Biological Forum – An International Journal **15(2): 580-585(2023)**

ISSN No. (Print): 0975-1130
ISSN No. (Online): 2249-3239

Combination of *Cinnamomum verum* Bark Extract and Antibiotics: Potent Antimicrobial Activity

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(Received: 27 December 2022; Revised: 08 February 2023; Accepted: 10 February 2023; Published: 16 February 2023)
(Published by Research Trend)

ABSTRACT: Antimicrobial substances derived from plants are not capable alone to fight completely against microorganisms due to several limitations in context resistant developed by the microbe. Continuous research has identified that antimicrobial substances derived from plants have been discovered to be synergistic enhancers, meaning that even while they may have fewer antibacterial activities when taken alone, but on combining with conventional medications, they increase the drug's efficacy. Antibiotics and plant extracts work together synergistically to combat resistant infections, opening up new options for the treatment of infectious disorders. Using the Agar well diffusion method, the synergistic interaction between plant extracts and antibacterial drugs was evaluated. According to the study's findings, there is a higher level of activity when *Cinnamomum verum* plant extracts are combined with antimicrobial compounds under examination. The findings of this study suggest that combining plant extract with antibiotics may be effective in battling newly developed drug-resistant microbes. The combination of the extract and the antibiotics did not result in the formation of any new compounds, according to HPTLC data.

Keywords: *Cinnamomum verum,* Plant Extract, Antibiotics, Antimicrobial, HPTLC.

INTRODUCTION

A critical and expanding worldwide health concern is the growth of illnesses brought on by drug-resistant bacteria. Consequently, substantial efforts are being conducted to create novel antibacterial chemicals with increased efficacy (Prestinaci *et al*., 2015; Manna *et al*., 2015; Alabi *et al.,* 2013). Although, despite these attempts, Methicillin-Resistant *Staphylococcus aureus* (MRSA), *Staphylococcus aureus*, *Klebsiella pneumonia*, and *Pseudomonas aeruginosa* are among the multidrug-resistant bacteria that are continually reported (Alabi *et al.,* 2013*;* Nurjadi *et al.,* 2015; Klein *et al.,* 2013). This study sought to identify the antibacterial activity of *Cinnamomum verum* bark extracts against specific MDR isolates using various solvents to identify potential alternative treatment(s) for illnesses brought on by these organisms.

One of the vital culinary elements that are used in the creation of meals is spices. Around the world, more than a hundred plant species are utilized as seasonings and condiments. They are fragrant, dried plant components that can be found in seeds, fruits, leaves, roots, and bark, among other plant parts (Sangal, 2011). Numerous spices help delay the decaying process, extending the shelf life of food goods and acting as great preservatives (Asimi *et al.,* 2013). Additionally, because they are a rich source of biologically active substances, spices have additional benefits like antioxidant, antibacterial, anti-inflammatory, antidiabetic, and anticancer properties (Abeysekera *et al.,* 2013). These characteristics of spices aid in treating several physical illnesses.

One of the earliest documented spices used in cooking is cinnamon (Rao and Gan 2014). Although many species of this genus are sold as cinnamon, *Cinnamomum verum* J. Presl, a member of the Lauraceae family, has traditionally been regarded as the authentic cinnamon (Avula *et al.,* 2015). Its culinary and therapeutic applications have been abundantly documented in literature reaching back 4,000 years (Rao and Gan 2014). One of the most often used essential oils in the world of aromatherapy is *Cinnamomum verum* L. essential oil (CEO), sometimes known as Ceylon cinnamon or cinnamon tree. It works as an astringent, antipruritic, rubefacient, and antiseptic agent when administered externally (Barbarossa *et al.,* 2022). The bactericidal activity of *Cinnamomum burmannii* essential oil, which contains cinnamaldehyde and eugenol, was studied by Sasangka *et al.* (2023). Trans-cinnamaldehyde, eugenol, and linalool make up three of the primary ingredients of the essential oils extracted from Cinnamomum bark and account for 82.5 percent of the total composition (Chericoni *et al.,* 2005). About 49.9–62.8 percent of the entire volume of bark extract is made up of trans-cinnamaldehyde (Singh *et al.,* 2007; Simić *et al.,* 2004). The main active component of cinnamon, cinnamaldehyde, is principally in charge of giving meals their flavor, odor, and taste (Isaac-Renton *et al.,* 2015).

