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Phytochemical constituents of bark essential oils of *Cinnamomum zeylanicum* Blume and effects on liver tissue of rats

1st Duaa Abd Alazem Amran
Department of Biology/ College of Science/ University of Basrah
Basrah/ Iraq
hanz9899@gmail.com

2nd Karim H. Al-Derawi
Department of Biology/ College of Science/ University of Basrah
Basrah/ Iraq
karimhalderawi59@gmail.com

3rd Sahar A. A. Malik Al-Saadi
Department of Biology/ College of Science/ University of Basrah
Basrah/ Iraq
saharmalik2010@gmail.com

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Abstract*— *Cinnamomum zeylanicum* Blume is an evergreen tropical tree belonging to the Lauraceae family; it is a useful plant in traditional and modern medicines. Essential oils of *Cinnamomum zeylanicum* were prepared and identified using gas chromatography–mass spectrometry (GC-MS). For histological study 80 adult male rats were employed in this study. It is the same weight (30 ±5 gm) and 75 days in age. The animals were divided into 4 groups, with ten rats in each group. The results indicated that *C. zeylanicum* bark contained 27 different phytochemical components. The main components included Cinnamaldehyde (2-Propenal, 3-phenyl-) (46.46%), 9-Methoxybicyclo, [6.1.0] nona-2,4,6-triene (31.31%), alpha-, Muurolene (7.14%) and Copaene (1.63%). Sections of livers were examined for histological abnormalities, such as the breakdown of the liver architecture and increased inflammation, in comparison to control samples, some hepatocytes were swollen with pyknotic, large nuclei and dilated sinusoids. As well as in the rats treated with noticed sever congestion of central vein (CV), degeneration and sluggish of endothelial lining larger, Bile ducts hyperplasia and necrotic hepatocytes. It can be deduced that the main component of cinnamon bark oil is cinnamaldehyde and the liver displayed some tissue changes, including hepatocyte necrosis and the existence of steatosis foci. Histological and cellular changes in liver tissue were dramatically attenuated by *C. zeylanicum* essential oil.

Keywords: **bark, *Cinnamomum zeylanicum*, essential oil, liver, rats.**

I. INTRODUCTION

Cinnamomum zeylanicum (common Cinnamon) is an evergreen tropical tree 50 m high belonging to the family Lauraceae. The bark of trees of *C. zeylanicum* is a useful plant in traditional and modern medicines. More than 100 species of the genus *Cinnamomum* are found throughout Asia. Australia, Vietnam, Madagascar, and Mexico. It is widely, cultivated in southern India and Sri Lanka [1,2].

Numerous health benefits of cinnamon have been suggested, including a reduction in triglycerides, LDL cholesterol, total cholesterol, anti-yeast activity [3], antibacterial, antifungal activity, insects [4,5,6,7,8], blood circulation improvement, anti-platelet aggregation, anti-inflammatory activity, Enhancing mental function, decreasing colon cancer risk, anti-Parkinson, anti-Alzheimer, anti-angiogenesis, anti-HIV-1 activity, anti-inflammatory qualities, antibacterial action, heart disease prevention, and blood sugar regulation. Furthermore, cinnamon's possess an ability to reduce inflammation and its primary ingredients in a different variety of tissues, such as the pancreas, liver, kidney, heart, and brain [9].

Essential oils extracted from plants have long been used to enhance the flavor of food and drink [10,11]. Oil from the bark of the cinnamon plant is typically utilized in food and drink. It is highly valuable in industry [12,13], Because of their positive health effects. Traditional plants are increasingly being used as supplemental medicines, including their ability to prevent diabetic mellitus and cardiovascular disease, as well as their anti-inflammatory and antioxidant properties [14,15]. It was discovered that in healthy adults, *Cinnamon burmannii* tea significantly decreased maximal glucose levels after meals and variance in maximum concentration [16].

