International Journal of Pharmacy and Pharmaceutical Sciences

ISSN- 0975-1491 Vol 9, Issue 2, 2017

Review Article

CINNAMOMUM GENUS: A REVIEW ON ITS BIOLOGICAL ACTIVITIES

MADHU KATYAYANI BALIJEPALLI[1*], AYUBA SUNDAY BURU[2], RAGHAVENDRA SAKIROLLA[2], MALLIKARJUNA RAO PICHIKA[2]

[1]Faculty of Medicine, MAHSA University, Kuala Lumpur, Malaysia, [2]International Medical University, Kuala Lumpur, Malaysia
Email: madhu@mahsa.edu.my

Received: 08 Feb 2016 Revised and Accepted: 07 Dec 2016

ABSTRACT

The objective of this review is to systematically appraise the literature available to date on biological activities (*in vitro* and *in vivo*) of extracts and constituents from *Cinnamomum*. An extensive review of the literature available in various recognised databases including PubMed, Google Scholar and Scopus on the biological activities of various species of the *Cinnamomum* were undertaken. The literature provided information on biological activities of the species of the genus *Cinnamomum*. Crude extracts and constituents from about 30 species of *Cinnamomum* displayed significant antibacterial, antifungal, antiseptic, antiviral, anti-inflammatory, antipyretic, antioxidant, chemopreventive, cytotoxic, antidiabetic, hypolipidemic, antispasmodic, antiulcer, antiplatelet, anodyne, choleretic, immunostimulant, anaesthetic and sedative activities. Essential oil, aqueous/alcoholic extracts, cinnamaldehyde and proanthocyanidins were reported to be mainly responsible for biological activities displayed by most of the plants. Plants of *Cinnamomum* genus possess a wide spread of biological activities validating their use in traditional medicine. However, most of the available references lack information on active constituents, doses, duration of the treatment, storage conditions and positive controls for examining biological activities. The molecular mechanisms involved in eliciting biological activities were not comprehensively elucidated. Investigations to prove the safe use of these plants in traditional medicine are very limited. Thus, more studies on identification of bioactive constituents and their molecular mechanisms are needed. In addition, given that various species of *Cinnamomum* are being widely used in traditional medicine and culinary purposes, their main therapeutic aspects, toxicity, and adverse effects warrant further investigation in the future.

Keywords: *Cinnamomum*, Biological activities, Ethnomedicinal uses, Bioactive constituents

DOI: http://dx.doi.org/10.22159/ijpps.2017v9i2.11156

INTRODUCTION

In rural areas of the developing countries all over the world, plants have been used in the treatment of numerous human diseases for thousands of years and are the primary source of medicine [1]. The secondary metabolites produced by plants has been proven to possess various biological activities and was templates for the development of novel drugs.

There are a number of scientific reports on the use of medicinal plants and their secondary metabolites for the treatment of a wide array of diseases. Few natural products from plants have been recorded in pharmacopoeias. *Cinnamomum* is one such genus which has been extensively used for the treatment of wide-array of disorders in various traditional systems of medicine including western herbal medicine.

Apart from the wide array of medicinal uses of the genus *Cinnamomum,* the inner barks of the many species, commonly known as cinnamon, is used as a spice for cooking purposes across the world. In Ayurvedic medicine [2], cinnamon is being used for the common cold, cough, diabetes, fever, flatulence, indigestion, sinusitis and sore throat. Also it is a component of, herbal toothpaste to reduce the incidence of dental caries; chair a spiced black tea beverage consumed widely in India and in Yogi Bhajan's "Yogi Tea", used as a general tonic tea for a varied range of symptoms including digestive disorders, blood purification, and immunostimulation and as an antiparasitic. Ayurvedic physicians prescribe cinnamon for people with a "kapha dosha," an Ayurvedic term used to define a body type described by cold, heavy, slow functioning and wet.

Cinnamon is being prescribed in traditional Chinese medicine (TCM) for cold, diarrhoea, asthma, as an appetiser; to strengthen the uterus and increase fertility in women [2].

In Europe [2], cinnamon is used as a warming herb for the treatment of ailments associated with "cold". Cinnamon bark is approved by German health authorities (Commission E) for its use as an antispasmodic for mild gastrointestinal spasms, an appetiser, and for digestive disorders such as indigestion, bloating and gas.

In western herbal medicine [2], herbalists prescribe cinnamon for diabetes, diarrhoea, indigestion, nausea, toothache, and vomiting. Cinnamon oil is added in a few kinds of toothpaste for its antimicrobial properties and its capacity to reduce halitosis. The major constituent of cinnamon oil is eugenol which is still being widely used as a local anaesthetic and antibacterial agent in dental practice.

To the best of our knowledge, only two review articles focusing on a particular species of genus *cinnmaomum* were published in the literature. One article [3] reviewed the ethnobotanical uses of *cinnamomum* species available in Tamilnadu, India. Another article [4] reviewed the phytoconstituents, ethnobotanical and pharmacological uses of *Cinnamomum zeylanicum*. With the objective of providing an eagle's eye view on scientific literature available on biological activities of genus *Cinnamomum* and for the benefit of those who are interested in Natural Products research we herewith made an attempt to review the entire available literature on biological activities of *Cinnamomum* genus.

In this review article, the scientifically proven biological activities of all the species from the genus *Cinnamomum* were reported. Literature searches were performed using a keyword '*cinnamomum*' in the databases; PubMed, Scopus, and Google Scholar (all from inception to August 2016). All the biological studies including *ex vivo*, *in vitro* and *in vivo* studies related to the species of the genus *Cinnamomum* published in the English language were included.

Biological activities of *Cinnamomum* species

Species		Parts	Extracts/Chemical constituents	Biological activities	References
1.	*C. Osmo phloem*	Leaf	Essential oil	Antifungal	[5, 6]
				Antidiabetic	[7]
				Insecticidal	[8-10]
				Antitermitic	[11]
				Larvicidal	[12, 13]
				xanthine oxidase (XOD) inhibitory and anti-hyperuricemic	[14]
				Treatment of renal interstitial fibroblasts.	[15]
				Anti-inflammatory	[16-19]
				Antibacterial	[20-22]
				Apoptosis in cancer cells.	[23]
				Affects insulin signalling pathway	[24]
				Anxiolytic	[25]
				Antioxidant	[26]
			Ethanol extract	Tyrosinase inhibitory activity	[27]
			Water extract	Antioxidant wound healing	[27]
		Twig	Essential oil	Antioxidant	[28]
			Water Extract	Antihyperglycemic and antioxidant	[29]
2.	*C. camphora*	leaf	Water extract	Antimicrobial	[30, 31]
			Essential oil	Acaricidal	[32]
		Twig	Essential oil	Anti-inflammatory	[33, 34]
			Methanol extract	Antioxidant	[35]
		Bark	Essential oil	Anti-inflammatory	[36]
				Anticancer	[36]
				Cytotoxic	[37]
				Molluscicidal	[38]
				Antigenotoxic	[39]
			Hot water extract and essential oil	Antimicrobial	[40-42]
				Repellant and insecticidal	[43]
				Medium chain acyl-ACP hydrolysis activity	[44]
		Seed	Essential oil	Insecticidal	[45]
				Antioxidant, Anti-inflammatory	[46]
3.	*C. burmannii*	Leaf	Water extract	Antioxidant	[47]
			Methanol extract	Antidiabetic	[48-50]
		Bark		Cytotoxic	[51]
				Inhibition of cytochrome P450 3A4 (CYP3A4) and CYP2D6	[52]
				Antibacterial	[53]
4.	*C. zeylanicum*	Leaf	Essential oil	Acaricidal	[54]
				Ameliorative	[55]
				Antifungal	[56-59]
				Antioxidant and Antimicrobial	[60-64]
				Antioxidant	[65, 66]
		Bark	Unknown	Spermatogenesis	[67]
			Essential oil	Ovicidal and adulticidal	[68]
				Antimicrobial	[69, 70]
				Insecticidal	[71-73]
			Water extract	Cognitive impairment and oxidative stress	[74, 75]
			Ethanol extract	Increase sexuality	[76]
			Essential oil	Antiasthmatic	[77, 78]
			Chloroform extract	Analgesic	[79]
			Water extract	Gastroprotective	[80]
				Insect repellent	[81]
				Antibacterial and antifungal	[82, 83]
				Antioxidant	[84-86]
				Anti-nociceptive and Anti-inflammatory	[87, 88]
				Antidiabetic	[89-93]
				Mutagenic	[94, 95]
				Osteoclastogenesis	[96]
				Antioxidant and antimutagenic	[97]
5.	*C. parthenoxylon*	Bark	Water extract	Hypoglycemic	[98]
		Wood	Hinokenin, Cubebin	Antileukaemic	[99]
6.	*C. kanehira*	Leaf	Methanol extract	Antioxidant	[33, 35]
			Ethanol extract	Anticancer	[100]
			Water extract	Anti-inflammatory	[34]
		Twig	Essential oil	Antibacterial	[101]
7.	*C. cassia*	Unknown	Volatile oil, Cinnamaldehyde	Anticancer	[102]
			Coumarins	Anticancer	[103]
		Leaf	Water extract	Antioxidant	[47, 104-106]
				Antimutagenic	[107, 108]