Additionally, it provides a defense against oxidative stress and microbial infection. Additionally, it provides defense against microbial infection, oxidative stress, and other chronic diseases (Ribeiro-Santos *et al.,* 2017). Its essential oil comprises a variety of chemical classes, including polyphenols, oxygenated hydrocarbons, monoterpenes, diterpenes, and sesquiterpenes (Cardoso-Ugarte *et al.,* 2016). We looked into the antibacterial properties of three commonly used herbal ingredients: cinnamon, eucalyptus, and thyme, whose antimicrobial effects are tangentially described in old Persian medical literature as antiseptics and treatments for illnesses brought on by Havaye Vabaee (Sheikhrezaee *et al.,* 2022). Investigation of alternative medicines was prompted by the discovery of Clostridioides difficile strains that were resistant to currently available antibiotics and their side effects. When exposed to the four strains of C. difficile, *Cinnamomum verum* exhibits significant ZOI (Tosun *et al.,* 2022). *Escherichia coli* is the primary bacteria responsible for 80–90% of UTIs. Other bacteria that cause UTIs include Staphylococcus aureus, Enterococcus faecalis, Pseudomonas aeruginosa, Proteus mirabilis, and Klebsiella pneumoniae, and their treatment with antibiotics is associated with serious adverse effects (Ortega-Lozano *et at.,* 2023). Gas chromatography-mass spectrometry (GC-MS) was used to identify the five main components of cout, of which (E)-cinnamaldehyde was claimed to be the predominant one. These five chemicals were (E)-cinnamaldehyde, eugenol, (E)-caryophyllene, (E)-cinnamyl acetate, and -humulene (Azeredo *et al.,* 2014).

Antioxidant, antibacterial, antifungal, antiviral, antiulcer, antilipidemic, anticancer, antipyretic, antiplatelet, antiallergic, antihypertensive, insecticidal, nematicidal, antidiabetic, and anesthetic actions are just a few of the pharmacological properties it contains (Farahpour and Habibi 2012; Gulcin *et al.,* 2019; Mariappan *et al.,* 2013; Ribeiro-Santos *et al.,* 2017; Shrishrimal *et al.,* 2016; Wisal, 2018). Moreover, it has gastroprotective, cardioprotective, immunomodulatory, and function-enhancing properties for the brain (Gopinath *et al.,* 2014). Its efficacy in treating flatulence, diarrhea, amenorrhea, toothaches, fever, leucorrhea, the common cold, headaches, and blood pressure regulation was also reported (Azimi *et al.,* 2014; Hajimonfarednejad *et al.,* 2019). Because of its antibacterial characteristics, cinnamon oil extract helps preserve some foods (Vangalapati *et al.,* 2012*;* Khandelwal, 2008). Cinnamon can stop food spoiling caused by microorganisms, according to earlier research (Jessica Elizabeth *et al.,* 2017). According to studies (Miyashita *et al.,* 2013; Sheng and Zhu 2014), antibacterial activity is particularly effective against *Bacillus subtilis*, *Staphylococcus aureus*, *Escherichia coli*, *Salmonella typhi*, *Klebsiella*, and *Pseudomonas aeruginosa*. When coupled with antimicrobials, cinnamon EO and cinnamaldehyde both displayed unexpected antimicrobial activity, raising the possibility that they could enhance the antibacterial effect (dos Santos Franciscato *et al.,* 2022). Male oligospermia can be treated with cinnamon to boost fertility (Mahmoudi *et al.,* 2015).

