Antibacterial and Antifungal Effect of Cinnamon

Abstract:

Cinnamon (*Cinnamomum zeylanicum*, *and Cinnamon cassia*), the eternal tree of tropical medicine, belongs to the Lauraceae family. Cinnamon is one of the most important spices used daily by people all over the world. Cinnamon primarily contains vital oils and other derivatives, such as cinnamaldehyde, cinnamic acid, and cinnamate. Traditional uses of Cinnamon throughout Asia, Africa, and Europe have been recorded, where it has been used as a medicine.

Key words: Antibacterial, Antifungal, Cinnamon.

Introduction:

Spices are one of the most commonly used natural antimicrobial agents in foods and have been used traditionally for thousands of years by many cultures for preserving foods and as food additives to enhance aroma and flavour [1]. As concern over the safety of chemical additives has risen in recent years, consumer interest in the use of natural products as alternative food preservatives has increased [2]. Consequently, natural antimicrobials are receiving a good deal of attention for a number of microorganism control issues. Due to the increasing demand for natural food additives, herbs and spices have emerged as popular ingredients to replace synthetic antimicrobial and antioxidant agents [3, 4].

The bark of various cinnamon species is one of the most important and popular spices used worldwide not only for cooking but also in traditional and modern medicines. Overall, approximately 250 species have been identified among the cinnamon genus, with trees being scattered all over the world [5,6]. Cinnamon is one of the oldest herbal medicines, mentioned in Chinese texts as far back as 4,000 years ago, and it is also one of the most frequently consumed spices [7- 9].

Food borne illness can cause symptoms that ranged from an upset stomach to more serious symptoms such as diarrhea, fever, Vomiting, abdominal cramps and dehydration despending on the etiological agents. Food borne illnesses not only affects the health of individuals, but it can also have dramatic economic impact. The economic losses from various factors, such as medical treatment, lost wages and productivity, loss of

business, recall and destruction of products, and investigation of the outbreaks, can be very high. [10].

Methodology:

The current review was conducted using a complete and organized search of the available literature on the medicinal plant cinnamon. The searches were performed using various databases, including PubMed (http://www.ncbi.nlm.nih.gov/pubmed), Science Direct (http://www.sciencedirect.com/), Scopus (http://www.scopus.com/), Scirus (http://www.scirus.com/), and Google Scholar (http://www.scholar.google.com/).

Traditional uses:

In addition to being used as a spice and flavoring agent, cinnamon is also added to flavor chewing gums due to its mouth refreshing effects and ability to remove bad breath [11]. Cinnamon can also improve the health of the colon, thereby reducing the risk of colon cancer [12].

Cinnamon is a coagulant and prevents bleeding [13]. Cinnamon also increases the blood circulation in the uterus and advances tissue regeneration [14]. This plant plays a vital role as a spice, but its essential oils and other constituents also have important activities, including antimicrobial [15-18], antifungal [19], antioxidant [20-24], and antidiabetic [25-31].

Cinnamon has been used as anti-inflammatory [32-34], antitermitic [34], nematicidal [35-36], mosquito larvicidal [37], insecticidal [38], antimycotic, [38-41] and anticancer agent [42-45]. Cinnamon has also been traditionally used as tooth powder and to treat toothaches, dental problems, oral microbiota, and bad breath [46, 47].

Chemical Constituents:

Cinnamon consists of a variety of resinous compounds, including cinnamaldehyde, cinnamate, cinnamic acid, and numerous essential oils [48] (Table 1). [49] studied the qualitative and quantitative composition of cinnamon (bark) essential oil (Table 2). Singh et al. [50] reported that the spicy taste and fragrance are due to the presence of cinnamaldehyde and occur due to the absorption of oxygen. As cinnamon ages, it darkens in color, improving the resinous compounds [50].