				Angiogenesis	[109]
			Ethanol,	Antimicrobial	[110-117]
			Water extract	Antifungal	[118, 119]
			Essential oil	Hypouricemic	[120]
		Stem bark	Hexane extract	Anticancer	[121]
			Essential oil	Immunomodulatory	[122, 123]
			Hot water extract	Anticancer	[124]
			Ethanol extract	Antiviral	[125]
			Methanol extract	Antiproliferative	[126, 127]
				Antioxidant	[128-130]
				Antiulcerogenic	[131]
				Antidiabetic	[90, 132-138]
				Antihyperglycemic and Antihyperlipidemic	[139]
				Antitumor	[140-142]
				Antiallergic	[143-146]
				Anti-inflammatory	[147-152]
				Antipyretic	[153]
				Inhibitory activity on nitric oxide production and metalloproteinases-2 and-9 (MMP-2/9]	[154, 155]
				Stimulation of steroid hormones	[156]
				Diabetic nephropathy	[157]
				Insecticidal and larvicidal	[68, 158, 159]
			Diterpenoids	Immunosuppressant activity	[160]
			Lignans, tetrahydrofuran derivatives, gamma-butyrolactone	Anti-inflammatory	[161]
			Proanthocyanidin oligomers	Antihyperglycaemic	[162]
				Immunosuppressive effect	[163]
		Shoot	Essential oil	Antibacterial	[164, 165]
				Antiestrogenic	[166, 167]
		Plant	Water extract	Anxiolytic	[168, 169]
			Methanol extract	Stimulates angiogenesis	[170, 171]
			Essential oil	Xanthine oxidase inhibitor	[172-174]
				Antiprotozoal	[175]
		Twig	Methanol extract	Xanthine oxidase inhibitor	[176]
8.	*C. pauciflorum*	Leaf	Water extract	Antioxidant	[65]
9.	*C. tamala*	Leaf	Water extract	Antioxidant	[65]
			Essential oil	Gastroprotective	[177]
			Ethanol extract	Antidiarrhoeal	[178]
				Hypoglyceamic	[179]
10.	*C. carolinense*	Bark	Hot water extract	Medicinal tea and hot beverage	[180]
11.	*C. philippinense*	Root	Water extract	Antioxidant, Antiplatelet aggregation and	[181]
			Essential oil	Vasorelaxant	
				Thromboxane A2 receptor antagonist	[182]
12.	*C. insularimontanum*	Fruit	Essential oil	Anti-inflammatory	[183]
		Leaf	Methanol extract	Cytotoxic	[184]
13.	*C. verum*	Unknown	Essential oil	Antiparasitic	[185]
		Unknown	Unknown extract	Inhibition of amyloid fibril formation	[186]
		Leaf	Methanol extract	Antioxidant	[187-189]
			Water extract	Antimicrobial	[61, 110, 190-193]
			Essential oil		
			Ethanol and aqueous extracts	Antioxidant, Analgesic	[194]
			Essential oil	Insecticidal	[195-197]
		Cortex	Water extract	Bening prostatic hyperplasia	[198]
			2-Methoxycinnamaldehyde	Anticancer	[199-203]
		Bark	Essential oil	Antioxidant	[188, 204-206]
			Cuminaldedhyde	Anticancer	[207-209]
			Water extract	Anthelmintic	[210]
14.	*C. loureirii*	Unknown	Extract	Acetylcholinesterase activity	[211]
15.	*C. micranthum*	Fruit	Water extract	Anti-inflammatory	[34]]
16.	*C. ketoense*	Leaf	Methanol extract	Antiproliferative	[212]
				Induces caspase-dependent and-independent apoptosis in Hep G2 cells	[213]
				Anticancer	[212, 214, 215]
		Stem wood	Hot water extract	Antitubercular	[216]
17.	*C. longepaniculatum*	Leaf	Volatile oil	Anti-inflammatory	[217]
				Antibacterial	[218]
				Antihepatoma	[219]
18.	*C. japonicum*	Bark	Procyanidin oligomer-rich extract	Hypoglycemic	[136]

19.	*C. pubescens*	Leaf	Methanol extract	Platelet-activating factor (PAF) receptor-binding antagonist activity	[220]
20.	*C. altissimum*	Leaf	Methanol extract	PAF receptor-binding antagonist activity	[220]
21.	*C. bejolghota*	Leaf	Essential oil	Antimicrobial	[221]
22.	*C. griffithii*	Leaf/twig/root	Methanol extract	Antiplasmodial	[222]
		Leaf/Bark	Essential oil	Antioxidant, Anticholinesterase	[223]
23.	*C. loureirii*	Leaf bark	Methanol extract	Anti-inflammatory	[173]
24.	*C. massoiae*	Plant	Alcohol extract	Antihistaminic	[224]
25.	*C. mairei*	Plant	Boiling water extract	Mutagenic	[225]
26.	*C. aromaticum*	Herbs	Methylene chloride extract	Insecticidal	[226]
			Water extract	Immunotherapy for respiratory allergy	[227]
27.	*C. migao*	Leaf	Essential oil	the relaxation effect on smooth muscles	[228]
28.	*C. longa*	Plant	Acetone extract	Antioxidant	[229]
29.	*C. rhizome*	Plant	Acetone extract	Antioxidant	[229]
30.	*C. laubatii*	Fruit	Spiroacetals	Anticancer	[230]
31.	*C. bodineiri*	Leaf	Subamolide A	Antioxidant	[231]
32.	*C. impressinervium*		Water extract	Antidiabetic	[232]
33.	*C. glaucescens*		Essential oil	Insecticidal, antifungal, anti aflatoxin and antioxidant	[233]
34.	*C. subavenium*	Stem	Subamolide A	Cytotoxic	[231]
35.	*C. jensenianum*	Bark	Essential oil	Antifungal	[234]
36.	*C. iners*	Stembark	Volatile oil	Antibacterial	[235]
37.	*C. impressicostatum*	Stembark	Volatile oil	Antibacterial	[235]
38.	*C. porrectum*	Stembark	Volatile oil	Antibacterial	[235]
39.	*C. altissimum*	Stembark	Water extract	Antibacterial	[235]
40.	*C. mollissimum*	Stembark	Aporphine alkaloids	Antioxidant, Antibacterial	[236]

DISCUSSION

The genus *Cinnamomum* has been used in various traditional systems of medicine including Indian and traditional Chinese systems of medicine to treat a multitude of disorders, like indigestion, cold, cough, microbial infections. Only 40 out of the approximate 300 *Cinnamomum* species have been studied in some detail. The leaves and stem barks have been reported to be the main source for biological activities displayed by *Cinnamomum* species. One of the most widely investigated constituents of *Cinnamomum* species is essential oil and reported to exhibit a wide array biological activities including antibacterial, antifungal, antioxidant, antidiabetic, antitermitic, anticancer, anticholinesterase, larvicidal, hypouricemic, immunemodulatory and xanthine oxidase inhibitory activities. Very recently, few attempts are being made to isolate the bioactive constituents and to identify the molecular mechanisms. Adfa, M. *et al.* [99] reported lignans and phenylpropanoids isolated from *C. parthenoxylon* possess antileukemic activity mediated through apoptosis in human leukaemia HL-60 and U-937 cells. Chang, W. L. *et al.* [102] reported cinnamaldehyde, a major constituent of *Cinnamomum* essential oils, exhibit anticancer activity in human oral squamous cell carcinoma HSC-3 cells mediated through apoptosis, induced mitochondrial dysfunction, increased reactive oxygen species (ROS) production and antioxidant actions. Chen, L. *et al.* [163] reported procyanidin oligomer compounds, cinnamtannin B1, cinnamtannin D1, para meri tannin A1, procyanidin B2 and procyanidin C1 from *C. tamla* or *C. cassia* display immune-suppressive effects mediated through significant reduction of IFN-γ and IL-2 in LPS induced splenocytes proliferation model. Chen, T. W. *et al.* [207] and Yang, S. M. *et al.* [209] reported cumin aldehyde, a novel anticancer agent, isolated from *C. verum* exhibited significant anticancer activity in human lung adenocarcinoma A549 cells and human lung squamous cell carcinoma NCI-H520 cells accompanied by down regulations of proliferative control involving apoptosis, both topoisomerase I and II as well as telomerase activities, together with an upregulation of lysosomal vacuolation with increased volumes of acidic compartments. Tsai K. D. *et al.* [208] reported cumin aldehyde possess anticancer activity in human colorectal adenocarcinoma COLO 205 cells through downregulation of topoisomerases 1 and II. Cheng, B. H. *et al.* [25] reported linalool from *C. osmophloeum* essential oil has significant anxiolytic activity in mice model whose action is mediated through a decrease in the mice brain levels of serotonin, dopamine and norepinephrine. He, S. *et al.* [161] reported six new compounds including one γ-butyrolactone, cinncassin A, two tetrahydrofuran derivatives, cinncassins B and C, two lignans, cinncassins D and E, and one phenyl propanol glucoside, cinnacassoside D possessing anti-inflammatory activity in LPS induced inflammation in BV-2 microglial cells. Kang, B. H. *et al.* [162] reported proanthocyanidins from *C. cassia* do exhibit anti-hyperglycemic activity via carbohydrate hydrolyzing enzyme inhibition. Kim, C. R. *et al.* [211] reported 2, 4-bis (1,1-dimethylethyl) phenol inhibited acetyl cholinesterase activity and ameliorates trimethyl tin-induced cognitive dysfunction in mice. Lee, S. C. *et al.* [19] reported essential oil from *C. osmophloeum* kanehira protected endotoxin-induced intestinal injury in mice associated with suppression of toll-like receptor 4(TLR4) and Nod-like receptor family, pyrin domain containing 3 (NLRP3) signalling pathways. Li, L. *et al.* [218] reported γ-terpinene, α-terpineol, 1,8-cineole isolated from *C. longepaniculatum* leaf essential oil displayed significant antibacterial activity against *Staphylococcus aureus*, *Escherichia coli* and *Salmonella enteritidis*. Liu, Y. H. *et al.* [199].