MATERIALS AND METHOD

Material. The plant bark was collected from the market and authenticated by a local Taxonomist. The plant material was washed using distilled water to remove the surface pollutants followed by air drying. The dried sample was powdered, stored in a sterile condition and used for further studies.

Magnetic stirrer extraction (ME). 30 grams of fine powder of plant material was extracted with 120 ml of an appropriate solvent (methanol, ethanol, and acetone) in a round bottom flask with a magnetic stirrer for 6hr, 12hr and 24hr. The bark extract was then centrifuged at 3000 rpm for 10 min each.

Time	Methanol	Ethanol	Acetone
6 hr	0.941gm	0.896gm	0.661gm
12 hr	1.195gm	0.992gm	0.766gm
24 hr	1.321gm	1.199gm	0.889gm

Preparation of combination. The combination was prepared by mixing API with diff. extracts.

The ratio of API and plant extract was maintained 1:1

Antimicrobial Activity of Extracts, Antibiotics and Combinations. The well-diffusion method, as advised by (Arodiya *et al*., 2021) with some changes, was used to investigate the microbial activity of cinnamon different solvent extracts, antibiotics, and combinations (extracts+antibiotics). Muller Hinton agar medium was used. The spreading technique was used to inoculate bacteria and fungi. A 7 mm sterilized cup borer was used to create agar wells, which were then filled with 50 microlitres of the tested soln. Petri dishes were incubated at 36 °C for 26 hours. The ZOI was used to express the inhibitory action of cinnamon, antibiotics, and combination in mm.

HPTLC

Prewashing. HPTLC plates (10 cm 10 cm) (Merck) were activated at 110 °C for 18 min using a TLC plate heater III after being washed with methanol.

Preparation of standards. Methanol was used to prepare standard solutions of *Cinnamomum verum* methanol extract and antibiotics of conc. of 0.1 mg/ml. Equal amounts of each standard solution were combined to prepare a mixture of the standards.

Plate development and derivatization. The Linomat 5 semi-autosampler was used to apply the individual standard solutions and standard mixture as 2-lL bands in five tracks, 1 cm from the plate's base, with a bandwidth of 5 mm and spacing between bands of 2 mm. All tracks 1–5 on the plates received samples in the following order: antibiotic, MeOH extract, anti+ MeOH extract, EtOH extract, and anti+ EtOH extract. 10 mL of mobile phase were pre-saturated in HPTLC twin trough chambers (10 cm x 10 cm) for 10 minutes. Over a migration distance of 5 cm, the mobile phase was employed to resolve the adsorbed standard and standard mix after being dispersed equally across the twin trough chamber. The mobile phase was composed of n-butanol,

ammonia, water, and DMSO (8:3:1:2). In a fume closet, plates were allowed to dry.

RESULT AND DISCUSSION

Antimicrobial Activity. The extracts of the bark of *Cinnamomum verum* were mixed with the API and were exposed to antimicrobial activity. ZOI measured in mm.

Table 1: Antibacterial activity of pure bark extract.

Bacteria	MeOH Extract				EtOH Extract				Acetone Extract			
	Conc. in µg/ml											
	1000	500	250	125	1000	500	250	125	1000	500	250	125
S. aureus.	15	13	11	09	13	11	11	09	11	11	10	09
B. subtilis	13	11	09	09	12	10	10	09	10	09	09	08
P. aeruginosa	16	15	11	12	13	11	10	11	12	11	11	10
E. coli	18	16	13	12	16	15	14	13	14	13	13	12

Table 2: Antibacterial activity of extract + Amoxicilline.

Bacteria	Amoxicilline	MeOH extract +A				EtOH extract +A				Acetone extract +A			
	Conc. in µg/ml												
	50	1000	500	250	125	1000	500	250	125	1000	500	250	125
S. aureus.	31	30	30	29	28	30	29	29	28	29	28	28	27
B. subtilis	35	35	34	34	33	35	34	33	32	34	33	32	32
P.aeruginosa	02	13	12	12	11	13	12	11	11	13	12	11	11
E. coli	05	16	15	14	14	16	15	14	13	16	15	13	13

Table 3: Antibacterial activity of extract + Ceftadizime.