Table 1 Chemical constituents of different parts of cinnamon (Vangalapati et al., 2012)

Part of the plant	**Compound**
Leaves	Cinnamaldehyde: 1.00 to 5.00% Eugenol: 70.00 to 95.00%
Bark	Cinnamaldehyde: 65.00 to 80.00% Eugenol: 5.00 to 10.00%
Bark root	Camphor: 60.00%
Fruit	*trans*-Cinnamyl acetate (42.00 to 54.00%) and caryophyllene (9.00 to 14.00%)

C. zeylanicum buds	Terpene hydrocarbons: 78.00% *alpha*-Bergamotene: 27.38% *alpha*-Copaene: 23.05% Oxygenated terpenoids: 9.00%
C. zeylanicum flowers	(E)-Cinnamyl acetate: 41.98% *trans-alpha*-Bergamotene: 7.97% Caryophyllene oxide: 7.20%

66

67 Table 2 Qualitative and quantitative composition of cinnamon (bark) essential oil (Abd El-
68 Baky et al,2013)

Component	%
α-Thafone	0.37
α-pinene	1.12
Benzaldehyde	0.25
Heptanol	0.79
Sabinene	0.52
1-octen-3-ol	0.68
β-pinene	0.77
Myrcene	0.39
p-cymene	0.66
Limonene	1.48
β-phellandrene	0.37
1,8-cineole	1.01
γ-terpinene	0.99
Octanol	0.33
Linalool	0.54
terpinen-4-ol	0.38
α-terpineol	0.51
trans-carveol	0.51
Nerol	1.06
Neral	1.16
Geraniol	0.78
Geranial	1.79
neryl acetate	0.89
Trans- Cinnamaldehyde	45.13
Cinnamyl alcohol	5.13
Eugenol	7.47
Dihyroeugenol	3.31

Ethylcis-cinnamate	3.68
t-Methyl cinnamate	2.19
Methyl eugenol	5.23
Isoeugenol	1.59
Cis-Caryophyllene	Tr
t-Cinnamic acid	0.41
Cinnamyl actate	0.21
α-Caryphyllene	Tr
E-ethyl cinnamate	0.73

Antibacterial effect of cinnamon:

Cinnamon and cinnamon oil have been used for bacteria caused skin infection and food borne diseases.

Effect of cinnamon extract and cinnamon oil for bacteria cause skin infection:

Several studies on medicinal plants and their components have indicated the effect of cinnamon for bacteria cause skin infection. *Staphylococcus aureus* [51, 52], *Staphylococcus epidermidis* [53,54] *Staphylococcus aureus*, *Staphylococcus epidermidis* and *Streptococcus pyogenes*,[55]

Effect of cinnamon extract and cinnamon oil for foodborne bacteria:

Cinnamon is one of the most spices commonly used as natural antimicrobial agents in foods and have been used traditionally for thousands of years by many cultures for preserving foods and as food additives to enhance aroma and flavor [1] The most common bacteria causing food borne illness are *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* spp., *Listeris monocytogenes*, *Clostridium botulinus*, *Vibrio parahaemolyticus* and others [56].The antimicrobial properties of cinnamon have been documented [57] *Salmonella*, [58-63] *E. coli*, [64] reported two gram negative, *Escherichia coli*, *Salmonella typhi*, and two gram positive *Staphylococcus aureus* & *listeria monocytogens* , [65] studied *Bacillus cereus*.

Antibacterial effect of cinnamon for oral pathogens:

[66] reported the effect of cinnamon oil to oral bacterial pathogens *Streptococcus mutans*, *S. mitis*, *S. salivarius*, *Aggregatibacter actinomycetemcomitans*, *Porphyromonas gingivalis* and *Fusobacterium nucleatum*. [67] discussed the effect of cinnamon extract to *Streptococcus mutans* and *Streptococcus sanguinis.*

Phytochemical analysis of cinnamon:

Many studies showed that C. *verum* is an effective antioxidant and antibacterial spice. They attributed these activities of this plant to its phytochemicals as shown in table (3) reported by [68].