Perng, D. S. *et al.* [200, 201], Tsai K. D. *et al.* [202] and Wong Y. H. *et al.* [203] reported 2-methoxycinnamaldehyde exhibited anticancer activity in human lung squamous cell carcinoma NCI-H520 cells, hepatocellular carcinoma Hep 3B cells, human colorectal adenocarcinoma COLO 205 cells and human lung adenocarcinoma A549 cells through targeting topoisomerase I and II. Manson, F. F. *et al.* [236] reported five aporphine alkaloids; N-methyl-1,2,10-trimethoxyaprophine, N-methylhernagine, N-methylhemovine, hernagine and hernovine; showed significant antibacterial and antioxidant activities. Ngoc, T. M. *et al.* [103] reported a new coumarin derivative, coumacasia possessing significant growth inhibitory effects in two human cancer cell lines, HL-60 and A-549. Song, X. *et al.* [219] reported safrole from *C. longepaniculatum* exhibited anti-hepatoma effect mediated through apoptosis. Williams A. R. *et al.* [210] reported trans-cinnamaldehyde and A-and B-type proanthocyanidins obtained from *C. verum* exhibited anthelmintic activity. Yan Y. M. *et al.* [157] reported sesquiterpenoids may be responsible for anti-diabetic nephropathy displayed by *C. cassia* bark. Yang, F. *et al.* [38] reported linalool obtained from *C. camphora* leaf extracts exhibited molluscicidal activity against *Oncomelania hupensis* and inhibits infection of

schistosoma japonicum. Zeng, J. *et al.* [160] reported diterpenoids isolated from *C. aromaticum* possess immunosuppressive effect.

CONCLUSION

In this review, we summarised the existing studies on the biological activities of *Cinnamomum* genus. Only 40 out of available 300 *Cinnamomum* species were scientifically investigated for biological activities which implies that there is a huge potential for researchers to explore further the potential biological activities of *Cinnamomum* species because majority of the species have been used for various purposes in different traditional systems of medicine and as a food ingredient all over the world for a quite long time. *C. verum*, *C. cassia*, *C. zeylanicum*, *C. camphora* and *C. osmophloeum* are the only five species that have been somewhat thoroughly investigated in the identification of potential biological activities, bioactive constituents and molecular mechanisms. Also, the majority of the studies have been concentrated on essential oil and aqueous/alcohol extracts of leaves and stem barks with the main focus on validating the uses of *Cinnamomum* in various traditional systems of medicine. Detailed studies were performed only on two bioactive compounds namely 2-methoxycinnamaldehyde and cumin aldehyde for their anticancer activity in various human cancer cells. Based on the published results in the literature, these two compounds have exhibited promising effects and could be good leads in anticancer drug discovery. However, further studies have to be carried out to assess the bioavailability, toxicity, drug-like properties, *in vivo* efficacy and molecular targets. Also, there is an opportunity for the medicinal chemists to look at structure-activity relationship studies on these two compounds.

CONFLICTS OF INTERESTS

Declared none

REFERENCES

1. Cragg GMNDJ. Medicinals for the Millennia. Ann New York Acad Sci 2001;953:3-25.
2. http://www.naturalstandard.com. [Last accessed on 05 Jan 2016]
3. Muthiah Maridass, Bonfilius Victor. Ethnobotanical uses of *Cinnamomum* species, Tamil Nadu, India. Ethnobotanical Leaflets 2008;12:150-5.
4. Das Manosi, Mandal Suvra, Mallick Budhimanta, Hazra Jayram. Ethnobotany, phytochemical and pharmacological aspects of *Cinnamomum zeylanicum*. Int Res J Pharm 2013;4:4.
5. Cheng S, Liu J, Hsui Y, Chang S. Chemical polymorphism and antifungal activity of essential oils from leaves of different provenances of indigenous cinnamon (*Cinnamomum osmophloeum*). Bioresour Technol 2006;97:306-12.
6. Wang S, Chen P, Chang S. Antifungal activities of essential oils and their constituents from indigenous cinnamon (*Cinnamomum osmophloeum*) leaves against wood decay fungi. Bioresour Technol 2005;96:813-8.
7. Lee M, Rao YK, Chen K, Lee Y, Tzeng Y. Effect of flavonol glycosides from *Cinnamomum osmophloeum* leaves on adiponectin secretion and phosphorylation of insulin receptor-β in 3T3-L1 adipocytes. J Ethnopharmacol 2009;126:79-85.
8. Cheng S, Liu J, Huang C, Hsui Y, Chen W, Chang S. Insecticidal activities of leaf essential oils from *Cinnamomum osmophloeum* against three mosquito species. Bioresour Technol 2009;100:457-64.
9. Cheng S, Liu J, Lin C, Hsui Y, Lu M, Wu W, *et al.* Terminating red imported fire ants using *Cinnamomum osmophloeum* leaf essential oil. Bioresour Technol 2008;99:889-93.
10. Mdoe FP, Cheng SS, Msangi S, Nkwengulila G, Chang ST, Kweka EJ. The activity of *Cinnamomum osmophloeum* leaf essential oil against *Anopheles gambiae* s. s. Parasit Vectors 2014;7:209.
11. Chang ST, Cheng SS. Antitermitic activity of leaf essential oils and components from *Cinnamomum osmophleum*. J Agric Food Chem 2002;50:1389-92.
12. 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 Agric Food Chem 2004;52:4395-400.
13. Cheng S, Liu J, Hsui Y, Chang S. Chemical polymorphism and antifungal activity of essential oils from leaves of different provenances of indigenous cinnamon (*Cinnamomum osmophloeum*). Bioresour Technol 2006;97:306-12.
14. Wang SY, Yang CW, Liao JW, Zhen WW, Chu FH, Chang ST. Essential oil from leaves of *Cinnamomum osmophloeum* acts as a xanthine oxidase inhibitor and reduces the serum uric acid levels in oxonate-induced mice. Phytomedicine 2008;15:940-5.
15. Chao LK, Chang W, Shih Y, Huang J. Cinnamaldehyde impairs high glucose-induced hypertrophy in renal interstitial fibroblasts. Toxicol Appl Pharmacol 2010;244:174-80.
16. Fang S, Rao YK, Tzeng Y. Inhibitory effects of flavonol glycosides from *Cinnamomum osmophloeum* on inflammatory mediators in LPS/IFN-γ-activated murine macrophages. Bioorg Med Chem 2005;13:2381-8.
17. Shen Y, Chou C, Wang Y, Chen C, Chou Y, Lu M. Anti-inflammatory activity of the extracts from mycelia of *Antrodia camphorata* cultured with water-soluble fractions from five different *Cinnamomum* species. FEMS Microbiol Lett 2004;231:137-43.
18. Chao LK, Hua K, Hsu H, Cheng S, Lin I, Chen C, *et al.* Cinnamaldehyde inhibits pro-inflammatory cytokines secretion from monocytes/macrophages through suppression of intracellular signalling. Food Chem Toxicol 2008;46:220-31.
19. Lee SC, Hsu JS, Li CC, Chen KM, Liu CT. Protective effect of leaf essential oil from *Cinnamomum osmophloeum Kanehira* on endotoxin-induced intestinal injury in mice associated with suppressed local expression of molecules in the signalling pathways of TLR4 and NLRP3. PLoS One 2015;10:e0120700.
20. Chang ST, Chen PF, Chang SC. Antibacterial activity of leaf essential oils and their constituents from *Cinnamomum osmophloeum*. J Ethnopharmacol 2001;77:123-7.
21. Chang C, Chang W, Chang S. Influence of pH on the bioactivity of cinnamon oil against *Legionella pneumophila* and its disinfection efficacy in hot springs. Water Res 2008;42:5022-30.
22. Chang C, Chang W, Chang S, Cheng S. Antibacterial activities of plant essential oils against *Legionella pneumophila*. Water Res 2008;42:278-86.
23. Huang T, Fu H, Ho C, Tan D, Huang Y, Pan M. Induction of apoptosis by cinnamaldehyde from indigenous cinnamon *Cinnamomum osmophloeum* Kaneh through reactive oxygen species production, glutathione depletion, and caspase activation in human leukaemia K562 cells. Food Chem 2007;103:434-43.
24. Tzeng Y, Chen K, Rao YK, Lee M. Kaempferitrin activates the insulin signalling pathway and stimulates secretion of adiponectin in 3T3-L1 adipocytes. Eur J Pharmacol 2009;607:27-34.
25. Cheng BH, Sheen LY, Chang ST. Evaluation of anxiolytic potency of essential oil and S-(+)-linalool from *Cinnamomum osmophloeum* ct. linalool leaves in mice. Afr J Tradit Complementary Altern Med 2014;5:27-34.
26. Lin K, Yeh S, Lin M, Shih M, Yang K, Hwang S. Major chemotypes and antioxidative activity of the leaf essential oils of *Cinnamomum osmophloeum* Kaneh. from a clonal orchard. Food Chem 2007;105:133-9.
27. Lee MG, Kuo SY, Yen SY, Hsu HF, Leung CH, Ma DL, *et al.* Evaluation of *Cinnamomum osmophloeum* Kanehira extracts on tyrosinase suppressor, wound repair promoter, and antioxidant. Sci World J 2015. http://dx.doi.org/10.1155/2015/303415.
28. Chua M, Tung Y, Chang S. Antioxidant activities of ethanolic extracts from the twigs of *Cinnamomum osmophloeum*. Bioresour Technol 2008;99:1918-25.
29. Lin GM, Chen YH, Yen PL, Chang ST. Antihyperglycemic and antioxidant activities of twig extract from *Cinnamomum osmophloeum*. Afr J Tradit Complementary Altern Med 2015;6:281-8.
30. Hsu Y, Shieh HK, Chen W, Sun T, Shiang J. Antimicrobial susceptibility, plasmid profiles and haemocin activities of *Avibacterium paragallinarum* strains. Vet Microbiol 2007;124:209-18.