Bacteria	Ceftadizime	MeOH extract + C				EtOH extract + C				Acetone extract + C			
	Conc. in µg/ml												
	50	1000	500	250	125	1000	500	250	125	1000	500	250	125
S. aureus.	02	12	12	11	11	12	12	11	10	12	11	11	10
B. subtilis	03	10	10	09	08	10	10	10	09	10	10	09	09
P. aeruginosa	06	16	16	15	14	16	15	14	14	16	15	15	14
E. coli	16	19	19	18	18	19	18	18	18	19	18	17	17

Table 4: Antibacterial activity of extract + Ciprofloxacin.

Bacteria	Ciprofloxacin	MeOH extract +C				EtOH extract +C				Acetone extract +C			
	Conc. in µg/ml												
	50	1000	500	250	125	1000	500	250	125	1000	500	250	125
S. aureus.	26	23	23	22	22	23	23	22	21	23	22	22	21
B. subtilis	26	25	25	24	24	25	24	24	23	25	24	23	22
P. aeruginosa	27	26	26	25	25	26	25	25	24	26	25	25	24
E. coli	28	26	25	24	24	25	25	24	24	25	24	24	23

Table 5: Antifungal activity of pure bark extract.

Fungus	MeOH extract				EtOH extract				Acetone extract			
	Conc. in µg/ml											
	1000	500	250	125	1000	500	250	125	1000	500	250	125
A. niger	12	12	10	09	12	11	10	09	11	10	09	08
C. albicans	10	09	08	08	12	11	10	10	13	12	12	11

Table 6: Antifungal activity of extract + Fluconazole.

Fungus	Fluconazole	MeOH extract +F				EtOH extract +F				Acetone extract +F			
	Conc. in µg/ml												
	50	1000	500	250	125	1000	500	250	125	1000	500	250	125
A. niger	02	11	11	10	10	11	11	10	09	11	10	10	09
C. albicans	00	07	07	06	06	07	06	06	05	06	06	05	05

Table 7: Antifungal activity of extract + Amphotericin-B.

Fungus	Amphotericin -B	MeOH extract +A				EtOH extract +A				Acetone extract +A			
	Conc. in µg/ml												
	50	1000	500	250	125	1000	500	250	125	1000	500	250	125
A. niger	18	17	16	16	15	17	16	15	15	16	15	15	14
C. albicans	12	12	12	11	11	12	12	11	10	12	11	10	10

The extracts prepared using the bark of the plant were employed for their antibacterial and antifungal potential against two gram-positive (*Staphylococcus aureus, Bacillus subtilis*) and two gram-negative bacteria (*Pseudomonas aeruginosa, Escherichia coli*) along with two fungi (*Aspergillus niger* and *Candida albicans*).

The plant extracts were prepared using the solvents *viz*., methanol, ethanol, and acetone and were exposed to bacterial and fungal strains for their antimicrobial potential. It was noted that the MeOH extracts exhibited the highest values of a zone of inhibition in comparison to all other extracts. The ZOI values for the plant extracts related to the theory regarding the solubility of plant products to be more in polar solvents in comparison to the non-polar solvents which can be correlated from the antimicrobial evaluation. The Three drugs Amoxiciline, Ceftadizime, Ciprofloxacin, and Two drug Amphotericin and Fluconazole were exposed to bacterial and fungal strains for their antimicrobial potential respectively. Fluconazole did not show any positiveresults against *C. albicans.*