Table-3

Component	*Cinnamomum verum*
Carbohydrates	+
Proteins	+
Glycosides	+
Steroids	++
Alkaloids	++
Flavanoids	++
Saponins	+
Anthraquinones	++
Tannins	++
Terpenoids	+
Anthocyanins	-
Leucoanthocyanins	-
Coumarins	+
Emodins	-

[69] documented that An important characteristic of plant extracts and their components is their hydrophobicity, which enable them to partition the lipids of the bacterial cell membrane and mitochondria and rendering them more permeable. Extensive leakage from bacterial cells or the exit of critical molecules and ions will lead to death. [70] certified the antibacterial activity to the presence of some phytochemicals in the extracts and recommended that it was possibly due to their major component cinnamaldehyde.

Antifungal effect of cinnamon and cinnamon oil:

[71-75] studied the effect of cinnamon for *Candida albicans*[76] evaluated the inhibitory effects of cinnamonon the growth of mycelial of various spoilage pathogens (*Aspergillus. niger*, *Fusarium sambucinum Pythium sulcatum* and *Rhizopus stolonifera*. [77] reported the effect against *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus fumigatus*, *Penicillium chrysogenum*, *Penicillium notatum* and *Rhizopus oryzae*. [73] *Cryptococcus* species, [78] *Aspergillus niger*, *Alternaria alternata*, *Colletotrichum gloeosporioides*, *Lasiodiplodia*

theobromae, *Phomopsis viticola* and *Rhizopus stolonifera*, [79] *Aspergillus fumigatus* [80] *Phaeomoniella chlamydospora* , [81] *Penicillium italicum*, [82] *Mucor* species, [83] *Microsporum gypseum*, *Trichophyton rubrum and T. mentagraphytes*

Mechanism of cinnamon oil against fungi:

[84] Investigated the mechanism of how cinnamon oil affect the cell morphology, cell membrane and the activities of the key enzymes in scanning electron microscope (SEM) observations revealed that the mycelia morphology alterations of fungi were the markedly shriveled and collapsed hypha, even flatted empty hyphae, swelled cell wall, disrupted plasma membrane, with cytoplasmic matrix leakage. Furthermore, cinnamon oil inhibited the biosynthesis of ergosterol significantly damaging the cell membrane structure, causing the leakage of intracellular ions, protein and the higher absorbance at 260nm. Moreover, cinnamon oil affected the energy metabolism of fungi by decreasing the activities of succinate dehydrogenase (SDH) and malate dehydrogenase (MDH) in tricarboxylic acid (TCA) cycle.

References:

1- Snyder O P. Antimicrobial effects of spices and herbs. Hospitality Institute of Technology and Management. St. Paul, Minnaesota. http ://www. hitm.com/Documents/Spices.html. 1997.

2- Govaris A N, Solomakos A, Pexara, Chatzopoulou PS (). The antimicrobial effect of oregano essential oil, nisin and their combination against SalmonellaEnteritidis in minced sheep meat during refrigerated storage.Int. J. Food Microbiol. 2010;137:175–180.

3- Mayachiew P and Devahastin S. Antimicrobial and antioxidant activities of Indian gooseberry and galangal extracts. LWT Food Sci. Technol.2008; 41:1153–1159.

4- Nychas G J E. Natural antimicrobials from plants. In G. W. Gould (ed.). New methods of food preservation. Blackie Academic and Professional, London.1995; 58–89.

5- . Sangal A. Role of cinnamon as beneficial antidiabetic food adjunct: a review. Advan in Appl Sci Res. 2011;2(4):440–450.

6- Vangalapati M, Sree Satya N, Surya Prakash D, Avanigadda S. A review on pharmacological activities and clinical effects of cinnamon species. Res J of Pharmaceut, Biolo and Chem Sci. 2012;3(1):653–663.