31. Vismer HF, Eicker A. Growth of human pathogenic isolates of *Sporothrix schenckii* on indigenous and exotic wood species in South Africa. Mycol Res 1994;98:121-4.
32. Kim S, Na Y, Yi J, Kim B, Ahn Y. Contact and fumigant toxicity of oriental medicinal plant extracts against *Dermanyssus gallinae* (Acari: Dermanyssidae). Vet Parasitol 2007;145:377-82.
33. Lee HJ, Hyun E, Yoon WJ, Kim BH, Rhee MH, Kang HK, *et al. In vitro* anti-inflammatory and anti-oxidative effects of *Cinnamomum camphora* extracts. J Ethnopharmacol 2006;103:208-16.
34. Shen Y, Chou C, Wang Y, Chen C, Chou Y, Lu M. Anti-inflammatory activity of the extracts from mycelia of Antrodia camphorata cultured with water-soluble fractions from five different *Cinnamomum* species. FEMS Microbiol Lett 2004;231:137-43.
35. Lee M, Jiang C, Juan S, Lin R, Hou W. Antioxidant and heme oxygenase-1 (HO-1)-induced effects of selected Taiwanese plants. Fitoterapia 2006;77:109-15.
36. Rao YK, Fang S, Tzeng Y. Evaluation of the anti-inflammatory and anti-proliferation tumoral cells activities of *Antrodia camphorata*, *Cordyceps sinensis*, and *Cinnamomum osmophloeum* bark extracts. J Ethnopharmacol 2007;114:78-85.
37. Bakkali F, Averbeck S, Averbeck D, Zhiri A, Idaomar M. Cytotoxicity and gene induction by some essential oils in the yeast *Saccharomyces cerevisiae*. Mutation Res/Genetic Toxicol Environ Mutagenesis 2005;585:1-13.
38. Yang F, Long E, Wen J, Cao L, Zhu C, Hu H, *et al.* Linalool, derived from *Cinnamomum camphora* (L.) Presl leaf extracts, possesses molluscicidal activity against *Oncomelania hupensis* and inhibits infection of *Schistosoma japonicum*. Parasit Vectors 2014;407:3305-7.
39. Bakkali F, Averbeck S, Averbeck D, Zhiri A, Baudoux D, Idaomar M. Antigenotoxic effects of three essential oils in diploid yeast (*Saccharomyces cerevisiae*) after treatments with UVC radiation, 8-MOP plus UVA and MMS. Mutat Res 2006;606:27-38.
40. Yeh R, Shiu Y, Shei S, Cheng S, Huang S, Lin J, *et al.* Evaluation of the antibacterial activity of leaf and twig extracts of stout camphor tree, *Cinnamomum kanehirae*, and the effects on immunity and disease resistance of white shrimp, *Litopenaeus vannamei*. Fish Shellfish Immunol 2009;27:26-32.
41. Dutta BK, Karmakar S, Naglot A, Aich JC, Begam M. Anticandidial activity of some essential oils of a mega biodiversity hotspot in India. Mycoses 2007;50:121-4.
42. Xu G, Wang L, Liu J, Hu S. Decay resistance and thermal stability of bamboo preservatives prepared using camphor leaf extract. Int Biodeterior Biodegrad 2013;78:103-7.
43. Liu CH, Mishra AK, Tan RX, Tang C, Yang H, Shen YF. Repellent and insecticidal activities of essential oils from *Artemisia princeps* and *Cinnamomum camphora* and their effect on seed germination of wheat and broad bean. Bioresour Technol 2006;97:1969-73.
44. Davies HM. Medium chain acyl-ACP hydrolysis activities of developing oilseeds. Phytochemistry 1993;33:1353-6.
45. Zhou X, Li X, Yuan J, Tang Z, Wang-Yi Liu. Toxicity of cinnamomin—a new type II ribosome-inactivating protein to bollworm and mosquito. Insect Biochem Mol Biol 2000;30:259-64.
46. Fu J, Zeng C, Zeng Z, Wang B, Gong D. *Cinnamomum camphora* seed kernel oil ameliorates oxidative stress and inflammation in diet-induced obese rats. J Food Sci 2016;81:H1295-300.
47. Prasad KN, Yang B, Dong X, Jiang G, Zhang H, Xie H, *et al.* Flavonoid contents and antioxidant activities from *Cinnamomum* species. Innovative Food Sci Emerging Technol 2009;10:627-32.
48. Cao H, Graves DJ, Anderson RA. Cinnamon extract regulates glucose transporter and insulin-signaling gene expression in mouse adipocytes. Phytomedicine 2010;17:1027-32.
49. Nailufar F, Tandrasasmita OM, Tjandrawinata RR. DLBS3233 increases glucose uptake by mediating upregulation of PPARγ and PPARδ expression. Biomed Preventive Nutr 2011;1:71-8.
50. Cheng DM, Kuhn P, Poulev A, Rojo LE, Lila MA, Raskin I. *In vivo* and *in vitro* antidiabetic effects of aqueous cinnamon extract and cinnamon polyphenol-enhanced food matrix. Food Chem 2012;135:2994-3002.
51. Ahmad M, Lim CP, Akowuah GA, Ismail NN, Hashim MA, Hor SY, *et al.* Safety assessment of standardised methanol extract of *Cinnamomum burmannii*. Phytomedicine 2013;20:1124-30.
52. Subehan, Usia T, Iwata H, Kadota S, Tezuka Y. Mechanism-based inhibition of CYP3A4 and CYP2D6 by Indonesian medicinal plants. J Ethnopharmacol 2006;105:449-55.
53. Shan B, Cai YZ, Brooks JD, Corke H. Antibacterial properties and major bioactive components of cinnamon stick (*Cinnamomum burmannii*): activity against foodborne pathogenic bacteria. J Agric Food Chem 2007;55:5484-90.
54. Fichi G, Flamini G, Zaralli LJ, Perrucci S. Efficacy of an essentifal oil of *Cinnamomum zeylanicum* against *Psoroptes cuniculi*. Phytomedicine 2007;14:227-31.
55. Mishra A, Bhatti R, Singh A, Singh Ishar MP. Ameliorative effect of the cinnamon oil from *Cinnamomum zeylanicum* upon early stage diabetic nephropathy. Planta Med 2010;76:412-7.
56. Tzortzakis NG. Impact of cinnamon oil-enrichment on microbial spoilage of fresh produce. Innovative Food Sci Emerging Technol 2009;10:97-102.
57. Simic A, Sokovic MD, Ristic M, Grujic-Jovanovic S, Vukojevic J, Marin PD. The chemical composition of some Lauraceae essential oils and their antifungal activities. Phytother Res 2004;18:713-7.
58. de Assis CPO, Gondim Jr MGC, de Siqueira HAA, da Câmara CAG. Toxicity of essential oils from plants towards *Tyrophagus putrescentiae* (Schrank) and *Suidasia pontifica* Oudemans (Acari: Astigmata). J Stored Prod Res 2011;47:311-5.
59. Kloucek P, Smid J, Frankova A, Kokoska L, Valterova I, Pavela R. Fast screening method for assessment of antimicrobial activity of essential oils in vapor phase. Food Res Int 2012;47:161-5.
60. 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 Chem Toxicol 2007;45:1650-61.
61. Arnal-Schnebelen B, Hadji-Minaglou F, Peroteau J, Ribeyre F, de Billerbeck VG. Essential oils in infectious gynaecological disease: a statistical study of 658 cases. Int J Aromather 2004;14:192-7.
62. Tzortzakis NG. Maintaining postharvest quality of fresh produce with volatile compounds. Innovative Food Sci Emerging Technol 2007;8:111-6.
63. Rodríguez A, Batlle R, Nerín C. The use of natural essential oils as antimicrobial solutions in paper packaging. Part II. Prog Org Coat 2007;60:33-8.
64. Jayathilakan K, Sharma GK, Radhakrishna K, Bawa AS. Antioxidant potential of synthetic and natural antioxidants and its effect on warmed-over-flavour in different species of meat. Food Chem 2007;105:908-16.
65. Prasad KN, Yang B, Dong X, Jiang G, Zhang H, Xie H, *et al.* Flavonoid contents and antioxidant activities from *Cinnamomum* species. Innovative Food Sci Emerging Technol 2009;10:627-32.
66. Kitazuru ER, Moreira AVB, Mancini-Filho J, Delincée H, Villavicencio ALCH. Effects of irradiation on natural antioxidants of cinnamon (*Cinnamomum zeylanicum* N.). Radiat Phys Chem 2004;71:39-41.
67. Khaki A. Effect of *Cinnamomum zeylanicum* on spermato-genesis. Iran Red Crescent Med J 2015;17:e18668.
68. Yang Y, Lee H, Lee SH, Clark JM, Ahn Y. Ovicidal and adulticidal activities of *Cinnamomum zeylanicum* bark essential oil compounds and related compounds against *Pediculus humanus capitis* (Anoplura: Pediculicidae). Int J Parasitol 2005;35:1595-600.
69. Unlu M, Ergene E, Unlu GV, Zeytinoglu HS, Vural N. Composition, antimicrobial activity and *in vitro* cytotoxicity of essential oil from *Cinnamomum zeylanicum* Blume (Lauraceae). Food Chem Toxicol 2010;48:3274-80.
70. Ghosh V, Saranya S, Mukherjee A, Chandrasekaran N. Antibacterial microemulsion prevents sepsis and triggers healing of wound in wistar rats. Colloids Surf B 2013;105:152-7.
71. Pugazhvendan SR, Ross PR, Elumalai K. Insecticidal and repellant activities of plants oil against stored grain pest, *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae). Asian Pac J Trop Dis 2012; Suppl 1:S412-5.