After observing the individual antimicrobial activity of plant extract and API, the activity of their combination was also done in which their ratio was 1:1. Result displayed in the above table clearly showed by using the half volume of API with extract we get a nearly equivalent result of ZOI of ZOI of pure API which is somewhat relative positive result discussed by (Barbarossa *et al.,* 2022). In combination with sertraline, a selective serotonin reuptake inhibitor with successfully reported antibacterial activity, the cinnamon essential oil has a significant and potent action against a broad panel of pathogens. All studied Gram-positive and Gram-negative bacteria exhibited a very potent synergistic mode of action in response to the sertraline-CEO interaction. Among all the combination, the combination of MeOH and EtOH extract with Amoxiciline show 35 mm ZOI against *B. subtilis* which is the highest and thecombination of all three extracts with Ceftadizime show10 mm ZOI is lowest in *B. subtilis* in antibacterial for 1000 µg/ml**.**

In antifungal activity, the combination of EtOH and MeOH extract with Amphotericin-B show 17 mm ZOI against *A. niger* which is the highest ZOI, and the combination of Acetone extract with Fluconazole show 06 mm ZOI against *C. albicans* which is lowest ZOI for 1000 µg/ml.

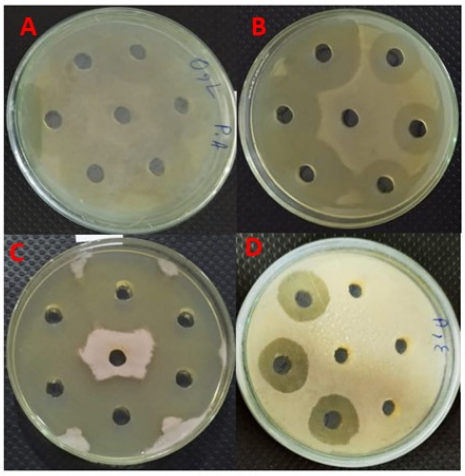

Fig. 1. (A) antibacterial of combination of EtOH extract + Amoxicilline against *S. aureus* (B) antibacterial of combination of EtOH extract + Ceftadizime against *S. aureus* (C) antibacterial of combination of EtOH extract + Ciprofloxacin against *B. subtilis* (D) antifungal of combination of EtOH.

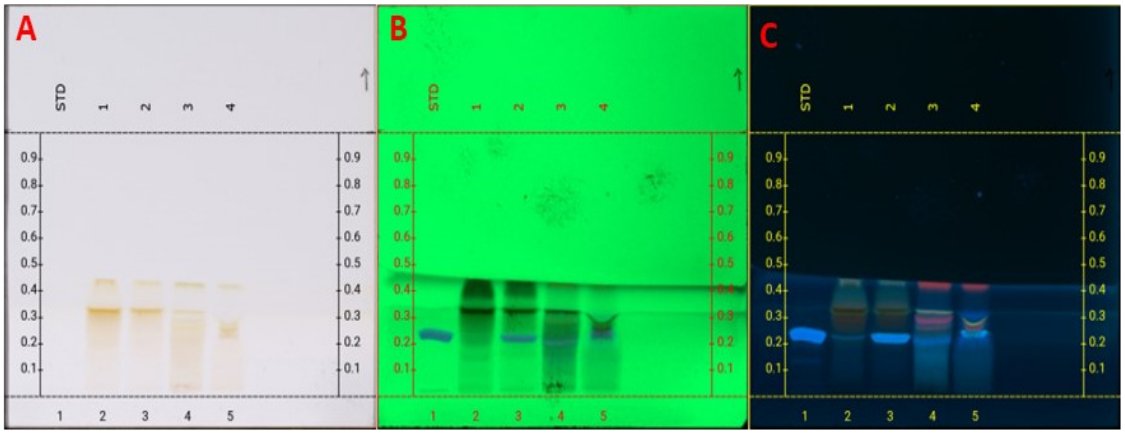

Fig. 2. HPTLC profile of Amoxicilline, Extracts and combinations at (A) visible, (B) UV 254 nm, (C) UV 366 nm. HPTLC.