7- Qin B, Nagasaki M, Ren M, Bajotto G, Oshida Y, Sato Y. Cinnamon extract (traditional herb) potentiates in vivo insulinregulated glucose utilization via enhancing insulin signaling in rats. Diabetes Res. Clin. Pract.2003; 6:139–148.

8- Qin B, Nagasaki M, Ren M, Bajotto G, Oshida Y, and Sato Y. Cinnamon extract prevents the insulin resistance induced by a high-fructose diet. Horm. Metab. Res. 2004; 36:119–125

9- Ranasinghe L, Jayawardena B, Abeywickrama K. Fungicidal activity of essential oils ofCinnamomum zeylanicum(L.) and Syzygium aromaticum(L.) Merr et L.M. Perry against crown rot and anthracnose pathogens isolated from banana. Lett. Appl. Microbiol. 2002; 35:208–211.

10- Doors S. Food Safety: Current Status and Future Needs, American Academy of Microbiologists, Washington, D.C. 1999.

11- Jakhetia V, Patel R, Khatri P . Cinnamon: a pharmacological review. J of Advan Scient Res. 2010;1(2):19–12

12- Wondrak GT, Villeneuve NF, Lamore SD, Bause AS, Jiang T, Zhang DD. The cinnamon-derived dietary factor cinnamic aldehyde activates the Nrf2-dependent antioxidant response in human epithelial colon cells. Molecules. 2010;15(5):3338–3355.

13- Hossein N, Zahra Z, Abolfazl M, Mahdi S and Ali K. Effect of *Cinnamon zeylanicum* essence and distillate on the clotting time. J of Med Plants Res. 2013;7(19):1339–1343.

14- Minich St, Msom L. Chinese Herbal Medicine in Women's Health. Women's Health; 2008.

15- Chang ST, Chen PF, Chang SC. Antibacterial activity of leaf essential oils and their constituents from *Cinnamomum osmophloeum* . J of Ethnopharmacol. 2001;77(1):123–127.

16- Hili P, Evans CS, Veness RG. Antimicrobial action of essential oils: the effect of dimethylsulphoxide on the activity of cinnamon oil. Lett in Appl Microbiol. 1997;24(4):269–275.

17- Matan N, Rimkeeree H, Mawson AJ, Chompreeda P, Haruthaithanasan V, Parker M. Antimicrobial activity of cinnamon and clove oils under modified atmosphere conditions. Int J of Food Microbiol. 2006;107(2):180–185.

178 18- Gende LB, Floris I, Fritz R, Eguaras MJ. Antimicrobial activity of cinnamon
179 (*Cinnamomum zeylanicum*) essential oil and its main components against
180 paenibacillus larvae from argentine. Bull of Insectol. 2008;61(1):1–4.
181 19- Wang SY, Chen PF, Chang ST. Antifungal activities of essential oils and their
182 constituents from indigenous cinnamon (*Cinnamomum osmophloeum*) leaves
183 against wood decay fungi. Bioresour Technol. 2005;96(7):813–818.
184 20- Mancini-Filho J, van-Koiij A, Mancini DAP, Cozzolino FF, Torres RP.
185 Antioxidant activity of cinnamon (*Cinnamomum zeylanicum*, breyne) extracts.
186 Bollettino Chimico Farmaceutico. 1998;137(11):443–447.
187 21- Shobana S, Akhilender N K. Antioxidant activity of selected Indian spices.
188 Prostaglandins Leuko and Essen Fatty Acids. 2000;62(2):107–110.
189 22- Mathew S, Abraham TE. Studies on the antioxidant activities of cinnamon
190 (*Cinnamomum verum*) bark extracts, through various in vitro models. Food Chem.
191 2006;94(4):520–528.
192 23- Mathew S, Abraham TE. *In vitro* antioxidant activity and scavenging effects of
193 *Cinnamomum verum* leaf extract assayed by different methodologies. Food and
194 Chem Toxicol. 2006;44(2):198–206.
195 24- Kim N, Sung H and Kim W. Effect of solvents and some extraction conditions on
196 antioxidant activity in cinnamon extracts. Korean J of Food Sci and Tech.
197 1993;25(3):204–209.
198 25- Kim SH, Hyun SH, Choung SY. Anti-diabetic effect of cinnamon extract on
199 blood glucose in db/db mice. J of Ethnopharmacol. 2006;104(1-2):119–123.
200 26- . Prabuseenivasan S, Jayakumar M and Ignacimuthu S. *In vitro* antibacterial
201 activity of some plant essential oils. BMC Complementary and Altern Med.
202 2006;6, article 39
203 27- Jia Q, Liu X , Wu X. Hypoglycemic activity of a polyphenolic oligomer-rich
204 extract of *Cinnamomum parthenoxylon* bark in normal and streptozotocin-induced
205 diabetic rats. Phytomed. 2009;16(8):744–750.
206 28- Jarvill-Taylor KJ, Anderson RA, Graves DJ. A hydroxychalcone derived from
207 cinnamon functions as a mimetic for insulin in 3T3-L1 adipocytes. J of the Am
208 College of Nutri. 2001;20(4):327–336.
209 29- Lu Z, Jia Q, Wang R. Hypoglycemic activities of A- and B-type procyanidin
210 oligomer-rich extracts from different Cinnamon barks. Phytomed.
211 2011;18(4):298–302.