72. Prajapati V, Tripathi AK, Aggarwal KK, Khanuja SPS. Insecticidal, repellent and oviposition-deterrent activity of selected essential oils against *Anopheles stephensi*, *Aedes aegypti* and *Culex quinquefasciatus*. Bioresour Technol 2005;96:1749-57.
73. Govindarajan M. Larvicidal and repellent properties of some essential oils against *Culex tritaeniorhynchus* giles and *Anopheles subpictus* grassi (Diptera: Culicidae). Asian Pac J Trop Med 2011;4:106-11.
74. Jain S, Sangma T, Shukla SK, Mediratta PK. Effect of *Cinnamomum zeylanicum* extract on scopolamine-induced cognitive impairment and oxidative stress in rats. Nutr Neurosci 2015;18:210-6.
75. Madhavadas S, Subramanian S. Cognition enhancing effect of the aqueous extract of *Cinnamomum zeylanicum* on non-transgenic Alzheimer's disease rat model: biochemical, histological, and behavioural studies. Nutr Neurosci 2016;16:1-12.
76. Modaresi M, Mesripour M, Rajaii R. P879 Effect of cinnamon (*Cinnamomum zeylanicum*) on reproductive system in male mice. Int J Gynecol Obstet 2009;107 Suppl 2:S662.
77. Uragoda CG. Asthma and other symptoms in cinnamon workers. Br J Ind Med 1984;41:224-7.
78. Kandhare AD, Bodhankar SL, Singh V, Mohan V, Thakurdesai PA. Anti-asthmatic effects of type-A procyanidine polyphenols from cinnamon bark in ovalbumin-induced airway hyperresponsiveness in laboratory animals. Biomed Aging Pathol 2013;3:23-30.
79. Arzi A, Sarkaki A, Najad SS, Nazari Z, Aghel N. Analgesic effect of hydroalcoholic extract of *Cinnamomum Zeylanicum* in rat by formalin test. Toxicol Lett 2011;205 Suppl:S83-4.
80. Rafatullah S, Alqasoumi S, Al-Dosary M, Al-Yahya M, Al-Mofleh I. Gastroprotective effect of a popular spice cinnamon "*Cinnamomum zeylanicum*" in rats. Eur J Pharmacol 2011;668 Suppl 1:e42.
81. Hanifah AL, Ming HT, Narainasamy VV, Yusoff AT. Laboratory evaluation of six crude plant extracts as repellents against larval *Leptotrombidium deliense* (Acari: Trombiculidae). Asian Pacific J Trop Biomed 2012;2 Suppl 1:S257-9.
82. Rasheed MU, Thajuddin N. Effect of medicinal plants on *Moraxella cattarhalis*. Asian Pacific J Trop Med 2011;4:133-6.
83. Smitha SL, Gopchandran KG. Surface enhanced raman scattering, antibacterial and antifungal active triangular gold nanoparticles. Spectrochim Acta Part A 2013;102:114-9.
84. Özcan MM, Arslan D. Antioxidant effect of essential oils of rosemary, clove and cinnamon on hazelnut and poppy oils. Food Chem 2011;129:171-4.
85. Mancini-Filho J, Van-Koiij A, Mancini DA, Cozzolino FF, Torres RP. Antioxidant activity of cinnamon (*Cinnamomum Zeylanicum* Breyne) extracts. Boll Chim Farm 1998;137:443-7.
86. Misharina TA, Terenina MB, Krikunova NI. Antioxidant properties of essential oils. Prikl Biokhim Mikrobiol 2009;45:710-6.
87. Atta AH, Alkofahi A. Anti-nociceptive and anti-inflammatory effects of some Jordanian medicinal plant extracts. J Ethnopharmacol 1998;60:117-24.
88. Vetal S, Bodhankar SL, Mohan V, Thakurdesai PA. Anti-inflammatory and anti-arthritic activity of type-A procyanidine polyphenols from bark of *Cinnamomum zeylanicum* in rats. Food Sci Human Wellness 2013;2:59-67.
89. Magistrelli A, Chezem JC. Effect of ground cinnamon on postprandial blood glucose concentration in normal-weight and obese adults. J Acad Nutr Dietetics 2012;112:1806-9.
90. Verspohl EJ, Bauer K, Neddermann E. Antidiabetic effect of Cinnamomum cassia and *Cinnamomum zeylanicum in vivo* and *in vitro*. Phytother Res 2005;19:203-6.
91. Subash Babu P, Prabuseenivasan S, Ignacimuthu S. Cinnamaldehyde--a potential antidiabetic agent. Phytomedicine 2007;14:15-22.
92. Anand P, Murali KY, Tandon V, Murthy PS, Chandra R. Insulinotropic effect of cinnamaldehyde on transcriptional regulation of pyruvate kinase, phosphoenolpyruvate carboxykinase, and GLUT4 translocation in experimental diabetic rats. Chem Biol Interact 2010;186:72-81.
93. IM K, Issac A, NM J, Ninan E, Maliakel B, Kuttan R. Effects of the polyphenol content on the anti-diabetic activity of *Cinnamomum zeylanicum* extracts. Food Funct 2014;5:2208-20.
94. Ungsurungsie M, Suthienkul O, Paovalo C. Mutagenicity screening of popular thai spices. Food Chem Toxicol 1982;20:527-30.
95. Ungsurungsie M, Paovalo C, Noonai A. Mutagenicity of extracts from ceylon cinnamon in the rec assay. Food Chem Toxicol 1984;22:109-12.
96. Tsuji-Naito K. Aldehydic components of Cinnamon bark extract suppresses RANKL-induced osteoclastogenesis through NFATc1 downregulation. Bioorg Med Chem 2008;16:9176-83.
97. Jayaprakasha GK, Negi PS, Jena BS, Jagan Mohan Rao L. Antioxidant and antimutagenic activities of *Cinnamomum zeylanicum* fruit extracts. J Food Compos Anal 2007;20:330-6.
98. Jia Q, Liu X, Wu X, Wang R, Hu X, Li Y, *et al.* Hypoglycemic activity of a polyphenolic oligomer-rich extract of *Cinnamomum parthenoxylon* bark in normal and streptozotocin-induced diabetic rats. Phytomedicine 2009;16:744-50.
99. Adfa M, Rahmad R, Ninomiya M, Yudha SS, Tanaka K, Koketsu M. Antileukemic activity of lignans and phenylpropanoids of *Cinnamomum parthenoxylon*. Bioorg Med Chem Lett 2016;26:761-4.
100. Liu YK, Chen KH, Leu YL, Way TD, Wang LW, Chen YJ, *et al.* Ethanol extracts of *Cinnamomum kanehirai* Hayata leaves induce apoptosis in human hepatoma cell through caspase-3 cascade. Onco Targets Ther 2014;8:99-109.
101. Yeh R, Shiu Y, Shei S, Cheng S, Huang S, Lin J, *et al.* Evaluation of the antibacterial activity of leaf and twig extracts of stout camphor tree, *Cinnamomum kanehirae*, and the effects on immunity and disease resistance of white shrimp, Litopenaeus vannamei. Fish Shellfish Immunol 2009;27:26-32.
102. Chang WL, Cheng FC, Wang SP, Chou ST, Shih Y. Cinnamomum cassia essential oil and its major constituent cinnamaldehyde induced cell cycle arrest and apoptosis in human oral squamous cell carcinoma HSC-3 cells. Environ Toxicol 2016. Doi:10.1002/tox.22250.
103. Ngoc TM, Nhiem NX, Khoi NM, Son DC, Hung TV, Van Kiem P. A new coumarin and cytotoxic activities of constituents from *Cinnamomum cassia*. Nat Prod Commun 2014;9:487-8.
104. Jang H, Chang K, Huang Y, Hsu C, Lee S, Su M. Principal phenolic phytochemicals and antioxidant activities of three Chinese medicinal plants. Food Chem 2007;103:749-56.
105. Luo H, Lin S, Ren F, Wu L, Chen L, Sun Y. Antioxidant and antimicrobial capacity of Chinese medicinal herb extracts in raw sheep meat. J Food Prot 2007;70:1440-5.
106. Kim SH, Hyun SH, Choung SY. Antioxidative effects of *Cinnamomi cassiae* and *Rhodiola rosea* extracts in liver of diabetic mice. BioFactors 2006;26:209-19.
107. Miyamura M, Nohara T, Tomimatsu T, Nishiokat I. Seven aromatic compounds from bark of *Cinnamomum cassia*. Phytochemistry 1983;22:215-8.
108. Sharma N, Trikha P, Athar M, Raisuddin S. Inhibition of benzo[a]pyrene-and cyclophoshamide-induced mutagenicity by *Cinnamomum cassia*. Mutation Res/Fundamental Mol Mechanisms Mutagenesis 2001;480–481:179-88.
109. Kim EC, Kim HJ, Kim TJ. Water extract of *Cinnamomum cassia* suppresses angiogenesis through inhibition of VEGF receptor 2 phosphorylation. Biosci Biotechnol Biochem 2015;79:617-24.
110. Oussalah M, Caillet S, Saucier L, Lacroix M. Antimicrobial effects of selected plant essential oils on the growth of a *Pseudomonas putida* strain isolated from meat. Meat Sci 2006;73:236-44.
111. Oussalah M, Caillet S, Saucier L, Lacroix M. Inhibitory effects of selected plant essential oils on the growth of four pathogenic bacteria: *E. coli* O157:H7, *Salmonella Typhimurium*, *Staphylococcus aureus* and *Listeria monocytogenes*. Food Control 2007;18:414-20.
112. Alzoreky NS, Nakahara K. Antibacterial activity of extracts from some edible plants commonly consumed in Asia. Int J Food Microbiol 2003;80:223-30.
113. Arnal-Schnebelen B, Hadji-Minaglou F, Peroteau J, Ribeyre F, de Billerbeck VG. Essential oils in infectious gynaecological

