranged from 12-39 mm. Shiney and Ganseh[36] and Sana and Ifra[19] found highest inhibition of *E.coli* with ethanol extracts in their studies which corroborates with present findings. On the other hand, Abdul *et. al.*[37] and Usha, Ragini and Naqui,[17] observed greater antimicrobial activity against *P.aeruginosa* and *E.coli* and *P.aeruginosa* respectively in their studies which are in agreement with the current findings.

Methanol extract also showed highest inhibition towards *E.coli* followed by *P. aeruginosa, Klebsiella pneumonia* and *Pseudomonas putida*. The zone of inhibition ranged from 13-36 mm. The results are in agreement with the studies of Senhaji, Faid and Elyachioui [20] who reported that the most inhibited bacteria with methanolic extract of Cinnamon is *E.coli*. However, they also reported that *K.pneumoniae* and *P.aeruginosa* are not inhibited which are in contrast to the findings of the current study.

In contrast, cool and warm water extracts highly inhibited *Pseudomonas aeruginosa* followed by *Klebsiella pneumonia, Pseudomonas putida* and *E.coli*. The zone of inhibition ranged from 9-23 mm. Senhaji, Faid and Elyachioui[20] and Abdul *et. al.*,[37]; Puangpronpitag and Sittiwet[38] and Papachan *et. al.*,[21] reported inhibition of *E.coli* and *Pseudomonas; E.coli, K.pneumoniae* and *P.aeruginosa* and *E.coli* respectively in their studies.

It was found that among the gram –ve bacteria, most sensitive bacteria is *E.coli* with n-hexane, acetone ,ethanol and methanol extracts; *K. pneumonia* with ethyl acetate extract and *P. aeruginosa* with cool and warm water extracts (Fig.4).

It was observed that zones of inhibition were very active in case of *A. niger* and *C. tropicalis*; active in *C. albicans* and partially active in *S. cerevisiae* with ethyl acetate extract. The zones of inhibition ranged from 9-26 mm (Fig.5).

All the yeast species and mold exhibited partial activeness of inhibition with the n-Hexane extract. The zone of inhibition ranged between 9-12 mm. However, Senhaji, Faid and Elyachioui[20] reported strongest inhibition against *C. albicans.*

The ascending order of inhibition with acetone extract is *A. niger*> *S. cerevisiae*> *C. albicans*> *C. tropicalis*. Except *C. tropicalis*, rest of the species showed very active inhibition. The zone of inhibition ranged from 13-34 mm. Kamal Rai, Radhika and Chetan [39] reported that the acetonic Cinnamon bark extracts showed greater antimicrobial activities against *Candida albicans* and *Saccharomyces cerevisiae* which are in agreement with the present findings.

Fig.4. Inhibition of gram - ve bacteria with different solvents, cool and warm water extracts of cinnamon bark

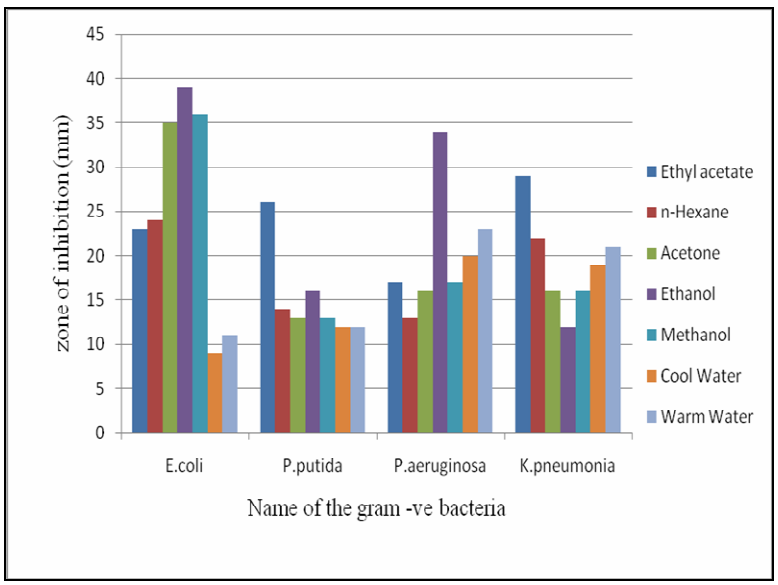
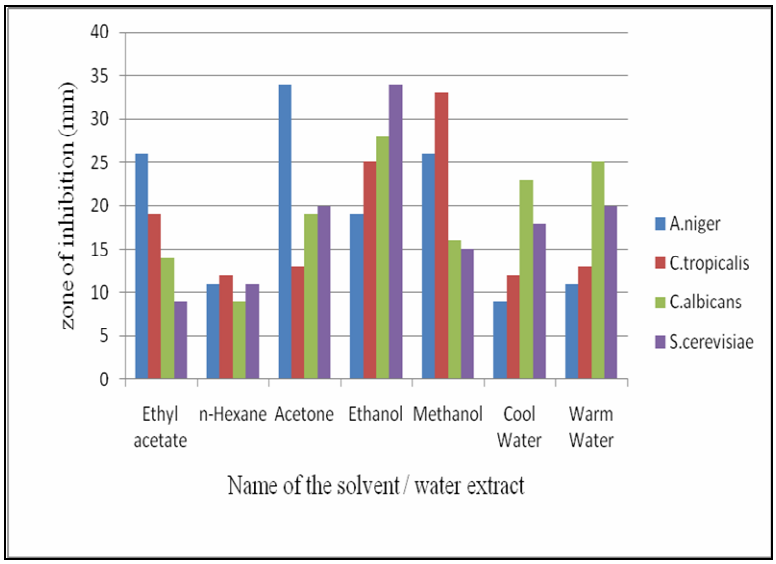