30- Subash Babu P, Prabuseenivasan S, Ignacimuthu S. Cinnamaldehyde—a potential antidiabetic agent. Phytomed. 2007;14(1):15–22.

31- Onderoglu S, Sozer S, Erbil KM, Ortac R and Lermioglu F. The evaluation of long-term effects of cinnamon bark and olive leaf on toxicity induced by streptozotocin administration to rats. J of Pharm and Pharmacol. 1999;51(11):1305–1312.

32- Chao LK, Hua KF, Hsu HY, Cheng SS, Liu JY, Chang ST. Study on the Antiinflammatory activity of essential oil from leaves of *Cinnamomum osmophloeum* . J of Agri and Food Chem. 2005;53(18):7274–7278.

33- Tung YT, Chua MT, Wang SY, Chang ST. Anti-inflammation activities of essential oil and its constituents from indigenous cinnamon (*Cinnamomum osmophloeum*) twigs. Bioresour Tech. 2008;99(9):3908–3913.

34- Tung YT, Yen PL, Lin CY, Chang ST. Anti-inflammatory activities of essential oils and their constituents from different provenances of indigenous cinnamon (*Cinnamomum osmophloeum*) leaves. Pharm Biol. 2010;48(10):1130–1136.

35- Park IK, Park JY, Kim KH. Nematicidal activity of plant essential oils and components from garlic (*Allium sativum*) and cinnamon (*Cinnamomum verum*) oils against the pine wood nematode (*Bursaphelenchus xylophilus*). Nematol. 2005;7(5):767–774.

36- Kong JO, Lee SM, Moon YS, Lee SG, Ahn YJ. Nematicidal activity of cassia and cinnamon oil compounds and related compounds toward *Bursaphelenchus xylophilus* (Nematoda: Parasitaphelenchidae). J of Nematol. 2007;39(1):31–36.

37- Cheng SS, Liu JY, Tsai KH, Chen WJ , Chang ST. Chemical composition and mosquito larvicidal activity of essential oils from leaves of different *Cinnamomum osmophloeum* provenances. J of Agri and Food Chem. 2004;52(14):4395–4400.

38- Cheng SS, Liu JY, Huang CG, Hsui YR, Chen WJ, Chang ST. Insecticidal activities of leaf essential oils from *Cinnamomum osmophloeum* against three mosquito species. Bio Reso Tech. 2009;100(1):457–464.

39- Dhulasavant V, Shinde S, Pawar M, Naikwade NS. Antihyperlipidemic activity of *Cinnamomum tamala* Nees. on high cholesterol diet induced Hyperlipidemia. Int Journal of PharmTech Res. 2010;2(4):2517–2521.