In Fig. 2 (A, B, C) represent the same HPTLC experiments result in diff. lights. The first band of Amoxicilline also present at the same Rf value in the third and fifth band which is the combination of Amoxicilline and MeOH extract & Amoxicilline and EtOH extract respectively. No any new band is visible and no old band has Disappeared which confirms no any new compound formed by combining antibiotics and extract, therefore is no need to think about Toxicity.

CONCLUSIONS

Effective antimicrobial activity against microorganisms has been demonstrated by plant extract. It can be used to enhance the antimicrobial activity of antibiotics and so

as well we can reduce side effect of antibiotics by decreasing their concentrations.

FUTURE SCOPE

Combinatorial chemistry can replace regular drug uses after proper toxicology studies.

Acknowledgments. I extend my sincere thanks to Dr. Deep Joshi and Chemistry Department Faculties at Sheth M.N. Science College Patan. We thankful as well the IDMC College of Science and Technology, Patan's Microbiology Department for providing lab. facilities throughout the microbiology Experiment.

Conflict of Interest. None.

REFERENCES

Abeysekera, W. P. K. M., Premakumara, G. A. S. and Ratnasooriya, W. D. (2013). *In vitro* antioxidant properties of leaf and bark extracts of *Ceylon cinnamon* (*Cinnamomum zeylanicum* Blume). *Tropical Agricultural Research, 24*(2), 128 – 138.

Alabi, A. S., Frielinghaus, L., Kaba, H., Kösters, K., Huson, M. A., Kahl, B. C. and Schaumburg, F. (2013). Retrospective analysis of antimicrobial resistance and bacterial spectrum of infection in Gabon, Central Africa. *BMC Infectious Diseases*, *13*, 1-6.

Arodiya, F., Makvana, C. and Parmar, K. (2021). Polymer Capped Silver Nanoparticles from *Ziziphus nummularia* Leaves Extract: Potent Antibacterial and Antioxidant Activity. *Biosciences Biotechnology Research Asia*, *18*(4), 691-701.

Asimi, O. A., Sahu, N. P. and Pal, A. K. (2013). Antioxidant activity and antimicrobial property of some Indian spices. *International Journal of Scientific and Research Publications*, *3*(3), 1-8.

Avula, B., Smillie, T. J., Wang, Y. H., Zweigenbaum, J. and Khan, I. A. (2015). Authentication of true cinnamon (*Cinnamon verum*) utilising direct analysis in real time (DART)-QToF-MS. *Food Additives & Contaminants: Part A*, *32*(1), 1-8.

Azeredo, C. M. O., Santos, T. G., Maia, B. H. L. D. N. S. and Soares, M. J. (2014). In vitro biological evaluation of eight different essential oils against *Trypanosoma cruzi*, with emphasis on *Cinnamomum verum* essential oil. *BMC complementary and alternative medicine*, *14*(1), 1-8.

Azimi, P., Ghiasvand, R., Feizi, A., Hariri, M. and Abbasi, B. (2014). Effects of cinnamon, cardamom, saffron, and ginger consumption on markers of glycemic control, lipid profile, oxidative stress, and inflammation in type 2 diabetes patients. *The review of diabetic studies: RDS*, *11*(3), 258.

Barbarossa, A., Sblano, S., Rosato, A., Carrieri, A., Corbo, F., Clodoveo, M. L. and Carocci, A. (2022). Synergistic Action of *Cinnamomum verum* Essential Oil with Sertraline. *Antibiotics*, *11*(11), 1617.

Cardoso-Ugarte, G. A., López-Malo, A., & Sosa-Morales, M. E. (2016). Cinnamon (*Cinnamomum zeylanicum*) essential oils. In *Essential oils in food preservation, flavor and safety* (pp. 339-347). Academic Press.