disease: a statistical study of 658 cases. Int J Aromather 2004;14:192-7.
114. Sharma A, Chandraker S, Patel VK, Ramteke P. Antibacterial activity of medicinal plants against pathogens causing complicated urinary tract infections. Indian J Pharm Sci 2009;71:136-9.
115. Ooi LS, Li Y, Kam SL, Wang H, Wong EY, Ooi VE. Antimicrobial activities of cinnamon oil and cinnamaldehyde from the Chinese medicinal herb *Cinnamomum cassia* Blume. Am J Chin Med 2006;34:511-22.
116. Mau J, Chen C, Hsieh P. Antimicrobial effect of extracts from Chinese chive, cinnamon, and corni fructus. J Agric Food Chem 2001;49:183-8.
117. Turgis M, Vu KD, Dupont C, Lacroix M. Combined antimicrobial effect of essential oils and bacteriocins against foodborne pathogens and food spoilage bacteria. Food Res Int 2012;48:696-702.
118. Lee S, Chang K, Su M, Huang Y, Jang H. Effects of some Chinese medicinal plant extracts on five different fungi. Food Control 2007;18:1547-54.
119. Atanda OO, Akpan I, Oluwafemi F. The potential of some spice essential oils in the control of A. parasiticus CFR 223 and aflatoxin production. Food Control 2007;18:601-7.
120. Zhao X, Zhu JX, Mo SF, Pan Y, Kong LD. Effects of cassia oil on serum and hepatic uric acid levels in oxonate-induced mice and xanthine dehydrogenase and xanthine oxidase activities in mouse liver. J Ethnopharmacol 2006;103:357-65.
121. Rad SK, Kanthimathi MS, Abd Malek SN, Lee GS, Looi CY, Wong WF. *Cinnamomum cassia* suppresses caspase-9 through stimulation of AKT1 in MCF-7 cells but not in MDA-MB-231 Cells. PLoS One 2015;10:e0145216.
122. Koh WS, Yoon SY, Kwon BM, Jeong TC, Nam KS, Han MY. Cinnamaldehyde inhibits lymphocyte proliferation and modulates T-cell differentiation. Int J Immunopharmacol 1998;20:643-60.
123. Hwang H, Jeon H, Ock J, Hong SH, Han Y, Kwon B, *et al.* 2′-Hydroxycinnamaldehyde targets low-density lipoprotein receptor-related protein-1 to inhibit lipopolysaccharide-induced microglial activation. J Neuroimmunol 2011; 230:52-64.
124. Ka H, Park H, Jung H, Choi J, Cho K, Ha J, *et al.* Cinnamaldehyde induces apoptosis by ROS-mediated mitochondrial permeability transition in human promyelocytic leukemia HL-60 cells. Cancer Lett 2003;196:143-52.
125. Yeh CF, Chang JS, Wang KC, Shieh DE, Chiang LC. Water extract of *Cinnamomum cassia* Blume inhibited human respiratory syncytial virus by preventing viral attachment, internalization, and syncytium formation. J Ethnopharmacol 2013;147:321-6.
126. Ng LT, Wu SJ. Antiproliferative activity of *Cinnamomum cassia* constituents and effects of pifithrin-alpha on their apoptotic signaling pathways in Hep G2 cells. J Evidence-Based Complementary Altern Med 2011. Doi:10.1093/ecam/nep220.
127. 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;10:210.
128. Lin CC, Wu SJ, Chang CH, Ng LT. Antioxidant activity of *Cinnamomum cassia*. Phytother Res 2003;17:726-30.
129. Kumar U, Mishra M, Prakash V. Assessment of antioxidant enzymes and free radical scavenging activity of selected medicinal plants. Free Radicals Antioxid 2012;2:58-63.
130. Patra K, Bose S, Sarkar S, Rakshit J, Jana S, Mukherjee A, *et al.* Amelioration of cyclophosphamide induced myelosuppression and oxidative stress by cinnamic acid. Chem Biol Interact 2012;195:231-9.
131. Tanaka S, Yoon YH, Fukui H, Tabata M, Akira T, Okano K, *et al.* Antiulcerogenic compounds isolated from Chinese cinnamon. Planta Med 1989;55:245-8.
132. Bradley R, Oberg EB, Calabrese C, Standish LJ. Algorithm for complementary and alternative medicine practice and research in type 2 diabetes. J Alternative Complementary Med 2007;13:159-75.
133. Kim SH, Hyun SH, Choung SY. Anti-diabetic effect of cinnamon extract on blood glucose in db/db mice. J Ethnopharmacol 2006;104:119-23.
134. Jitomir J, Willoughby DS. *Cassia cinnamon* for the attenuation of glucose intolerance and insulin resistance resulting from sleep loss. J Med Food 2009;12:467-72.
135. Anderson RA. Chromium and polyphenols from cinnamon improve insulin sensitivity. Proc Nutr Soc 2008;67:48-53.
136. Lu Z, Jia Q, Wang R, Wu X, Wu Y, Huang C, *et al.* Hypoglycemic activities of A-and B-type procyanidin oligomer-rich extracts from different Cinnamon barks. Phytomedicine 2011;18:298-302.
137. He K, Li X, Chen X, Ye X, Huang J, Jin Y, *et al.* Evaluation of antidiabetic potential of selected traditional Chinese medicines in STZ-induced diabetic mice. J Ethnopharmacol 2011;137:1135-42.
138. Chen G, Lu F, Xu L, Dong H, Yi P, Wang F, *et al.* The anti-diabetic effects and pharmacokinetic profiles of berberine in mice treated with Jiao-Tai-Wan and its compatibility. Phytomedicine 2013;20:780-6.
139. Kim SH, Choung SY. Antihyperglycemic and antihyperlipidemic action of *Cinnamomi Cassiae* (Cinnamon bark) extract in C57BL/Ks db/db mice. Arch Pharm Res 2010;33:325-33.
140. Moon E, Lee M, Wang A, Lee J, Kim H, Kim H, *et al.* Delayed occurrence of H-ras12V-induced hepatocellular carcinoma with long-term treatment with cinnamaldehydes. Eur J Pharmacol 2006;530:270-5.
141. Hong SH, Kim J, Kim J, Lee S, Shin D, Son K, *et al.* Apoptosis induction of ′2 -hydroxycinnamaldehyde as a proteasome inhibitor is associated with ER stress and mitochondrial perturbation in cancer cells. Biochem Pharmacol 2007;74:557-65.
142. Lee CW, Lee SH, Lee JW, Ban JO, Lee SY, Yoo HS, *et al*. 2-hydroxycinnamaldehyde inhibits SW620 colon cancer cell growth through AP-1 inactivation. J Pharmacol Sci 2007;104:19-28.
143. Nohara T, Kashiwada Y, Nishioka I. Cinncassiol E, A diterpene from the bark of *Cinnamomum cassia*. Phytochemistry 1985;24:1849-50.
144. Nohara T, Kashiwada Y, Tomimatsu T, Nishioka I. Two novel diterpenes from bark of *Cinnamomum cassia*. Phytochemistry 1982;21:2130-2.
145. Sung Y, Yoon T, Jang JY, Park S, Jeong G, Kim HK. Inhibitory effects of *Cinnamomum cassia* extract on atopic dermatitis-like skin lesions induced by mite antigen in NC/Nga mice. J Ethnopharmacol 2011;133:621-8.
146. Wang S, Lin L, Chen C, Lee S, Lin C, Wang J, *et al.* Xiao-qing-long-tang attenuates allergic airway inflammation and remodeling in repetitive dermatogoides pteronyssinus challenged chronic asthmatic mice model. J Ethnopharmacol 2012;142:531-8.
147. Liao B, Hsieh C, Liu Y, Tzeng T, Sun Y, Wung B. Cinnamaldehyde inhibits the tumor necrosis factor-α-induced expression of cell adhesion molecules in endothelial cells by suppressing NF-κB activation: effects upon IκB and Nrf2. Toxicol Appl Pharmacol 2008;229:161-71.
148. Hong CH, Hur SK, Oh O, Kim SS, Nam KA, Lee SK. Evaluation of natural products on inhibition of inducible cyclooxygenase (COX-2) and nitric oxide synthase (iNOS) in cultured mouse macrophage cells. J Ethnopharmacol 2002;83:153-9.
149. Reddy AM, Seo JH, Ryu SY, Kim YS, Kim YS, Min KR, *et al*. Cinnamaldehyde and 2-methoxycinnamaldehyde as NF-kappaB inhibitors from *Cinnamomum cassia*. Planta Med 2004;70:823-7.
150. Yu T, Lee S, Yang WS, Jang H, Lee YJ, Kim TW, *et al.* The ability of an ethanol extract of Cinnamomum cassia to inhibit Src and spleen tyrosine kinase activity contributes to its anti-inflammatory action. J Ethnopharmacol 2012;139:566-73.
151. Hwa JS, Jin YC, Lee YS, Ko YS, Kim YM, Shi LY, *et al.* 2-Methoxycinnamaldehyde from *Cinnamomum cassia* reduces rat myocardial ischemia and reperfusion injury *in vivo* due to HO-1 induction. J Ethnopharmacol 2012;139:605-15.
152. Zaidi SF, Muhammad JS, Shahryar S, Usmanghani K, Gilani A, Jafri W, *et al.* Anti-inflammatory and cytoprotective effects of selected Pakistani medicinal plants in *Helicobacter pylori*-