Fig.5.Antimicrobial activities of different solvents and water extract of cinnamon bark powder against mold and yeast species by agar well diffusion method



All the species of yeast and mold showed very active inhibition with ethanol extract of Cinnamon. The ascending order of inhibition is *S. cerevisiae*> *C. albicans*> *C. tropicalis*> *A. niger*. The zone of inhibition ranged from 19 – 34 mm. Kamal Rai, Radhika and Chetan[39] reported greater antimicrobial activities against *Candida albicans* and *Saccharomyces cerevisiae* which are in agreement with the present findings.

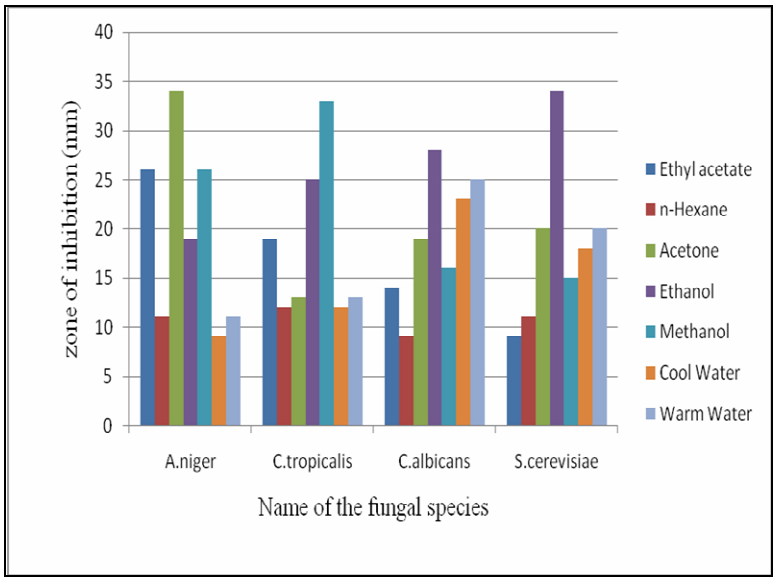
The zone of inhibition was very active in *C.tropicalis* and *A.niger* and active in *C.albicans* and *S. cerevisiae* with methanol extract. The ascending order of inhibition is *C.tropicalis* > *A.niger* > *C.albicans* > *S. cerevisiae*. The zone of inhibition ranged from 15-33 mm. Kamal Rai , Radhika and Chetan [39] reported greater antimicrobial activities against *Candida albicans* and *Saccharomyces cerevisiae.* On the other hand, Senhaji, Faid and Elyachioui [20] found complete inhibition of *C.albicans.*

C.albicans showed highest inhibition with both the cool water and warm water extracts. Similarly *S. cerevisiae* showed active inhibition with both the extracts. *C.tropicalis* and *A.niger* were partially active with cool water extract and only *A.niger* was partially active with warm water extract (the ascending order of inhibition with cool water and warm water extracts is *C.albicans* > *S. cerevisiae*> *C.tropicalis* > *A.niger)*. The zone of inhibition ranged from 9-23 mm with cool water extract and 11-25 mm with warm water extract. Senhaji, Faid and Elyachioui[20] found complete inhibition of *C.albicans* in cold water extracts of Cinnamon

which collaborates with the present findings. In contrast, Maha *et. al* [22] didn't find any antifungal activity with aqueous extracts.

It was observed that *A.niger* was most sensitive with ethyl acetate and acetone extracts; *C.tropicalis* with n-hexane and methanol extracts; *S. cerevisiae* with ethanol extract and *C.albicans* with cool water and warm water extracts of *Cinnamon* (Fig.6).

Fig.6. Inhibition of mold and yeast species with different solvents, cool and warm water extracts of cinnamon bark



Conclusions

It is enumerated that the selected gram +ve and gram –ve bacteria, mold and yeast species showed varying magnitudes of antibacterial and antifugal activity with different solvent and water extracts of Cinnamon. It is found that *S.aureus* is most sensitive bacteria with ethyl acetate and ethanol extracts; *L.fermentum* with n-hexane extract; *B.subtilis* with acetone and methanol extracts; and *A. acidocaldarius* with cool and warm water extracts respectively. Among the gram –ve bacteria, most sensitive bacteria is *E.coli* with n-hexane, acetone ,ethanol and methanol extracts; *K. pneumonia* with ethyl acetate extract and *P. aeruginosa* with cool and warm water extracts. It was observed that *A.niger* was most sensitive with ethyl acetate and acetone extracts; *C.tropicalis* with n-hexane and methanol extracts; *S. cerevisiae* with ethanol extract and *C.albicans* with cool water and warm water extracts of *Cinnamon*. As different solvent extracts and water extracts of *Cinnamon* exhibited varying degrees of antibacterial and antifungal activities towards different species of microorganisms, it may be used as a natural preservative or food additive in preventing spoilage and prolonging the shelf life of fruit juices.

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