Chericoni, S., Prieto, J. M., Iacopini, P., Cioni, P. and Morelli, I. (2005). In vitro activity of the essential oil of *Cinnamomum zeylanicum* and eugenol in peroxynitrite-induced oxidative processes. *Journal of agricultural and food chemistry*, *53*(12), 4762-4765.

dos Santos Franciscato, L. M. S., Sekine, K. H., Sakai, O. A., Caramão, E. B., Lancheros, C. A. C., Nakamura, C. V. and Moritz, C. M. F. (2022). Antimicrobial activity of cinnamon (*Cinnamomum verum*) essential oil and cinnamaldehyde against Staphylococcus aureus. *Research, Society and Development*, *11*(13), e560111335844-e560111335844.

Farahpour, M. R. and Habibi, M. (2012). Evaluation of the wound healing activity of an ethanolic extract of *Ceylon cinnamon* in mice. *Vet Med*, *57*(1), 53-57.

Gopinath, S. M., Vidya, G. M., Dayananda, K. S., Narasimha Murthy, T. P. and Ashalatha. (2014). Isolation, Characterization and Purification of Bio-Active Compounds from *Andrographis paniculata* and *Cinnamon verum* for Anti-Hiv Activity. *International Journal of Innovative Research in Science, Engineering and Technology, 3*(6), 13777-13783.

Gulcin, I., Kaya, R., Goren, A. C., Akincioglu, H., Topal, M., Bingol, Z. and Alwasel, S. (2019). Anticholinergic, antidiabetic and antioxidant activities of cinnamon (*Cinnamomum verum*) bark extracts: polyphenol contents analysis by LC-MS/MS. *International Journal of Food Properties*, *22*(1), 1511-1526.

Hajimonfarednejad, M., Ostovar, M., Raee, M. J., Hashempur, M. H., Mayer, J. G. and Heydari, M. (2019). Cinnamon: A systematic review of adverse events. *Clinical Nutrition*, *38*(2), 594-602.

Isaac-Renton, M., Li, M. K. and Parsons, L. M. (2015). Cinnamon spice and everything not nice: many features of intraoral allergy to cinnamic aldehyde. *Dermatitis*, *26*(3), 116-121.

Jessica Elizabeth, D. L. T., Gassara, F., Kouassi, A. P., Brar, S. K. and Belkacemi, K. (2017). Spice use in food: Properties and benefits. *Critical reviews in food science and nutrition*, *57*(6), 1078-1088.

Khandelwal, K. R. (2008). Practical Pharmacognosis, Pragati books Pvt. Ltd

Klein, E. Y., Sun, L., Smith, D. L. and Laxminarayan, R. (2013). The changing epidemiology of methicillin-resistant Staphylococcus aureus in the United States: a national observational study. *American Journal of Epidemiology*, *177*(7), 666-674.

Mahmoudi, M. N., Hejazi, S. and Afshari, F. (2015). The effect of hydroalcoholic extract of cinnamon on mice testis tissue. In *Biological Forum* (Vol. 7, No. 1, p. 1461).

Manna, D. K., Mandal, A. K., Sen, I. K., Maji, P. K., Chakraborti, S., Chakraborty, R. and Islam, S. S. (2015). Antibacterial and DNA degradation potential of silver nanoparticles synthesized via green route. *International Journal of Biological Macromolecules*, *80*, 455-459.

Mariappan, P. M., Sabesan, G., Koilpillai, B., Janakiraman, S. and Sharma, N. K. (2013). Chemical characterisation and antifungal activity of methanolic extract of *Cinnamomum verum* J. Presl bark against Malassezia spp. *Pharmacognosy Journal*, *5*(5), 197-204.

Miyashita, M. and Sadzuka, Y. (2013). Effect of linalool as a component of Humulus lupulus on doxorubicin-induced antitumor activity. *Food and Chemical Toxicology*, *53*, 174-179

Nurjadi, D., Friedrich-Jänicke, B., Schäfer, J., Van Genderen, P. J., Goorhuis, A., Perignon, A. and Zanger, P. (2015). Skin and soft tissue infections in intercontinental travellers and the import of multi-resistant Staphylococcus aureus to Europe. *Clinical microbiology and infection*, *21*(6), 567-e1.