infected gastric epithelial cells. J Ethnopharmacol 2012; 141:403-10.
153. Kurokawa M, Kumeda CA, Yamamura J, Kamiyama T, Shiraki K. Antipyretic activity of cinnamyl derivatives and related compounds in influenza virus-infected mice. Eur J Pharmacol 1998;348:45-51.
154. Lee SH, Lee SY, Son DJ, Lee H, Yoo HS, Song S, *et al.* Inhibitory effect of 2′-hydroxycinnamaldehyde on nitric oxide production through inhibition of NF-κB activation in RAW 264.7 cells. Biochem Pharmacol 2005;69:791-9.
155. Ha K, Kim J, Kang S, Kim D, Lee Y, Kim H, *et al.* Inhibitory effect of sihoga–yonggol–moryo–tang on matrix metalloproteinase-2 and-9 activities and invasiveness potential of hepatocellular carcinoma. Pharmacol Res 2004;50:279-85.
156. Iwaoka Y, Hashimoto R, Koizumi H, Yu J, Okabe T. Selective stimulation by cinnamaldehyde of progesterone secretion in human adrenal cells. Life Sci 2010;86:894-8.
157. Yan YM, Fang P, Yang MT, Li N, Lu Q, Cheng YX. Anti-diabetic nephropathy compounds from *Cinnamomum cassia*. J Ethnopharmacol 2015;165:141-7.
158. Kim S, Roh J, Kim D, Lee H, Ahn Y. Insecticidal activities of aromatic plant extracts and essential oils against *Sitophilus oryzae* and *Callosobruchus chinensis*. J Stored Prod Res 2003;39:293-303.
159. Kim S, Park C, Ohh M, Cho H, Ahn Y. Contact and fumigant activities of aromatic plant extracts and essential oils against *Lasioderma serricorne* (Coleoptera: Anobiidae). J Stored Prod Res 2003;39:11-9.
160. Zeng J, Xue Y, Shu P, Qian H, Sa R, Xiang M, *et al.* Diterpenoids with Immunosuppressive activities from *Cinnamomum cassia*. J Nat Prod 2014;77:1948-54.
161. He S, Zeng KW, Jiang Y, Tu PF. Nitric oxide inhibitory constituents from the barks of *Cinnamomum cassia*. Fitoterapia 2016;112:153-60.
162. Kang BH, Racicot K, Pilkenton SJ, Apostolidis E. Evaluation of the *in vitro* anti-hyperglycemic effect of *Cinnamomum cassia* derived phenolic phytochemicals, via carbohydrate hydrolyzing enzyme inhibition. Plant Foods Hum Nutr 2014;69:155-60.
163. Chen L, Yang Y, Yuan P, Yang Y, Chen K, Jia Q, *et al.* Immunosuppressive effects of A-type procyanidin oligomers from *Cinnamomum tamala*. J Evidence-Based Complementary Altern Med 2014. Doi:10.1155/2014/365258
164. Kim H, Park S, Park H. Inactivation of *Escherichia coli* O157:H7 by cinnamic aldehyde purified from *Cinnamomum cassia* shoot. Food Microbiol 2004;21:105-10.
165. de Oliveira MMM, Brugnera DF, do Nascimento JA, Piccoli RH. Control of planktonic and sessile bacterial cells by essential oils. Food Bioprod Process 2012;90:809-18.
166. Kim IG, Kang SC, Kim KC, Choung ES, Zee OP. Screening of estrogenic and antiestrogenic activities from medicinal plants. Environ Toxicol Pharmacol 2008;25:75-82.
167. Shinobu S, Hideki K, Tohru K, Katsuhiko K, Noriyuki K, Shuji S, *et al.* Effects of a Chinese herbal medicine, Keishi-bukuryogan, on the gonadal system of rats. J Ethnopharmacol 1988;23:151-8.
168. Yu H, Lee S, Jang C. Involvement of 5-HT1A and GABAA receptors in the anxiolytic-like effects of cinnamomum cassia in mice. Pharmacol Biochem Behav 2007;87:164-70.
169. Jung Y, Kwon S, Hong S, Lee S, Kim S, Lee S, *et al.* 5-HT1A receptor binding in the dorsal raphe nucleus is implicated in the anxiolytic-like effects of *Cinnamomum cassia*. Pharmacol Biochem Behav 2012;103:367-72.
170. Choi D, Baek Y, Huh J, Ko J, Woo H, Lee J, *et al.* Stimulatory effect of *Cinnamomum cassia* and cinnamic acid on angiogenesis through up-regulation of VEGF and Flk-1/KDR expression. Int Immunopharmacol 2009;9:959-67.
171. Shan BE, Yoshida Y, Sugiura T, Yamashita U. Stimulating activity of Chinese medicinal herbs on human lymphocytes *in vitro*. Int J Immunopharmacol 1999;21:149-59.
172. Seo U, Lee Y, Kim J, Cha B, Kim D, Nam K, *et al.* Large-scale and effective screening of Korean medicinal plants for inhibitory activity on matrix metalloproteinase-9. J Ethnopharmacol 2005;97:101-6.
173. Hong CH, Hur SK, Oh O, Kim SS, Nam KA, Lee SK. Evaluation of natural products on inhibition of inducible cyclooxygenase (COX-2) and nitric oxide synthase (iNOS) in cultured mouse macrophage cells. J Ethnopharmacol 2002;83:153-9.
174. Ngoc TM, Khoi NM, Ha DT, Nhiem NX, Tai BH, Don DV, *et al.* Xanthine oxidase inhibitory activity of constituents of *Cinnamomum cassia* twigs. Bioorg Med Chem Lett 2012;22:4625-8.
175. Lirussi D, Li J, Prieto JM, Gennari M, Buschiazzo H, Ríos JL, *et al.* Inhibition of *Trypanosoma cruzi* by plant extracts used in Chinese medicine. Fitoterapia 2004;75:718-23.
176. Kong LD, Cai Y, Huang WW, Cheng CHK, Tan RX. Inhibition of xanthine oxidase by some Chinese medicinal plants used to treat gout. J Ethnopharmacol 2000;73:199-207.
177. Eswaran MB, Surendran S, Vijayakumar M, Ojha SK, Rawat AKS, Rao CV. Gastroprotective activity of *Cinnamomum tamala* leaves on experimental gastric ulcers in rats. J Ethnopharmacol 2010;128:537-40.
178. Rao CV, Vijayakumar M, Sairam K, Kumar V. Antidiarrhoeal activity of the standardised extract of *Cinnamomum tamala* in experimental rats. J Nat Med 2008;62:396-402.
179. Kar A, Choudhary BK, Bandyopadhyay NG. Comparative evaluation of hypoglycaemic activity of some Indian medicinal plants in alloxan diabetic rats. J Ethnopharmacol 2003;84:105-8.
180. Reynertson KA, Balick MJ, Lee R, Raynor W, Pelep Y, Kennelly EJ. A traditional method of *Cinnamomum carolinense* preparation eliminates safrole from a therapeutic Pohnpean tea. J Ethnopharmacol 2005;102:269-74.
181. Wu T, Leu Y, Chan Y, Yu S, Teng C, Su J. Lignans and an aromatic acid from Cinnamomum philippinense. Phytochemistry 1994;36:785-8.
182. Yu S, Ko F, Wu T, Lee J, Teng C. Cinnamophilin, a novel thromboxane A2 receptor antagonist, isolated from *Cinnamomum philippinense*. Eur J Pharmacol 1994;256:85-91.
183. Lin C, Chen C, Lin T, Tung JC, Wang S. Anti-inflammation activity of fruit essential oil from *Cinnamomum insularimontanum* Hayata. Bioresour Technol 2008;99:8783-7.
184. Hsieh TJ, Liu TZ, Lu FJ, Hsieh PY, Chen CH. Actinodaphnine induces apoptosis through increased nitric oxide, reactive oxygen species and down-regulation of NF-kappaB signaling in human hepatoma Mahlavu cells. Food Chem Toxicol 2006;44:344-54.
185. Azeredo CM, Santos TG, Maia BH, Soares MJ. *In vitro* biological evaluation of eight different essential oils against Trypanosoma cruzi, with emphasis on *Cinnamomum verum* essential oil. BMC Complementary Altern Med 2014;14:309.
186. Ramshini H, Ebrahim-Habibi A, Aryanejad S, Rad A. Effect of *Cinnamomum Verum* extract on the amyloid formation of hen egg-white lysozyme and study of its possible role in alzheimer's disease. Basic Clin Neurosci 2015;6:29-37.
187. Mathew S, Abraham TE. *In vitro* antioxidant activity and scavenging effects of *Cinnamomum verum* leaf extract assayed by different methodologies. Food Chem Toxicol 2006;44:198-206.
188. Mathew S, Abraham TE. Studies on the antioxidant activities of cinnamon (*Cinnamomum verum*) bark extracts, through various *in vitro* models. Food Chem 2006;94:520-8.
189. Mehdipour Z, Afsharmanesh M, Sami M. Effects of dietary synbiotic and cinnamon (Cinnamomum verum) supplementation on growth performance and meat quality in Japanese quail. Livestock Sci 2013;154:152-7.
190. Otter JA, Havill NL, Boyce JM. Evaluation of real-time polymerase chain reaction for the detection of methicillin-resistant *Staphylococcus aureus* on environmental surfaces. Infection Control Hospital Epidemiol 2007;28:1003-5.
191. Hersch-Martínez P, Leaños-Miranda BE, Solórzano-Santos F. Antibacterial effects of commercial essential oils over locally prevalent pathogenic strains in Mexico. Fitoterapia 2005;76:453-7.
192. Macheboeuf D, Morgavi DP, Papon Y, Mousset J, Arturo-Schaan M. Dose–response effects of essential oils on *in vitro* fermentation activity of the rumen microbial population. Anim Feed Sci Technol 2008;145:335-50.
193. Khan MSA, Ahmad I. *In vitro* antifungal, anti-elastase and anti-keratinase activity of essential oils of *Cinnamomum*-, *Syzygium*- and *Cymbopogon*-species against *Aspergillus fumigatus* and *Trichophyton rubrum*. Phytomedicine 2011;19:48-55.