40- Amin KA, El-Twab TMA. Oxidative markers, nitric oxide and homocysteine alteration in hypercholesterolimic rats: role of atorvastatine and cinnamon. Int J of Clin and Exp Med. 2009;2(3):254–265.

41- Bandara T, Uluwaduge I and Jansz ER. Bioactivity of cinnamon with special emphasis on diabetes mellitus: a review. Int J of Food Sci and Nutri. 2012;63(3):380–386.

42- Lu J, Zhang K, Nam S, Anderson RA, Jove R, Wen W. Novel angiogenesis inhibitory activity in cinnamon extract blocks VEGFR2 kinase and downstream signaling. Carcinogenesis. 2010;31(3):481–488.

43- Kwon HK, Jeon WK and Hwang JS. Cinnamon extract suppresses tumor progression by modulating angiogenesis and the effector function of $CD8^+$ T cells. Cancer Lett. 2009;278(2):174–182.

44- Kwon HK, Hwang JS,So JS. Cinnamon extract induces tumor cell death through inhibition of NFκB and AP1. BMC Cancer. 2010;10(1), article 392.

45- Koppikar SJ, Choudhari AS, Suryavanshi SA, Kumari S, Chattopadhyay S, Kaul-Ghanekar R. Aqueous Cinnamon Extract (ACE-c) from the bark of Cinnamomum cassia causes apoptosis in human cervical cancer cell line (SiHa) through loss of mitochondrial membrane potential. BMC Cancer. 2010;10(1), 210.

46- Aneja K, Joshi R and Sharma C. Antimicrobial activity of dalchini (*Cinnamomum zeylanicum* bark) extracts on some dental caries pathogens. J of Pharm Res. 2009;2(9):1387–1390.

47- Gupta C, Kumari A, Garg AP, Catanzaro R, Marotta F. Comparative study of cinnamon oil and clove oil on some oral microbiota. Acta Bio-Medica: Atenei Parmensis. 2011;82(3) article 197.

48- Senanayake UM, Lee TH,Wills RBH. Volatile constituents of cinnamon (*Cinnamomum zeylanicum*) oils. J of Agri and Food Chem. 1978;26(4):822–824

49- Abdo-ElBaky HH, ElBaroty GS, Farag RS, Saleh MA. Characterization of antioxidant and antimicrobial compounds of cinnamon and ginger essential oils. Advan Res J of Biochem. 2013; 1 (4) : 078-085

50- Singh G, Maurya S, deLampasona MP, Catalan CAN. A comparison of chemical, antioxidant and antimicrobial studies of cinnamon leaf and bark volatile oils, oleoresins and their constituents. Food and Chem Toxicol. 2007;45(9):1650–1661

51- Zainab AA. The antibacterial activity of aqueous extract of cinnamon and clove against *Staphylococcus aureus*. J of Al-Nahrain Univ. 2008; 11(2): 131-135.

52- Oulkheir S , Aghrouch M, Mourabit FEl, Dalha F, Graich H, Amouch F, Ouzaid K, Moukale A, Chadli S. Antibacterial Activity of Essential Oils Extracts from