Ortega-Lozano, A. J., Hernández-Cruz, E. Y., Gómez-Sierra, T. and Pedraza-Chaverri, J. (2023). Antimicrobial Activity of Spices Popularly Used in Mexico against Urinary Tract Infections. *Antibiotics*, *12*(2), 325.

Prestinaci, F., Pezzotti, P. and Pantosti, A. (2015). Antimicrobial resistance: a global multifaceted

phenomenon. *Pathogens and global health*, *109*(7), 309-318.

Rao, P. V. and Gan, S. H. (2014). Cinnamon: a multifaceted medicinal plant. *Evidence-Based Complementary and Alternative Medicine*, Volume 2014.

Ribeiro-Santos, R., Andrade, M., Madella, D., Martinazzo, A. P., Moura, L. D. A. G., de Melo, N. R. and Sanches-Silva, A. (2017). Revisiting an ancient spice with medicinal purposes: Cinnamon. *Trends in Food Science & Technology*, *62*, 154-169.

Sangal, A. (2011). Role of cinnamon as beneficial antidiabetic food adjunct: a review. *Advances in Applied Science Research*, *2*(4), 440-450.

Sasangka, J. A., Suyono, H. and Waworuntu, G. L. (2023). Effects of combination of alcohol and *Cinnamomum burmannii* essential oil against Klebsiella pneumoniae resistance. *Journal of the Medical Sciences (Berkala Ilmu Kedokteran)*, *55*(1).

Sheikhrezaee, M., Mehrabani, M., Golnaraghi, A., Kobarfard, F. and Hosseini, O. (2022). Study of Antibacterial and Synergistic Activities of *Cinnamomum verum*, *Eucalyptus camaldulensis* and *Zataria multiflora* Boiss. in Persian Medicine Against Some Gram-Negative and Gram-positive Pathogenic Bacteria. *Egyptian Journal of Veterinary Sciences*, *53*(1), 87-97.

Sheng, L. and Zhu, M. J. (2014). Inhibitory effect of *Cinnamomum cassia* oil on non-O157 Shiga toxin-producing *Escherichia coli*. *Food Control*, *46*, 374-381.

Shrishrimal, R. P., Sharma, K. S., Sonawane, S., Sonawane, P. and Varpe, V. V. (2016). On barks of *Cinnamomomum zeylanicum* Nees. *International Journal of Research in Pharmacy and Pharmaceutical Sciences*, *1*(5), 01-09.

Simić, A., Soković, M. D., Ristić, M., Grujić Jovanović, S., Vukojević, J. and Marin, P. D. (2004). The chemical composition of some Lauraceae essential oils and their antifungal activities. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*, *18*(9), 713-717.

Singh, G., Maurya, S., DeLampasona, M. P. and Catalan, C. A. (2007). A comparison of chemical, antioxidant and antimicrobial studies of cinnamon leaf and bark volatile oils, oleoresins and their constituents. *Food and chemical toxicology*, *45*(9), 1650-1661.

Tosun, M. N., Taylan, G. and Demirel Zorba, N. N. (2022). Antibacterial and antibiofilm activities of some plant essential oils and synergistic effects of cinnamon essential oil with vancomycin against *Clostridioides difficile*: in vitro study. *Letters in Applied Microbiology*, *75*(3), 598-606.

Vangalapati, M., Satya, N. S., Prakash, D. S. and Avanigadda, S. (2012). A review on pharmacological activities and clinical effects of cinnamon species. *Research Journal of pharmaceutical, biological and chemical sciences*, *3*(1), 653-663.

Wisal, G. A. (2018). Antibacterial and antifungal effect of cinnamon. *Microbiology Research Journal International*, *23*(6), 1-8.

How to cite this article: Mitu Patel, Piyush Vyas, Jigar Patel and Poyam Patel (2023). Combination of *Cinnamomum verum* Bark Extract and Antibiotics: Potent Antimicrobial Activity. *Biological Forum – An International Journal, 15*(2): 580-585.