194. Pandey M, Chandra DR. Evaluation of ethanol and aqueous extracts of *Cinnamomum verum* Leaf galls for potential antioxidant and analgesic activity. Indian J Pharm Sci 2015;77:243-7.
195. Regnault-Roger C, Hamraoui A. Inhibition of reproduction of *Acanthoscelides obtectus* Say (Coleoptera), a kidney bean (Phaseolus vulgaris) bruchid, by aromatic essential oils. Crop Protection 1994;13:624-8.
196. Magro A, Carolino M, Bastos M, Mexia A. Efficacy of plant extracts against stored products fungi. Rev Iberoamericana Micología 2006;23:176-8.
197. Pandey A, Chattopadhyay P, Banerjee S, Pakshirajan K, Singh L. Antitermitic activity of plant essential oils and their major constituents against termite *Odontotermes assamensis* Holmgren (Isoptera: Termitidae) of North East India. Int Biodeterior Biodegrad 2012;75:63-7.
198. Choi HM, Jung Y, Park J, Kim HL, Youn DH, Kang J, *et al. Cinnamomi Cortex* (*Cinnamomum verum*) suppresses testosterone-induced benign prostatic hyperplasia by regulating 5alpha-reductase. Sci Rep 2016;6:31906.
199. Liu YH, Tsai KD, Yang SM, Wong HY, Chen TW, Cherng J, *et al. Cinnamomum verum* ingredient 2-methoxycinnamaldehyde: a new antiproliferative drug targeting topoisomerase I and II in human lung squamous cell carcinoma NCI-H520 cells. Eur J Cancer Prev 2016. Doi:10.1097/CEJ.0000000000000265.
200. Perng DS, Tsai YH, Cherng J, Kuo CW, Shiao CC, Cherng JM. Discovery of a novel anti-cancer agent targeting both topoisomerase I and II in hepatocellular carcinoma Hep 3B cells *in vitro* and *in vivo*: Cinnamomum verum component 2-methoxycinnamaldehyde. J Drug Target 2016;24:624-34.
201. Perng DS, Tsai YH, Cherng J, Wang JS, Chou KS, Shih CW, *et al.* Discovery of a novel anticancer agent with both anti-topoisomerase I and II activities in hepatocellular carcinoma SK-Hep-1 cells *in vitro* and *in vivo*: *Cinnamomum verum* component 2-methoxycinnamaldehyde. Drug Des Dev Ther 2016;10:141-53.
202. Tsai KD, Cherng J, Liu YH, Chen TW, Wong HY, Yang SM, *et al. Cinnamomum verum* component 2-methoxycinnamaldehyde: a novel antiproliferative drug inducing cell death through targeting both topoisomerase I and II in human colorectal adenocarcinoma COLO 205 cells. Food Nutr Res 2016;60:31607.
203. Wong HY, Tsai KD, Liu YH, Yang SM, Chen TW, Cherng J, *et al. Cinnamomum verum* component 2-methoxycinnamaldehyde: a novel anticancer agent with both anti-topoisomerase I and II activities in human lung adenocarcinoma A549 cells *In vitro* and *in vivo*. Phytother Res 2016;30:331-40.
204. Dhuley JN. Anti-oxidant effects of cinnamon (*Cinnamomum verum*) bark and greater cardamom (*Amomum subulatum*) seeds in rats fed high fat diet. Indian J Exp Biol 1999;37:238-42.
205. Shori AB, Baba AS. *Cinnamomum verum* improved the functional properties of bioyogurts made from camel and cow milks. J Saudi Soc Agric Sci 2011;10:101-7.
206. Shori AB, Baba AS. Viability of lactic acid bacteria and sensory evaluation in *Cinnamomum verum* and *Allium sativum*-bio-yogurts made from camel and cow milk. J Assoc Arab Univ Basic Appl Sci 2012;11:50-5.
207. Chen TW, Tsai KD, Yang SM, Wong HY, Liu YH, Cherng J, *et al.* Discovery of a novel anti-cancer agent targeting both topoisomerase I and II as well as telomerase activities in human lung adenocarcinoma A549 cells *in vitro* and *in vivo*: *cinnamomum verum* component cuminaldehyde. Curr Cancer Drug Targets 2016;16:796-806.
208. Tsai KD, Liu YH, Chen TW, Yang SM, Wong HY, Cherng J, *et al.* Cuminaldehyde from *Cinnamomum verum* induces cell death through targeting topoisomerase 1 and 2 in human colorectal adenocarcinoma COLO 205 cells. Nutrients 2016;8:E318.
209. Yang SM, Tsai KD, Wong HY, Liu YH, Chen TW, Cherng J, *et al.* Molecular mechanism of *Cinnamomum verum* component cuminaldehyde inhibits cell growth and induces cell death in human lung squamous cell carcinoma NCI-H520 cells *in vitro* and *in vivo*. J Cancer 2016;7:251-61.
210. Williams AR, Ramsay A, Hansen TV, Ropiak HM, Mejer H, Nejsum P, *et al.* Anthelmintic activity of trans-cinnamaldehyde and A-and B-type proanthocyanidins derived from cinnamon (*Cinnamomum verum*). Sci Rep 2015;5:14791.
211. Kim CR, Choi SJ, Kwon YK, Kim JK, Kim YJ, Park GG, *et al. Cinnamomum loureirii* extract inhibits acetylcholinesterase activity and ameliorates trimethyltin-induced cognitive dysfunction in mice. Biol Pharm Bull 2016;39:1130-6.
212. Chen C, Hsu Y, Chen Y, Hung J, Huang M, Kuo P. Isokotomolide A, a new butanolide extracted from the leaves of *Cinnamomum kotoense*, arrests cell cycle progression and induces apoptosis through the induction of p53/p21 and the initiation of mitochondrial system in human non-small cell lung cancer A549 cells. Eur J Pharmacol 2007;574:94-102.
213. Liu T, Cheng J, Yiin S, Chen C, Chen C, Wu M, *et al.* Isoobtusilactone a induces both caspase-dependent and-independent apoptosis in Hep G2 cells. Food Chem Toxicol 2008;46:321-7.
214. Kuo P, Chen C, Tzeng T, Lin C, Hsu Y. Involvement of reactive oxygen species/c-Jun NH2-terminal kinase pathway in kotomolide a induces apoptosis in human breast cancer cells. Toxicol Appl Pharmacol 2008;229:215-26.
215. Chen CY, Chen CH, Lo YC, Wu BN, Wang HM, Lo WL, *et al.* Anticancer activity of isoobtusilactone A from *Cinnamomum kotoense*: involvement of apoptosis, cell-cycle dysregulation, mitochondria regulation, and reactive oxygen species. J Nat Prod 2008;71:933-40.
216. Chen FC, Peng CF, Tsai IL, Chen IS. Antitubercular constituents from the stem wood of *Cinnamomum kotoense*. J Nat Prod 2005;68:1318-23.
217. Du YH, Feng RZ, Li Q, Wei Q, Yin ZQ, Zhou LJ, *et al.* Anti-inflammatory activity of leaf essential oil from *Cinnamomum longepaniculatum (*Gamble) N. Chao. Int J Clin Exp Med 2014;7:5612-20.
218. Li L, Li ZW, Yin ZQ, Wei Q, Jia RY, Zhou LJ, *et al.* Antibacterial activity of leaf essential oil and its constituents from *Cinnamomum longepaniculatum*. Int J Clin Exp Med 2014;7:1721-7.
219. Song X, Yin Z, Ye K, Wei Q, Jia R, Zhou L, *et al.* Anti-hepatoma effect of safrole from *Cinnamomum longepaniculatum* leaf essential oil *in vitro*. Int J Clin Exp Pathol 2014;7:2265-72.
220. Jantan I, Rafi IAA, Jalil J. Platelet-activating factor (PAF) receptor-binding antagonist activity of Malaysian medicinal plants. Phytomedicine 2005;12:88-92.
221. Wannissorn B, Jarikasem S, Siriwangchai T, Thubthimthed S. Antibacterial properties of essential oils from Thai medicinal plants. Fitoterapia 2005;76:233-6.
222. Horgen FD, Edrada RA, de los Reyes G, Agcaoili F, Madulid DA, Wongpanich V, *et al.* Biological screening of rain forest plot trees from Palawan Island (Philippines). Phytomedicine 2001;8:71-81.
223. Salleh WM, Ahmad F, Yen KH. Antioxidant and anticholinesterase activities of essential oils of *Cinnamomum griffithii* and *C. macrocarpum*. Nat Prod Commun 2015;10:1465-8.
224. Ikawati Z, Wahyuono S, Maeyama K. Screening of several Indonesian medicinal plants for their inhibitory effect on histamine release from RBL-2H3 cells. J Ethnopharmacol 2001;75:249-56.
225. Xue-jun Y, De-xiang L, Hechuan W, Yu Z. A study on the mutagenicity of 102 raw pharmaceuticals used in Chinese traditional medicine. Mutation Res/Genetic Toxicol 1991;260:73-82.
226. Huang Y, Ho SH. Toxicity and antifeedant activities of cinnamaldehyde against the grain storage insects, *Tribolium castaneum* (Herbst) and *Sitophilus zeamais* Motsch. J Stored Prod Res 1998;34:11-7.
227. Dhyani A, Arora N, Gaur SN, Jain VK, Sridhara S, Singh BP. Analysis of IgE binding proteins of mesquite (*Prosopis juliflora*) pollen and cross-reactivity with predominant tree pollens. Immunobiology 2006;211:733-40.
228. Sun X, Ye J. Effects of oil of *Cinnamomum migao* (CV-3) on isolated smooth muscles. Eur J Pharmacol 1990;183:554.
229. Jang H, Chang K, Huang Y, Hsu C, Lee S, Su M. Principal phenolic phytochemicals and antioxidant activities of three Chinese medicinal plants. Food Chem 2007;103:749-56.

230. Dong L, Schill H, Grange RL, Porzelle A, Johns JP, Parsons PG, *et al.* Anticancer agents from the Australian tropical rainforest: spiroacetals EBC-23, 24, 25, 72, 73, 75 and 76. Chemistry 2009;15:11307-18.
231. Liu C, Chen C, Huang A, Li J. Subamolide A, a component isolated from *Cinnamomum subavenium*, induces apoptosis mediated by mitochondria-dependent, p53 and ERK1/2 pathways in human urothelial carcinoma cell line NTUB1. J Ethnopharmacol 2011;137:503-11.
232. Tarak D, Namsa ND, Tangjang S, Arya SC, Rajbonshi B, Samal PK, *et al.* An inventory of the ethnobotanicals used as anti-diabetic by a rural community of Dhemaji district of Assam, Northeast India. J Ethnopharmacol 2011;138:345-50.
233. Prakash B, Singh P, Yadav S, Singh SC, Dubey NK. Safety profile assessment and efficacy of chemically characterized *Cinnamomum glaucescens* essential oil against storage fungi, insect, aflatoxin secretion and as antioxidant. Food Chem Toxicol 2013;53:160-7.
234. Tian J, Huang B, Luo X, Zeng H, Ban X, He J. The control of *Aspergillus flavus* with *Cinnamomum jensenianum* hand.-mazz essential oil and its potential use as a food preservative. Food Chem 2012;130:520-7.
235. Buru AS, Pichika MR, Neela V, Mohandas K. *In vitro* antibacterial effects of *Cinnamomum* extracts on common bacteria found in wound infections with emphasis on methicillin-resistant *Staphylococcus aureus*. J Ethnopharmacol 2014;153:587-95.
236. Masnon FF, Hassan NP, Ahmad F. Aporphine alkaloids of *Cinnamomum mollissimum* and their bioactivities. Nat Prod Commun 2014;9:31-2.

How to cite this article

- Madhu Katyayani Balijepalli, Ayuba Sunday Buru, Raghavendra Sakirolla, Mallikarjuna Rao Pichika. *Cinnamomum* genus: a review on its biological activities. Int J Pharm Pharm Sci 2017;9(2):1-11.