279 Cinnamon, Thyme, Clove and Geranium Against a Gram Negative and Gram
280 Positive Pathogenic Bacteria. Journal of disease and medical plant. 2017; 3:1-5.
281 53- Daud FS, Pande G, Joshi M, Pathak R,Wankhede SA study of antibacterial effect
282 of some selected essential oils and medicinal herbs against acne causing bacteria.
283 Int pharma science inven. 2013; 2: 27-34.
284 54- Julianti E, Rajah KK and Fidrianny I .Antibacterial activity of ethanol extract of
285 cinnamon bark, honey and their combination effects against acne- causing
286 bacteria. Sci pharm. 2017; 85(2):19.
287 55- Shabani NM, Ismail Z, Ismail WI, Zainuddin N, Rosdan NH, Roslan MNF, Mohd
288 Azahar NM . Antimicrobial activity of cinnamon oil against bacteria that cause
289 skin infections. Journal of Scientific Research and Development. 2016; 3 (2): 1-6
290
291 56- Van TTH, Moutafis G, Tran LT and Coloe PJ. Antibiotic resistance in
292 foodborne bacteria contaminants in Vietanam. Appl. Environ. Microbiol.2007;
293 73:7906-7911.
294 57- Abdel-Raouf, M, Nabil M, El-Sayed M. Antimicrobial Activities of Some Herbs
295 Extracts on Food Borne Bacteria. J of Am Sci 2014;10(11): 76-85.
296 58- Mari R, Kalirajan K, Ranjit S. Antimicrobial activity of turmeric natural dye
297 against different bacterial strains. J Appl Pharm Sci. 2012; 2(6):210-212.
298 59- Mukhtar S, Ghori I. Antibacterial Activity of Aqueous and Ethanolic Extracts
299 of Garlic, Cinnamon and Turmeric against *Escherichia coli* A TCC 25922
300 and *Bacillus subtilis* DSM 3256. Int J Appl Biol Pharm Tech. 2012;
301 3(2):131-136.
302 60- Usha M, Ragini S, S.M.A N. Antibacterial Activity of Acetone and Ethanol
303 Extracts of Cinnamon (*Cinnamomum zeylanicum*) and Ajowan
304 (Trachyspermum ammi) on four Food Spoilage Bacteria. Int Res J Biol Sci.
305 2012:1(4):7-11.
306 61- Hong Y, Minbae Y, Moon B and Lee S. Inhibitory Effect of Cinnamon Powder on
307 Pathogen Growth in Laboratory Media and Oriental-Style Rice Cakes
308 (Sulgidduk). Journal of Food Protection.2013; 76: 133–138
309 62- Senhaji Q, Faid M and Kalalou. Inactivation of *Escherichia coli* O157:H7 by
310 essential oil from *Cinnamomum zeylanicum*. Braz Infect Dis. 2007; 11: 234-236.
311 63- Pan X, Mak L, Nakano H. Efficacy of essential oils on inactivation of *Escherichia*
312 *coli* 0157:H7 in vegetable juice. Food Sci and Tech Res.2014; 20: 1043-1049.

64- Bharath M.R, Azeem MA, Sherien Basha , Keerthan H V (2016). Antimicrobial Activity of Cinnamon extracts against Foodborne Pathogens *E.coli*, S.*tyhimurium* and *S.aureus* & *L.monocytogens*. IOSR J of Pharma and Biol Sci.2016; 11(6) : 66-72

65- Sofia PK, Prasad R, Vijay VK, Srivastava AK . Evaluation of antibacterial activity of Indian spices against common foodborne pathogens. Int J of food Sci Tech. 2007; 42: 910-915.

66- Zainal-Abidin Z, Mohd-Said S, Abdul Majid FA, Mustapha WAW, Jantan I. Anti-Bacterial Activity of Cinnamon Oil on Oral Pathogens. The Open Conference Proceedings Journal. 2013; 4 (2) :12-16.

67- Kim H Y, Park J B (2017). In vitro evaluation of anti-caries effect of cinnamon extracts on oral pathogens. Biomedical Research. 2017; 28 (6): 2848-2853.

68- Harsha N, Sridevi V, Chandana Lakshmi MVV, Rani K, Divya Satya V N (2013). Phytochemical Analysis of Some Selected Spices. International Journal of Innovative Research in Science, Engineering and Technology. 2013; 2:6618-6621

69- Rastogi RP, Mehrotra BN. Glossary of Indian Medicinal Plants. National Institute of science communication, New Delhi, India. 2002.

70- Sharma R, Dutt R, Jadon S, Bhatia AK. Phytochemical analysis of *Cinnamomum zeylanicum* for antibacterial activity against *B.subtilis*. Int J for Res in Appl Sci and Engin Tech (IJRASET). 2016; 4:528-835.

71- Vazirian M, Alehabib S, Jamalifar H, Fazeli MR, Najarian Toosi A , Khanavi M . Antimicrobial effect of cinnamon (Cinnamomum verum J. Presl) bark essential oil in cream-filled cakes and pastries. Res J of Pharma (RJP). 2015; 2(4) : 11-16

72- Dalirsani Z, Adibpour M, Aghazadeh M, Amirchaghmaghi M, Falaki F, Mozafari PM, Hamzei FM . *In vitro* Comparison of Inhibitory Activity of 10 Plant Extracts Against *Candida Albicans*. Austral J of Basic and Appl Sci.2011; 5(5): 930-935.

73- Radwan, I A, Abed AH, Abeer MR, Ibrahim M A, Abdallah AS. Effect of Thyme, Clove and Cinnamon Essential Oils on *Candida albicans* and Moulds Isolated from Different Sources. Am J of Ani and Vet Sci. 2014; 9(4): 303.314.

74- Razzaq Abed A, Hussein IM. Effect of Cinnamon extract on radial growth of *Aspergillus ochraceus* and cellular growth of *Candida albicans*. Euph J of Agri Sci. 2015;7 (1): 23-31.

75- Gujjari S K, Shreeshyla HS, Sureshn J, Venkatesh, M.P. Evaluation of cinnamon mouth wash on *Candida albicans* in type II diabetics with chronic periodontitis : Apilot study. Int J of Res and Rev.2017; 4 (4):3937-3940.

76- Mvuemba HN, Green SE, Tsoomo A, Avis TJ. Antimicrobial efficacy of cinnamon, ginger, horseradish and nutmeg extracts against spoilage pathogens. Phytoprotection. 2009; 90:65–70

77- Doudi M, Setorki M, Rezayatmand Z . Effects of aqueous extract of Cinnamomum verumon growth of bread spoilage fungi. Int J of Med Res Hlth Sci. 2016; 5: 162-171.

78- Sukatta U, Haruthaithanasan V, Chantarapanont W, Dilokkunanant U , Suppakul P. Antifungal Activity of Clove and Cinnamon Oil and Their Synergistic Against Postharvest Decay Fungi of Grape in vitro. Kasetsart J. (Nat. Sci.). 2008; 42 : 169 – 174.

79- Carmo E S, Lima E O, Souza E L, Sousa F B. Effect of *Cinnamomum zeylanicumblume* essential oil on the growth and morphogenesis of some potentially pathogenic *A spergillus* species. Bra J of Microbiol. 2008; 39: 91-97.

80- Rusin C, Oliari ICR, Leite CD, Faria CMD R, Botelho RV, Almanc MAK. Antifungal activity of plant extracts on *Phaeomoniella chlamydospora.* BIO Web of Conferences7, 39 th World Congress of Vine and Wine.2016.

81- Anjum T and Akhtar N. Antifungal Activity of Essential Oils Extracted From Clove, Cumin and Cinnamon Against Blue Mold Disease on Citrus Fruit. Int Conf on Applied Life Sciences. 2012; 321:326.

82- Abdullah T. Al-fawwaz and Khaled A. Al-Khaza'leh. Antibacterial And Antifungal Effect Of Some Natural Extracts And Their Potential Use As Photosensitizers. Euro Sci J. 2016; 12 (6): 147-157

83- Coi LS, Li Y, Kam SL, Wang H , Ooi VE (2006). Antimicrobial Activities of Cinnamon Oil and Cinnamaldehyde from the Chinese Medicinal Herb *Cinnamomum cassia* Blume. Am. J. Chin. Med. 34, 511-522

84- Yaru Li Y, Ying N, Zhou L, Li S, Tang X, Ding Y, Li S. The possible mechanism of antifungal activity of cinnamon oil against *Rhizopus nigricans*. Journal of PharmTech Res. 2014;6(5):12-20.