There are numerous components.in Cinnamon such as Cinnamaldehyde, trans-cinnamaldehyde (Cin), and cinnamic acid, also known as aromatic aldehyde 3-phenyl-2(E)-propenal, are the three main components of cinnamon [17]. As well as eugenol, linalool, cinnamic acid, and *cinnamaldehyde* [18]. It has offered some health benefits include reducing blood glucose and analgesic properties, as well as antioxidant, anti-cholesterolemic, antibacterial, anti-inflammatory, anti-yeast, and anti-gastric ulcer properties [19]. Cinnamaldehyde was identified as the primary constituent of *Cinnamomum burmannii* oil (68.3%-82%), cinnamyl acetate (2.5%-16%), cinnamyl alcohol (2.25%-4.6%), and cinnamic acid (3%-8%) [20].

Several studies have reported that C. zeylanicum bark was rich in essential oil, while cinnamaldehyde is the main chemical compound that was isolated from *C. zeylanicum* bark [21,22,23,24]. Research showed that the *C. zeylanicum* contains thirty-eight components [4], Cinnamaldehyde was

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the major compound (68.41%), followed by benzaldehyde. [25] main constituents of the *C. zeylanicum* leaf are eugenol (79.75%), transcinnamaldehyde (16.25%), Linalool (0.14%), cinnamaldehyde (75 %), cinnamyl acetate (5%), and eugenol (1-10 %). [18] identified thirty essential oil compounds, including cinnamic acid, eugenol, linalool, and cinnamaldehyde. [26] investigated the essential oil from the bark of *C. zeylanicum* and its antibacterial, antioxidant, and antiproliferative properties, and found that the following constituents were present: (E)-cinnamaldehyde (71.50 %), linalool (7.00 %), β-caryophyllene, eucalyptol, and eugenol. Moreover, limonene, α-pinene, δ-cadinene, p-cymene, and α-humulene were important components. Other projectreported that the oil of cinnamon contains cinnamaldehyde (55- 76%), eugenol and safrole_[27]. The aim of the study identified chemical compounds in *C. zeylanicum* and assess the preventive properties of it against liver.

II. Materials and Methods

A. Plant material

This study was conducted in the Basrah University, Science College, Biology Department, Iraq. The GC-MS Chromatography carried at the Basrah University, Agriculture College of, Iraq..

B. Preparation of samples

The bark samples of *C. zeylanicum* were collected from the market of Basrah governorate. One hundred gram of the bark sample was washed with water, dried and ground in a grinder for 20 seconds. The small pieces were homogenized for 3 min to 40-mesh size. The air-dried sample of cinnamon was pulverized to get the powdered form [18].

C. Essential oils Extraction

A Clevenger apparatus was used to extract essential oils using water distillation for four hours at 100 °C, it was collected in sealed container to prevent any evaporation. Furthermore, Anhydrous sodium sulfate was used to dry the recovered oil, which was then placed in a dark glass container for analysis [28].

D. GC-MS analysis

GC-MS analysis was carried out by utilizing a Shimadzu GC-QP 2010 Ultra gas chromatograph. The temperature of the GC oven was set to rise at a rate of 4.3 °C per minute from 40 °C to 250 °C. The carrier gas was helium. The linear velocity was 48.1 cm/sec and the input pressure was 100.0 kPa. Column flow was 1.78 mL/min, Injector temperature: 250 °C; injection mode: split. MS scan conditions: source temperature, 200 °C; interface temperature, 250 °C; Detector Gain, 0.70 kV +0.10 kV; Scan speed, 1666 Start 50 m/z, End 800 m/z. The components of the Cinnamon oil were identified by comparing the spectra with those of known compounds stored in the NIST library (2005) (Figure 1-5).

E. The animals

In total, 80 adult male rats were employed in this study. They were in good health, approximately having the same weight (30 ±5 gm) and 75 days in age having cages with three animals in each group. at a temperature of 18-25 ºC under a 12 h dark–light cycle. The animals were left for one week before starting the treatments. The animals were divided into 4 groups, with ten rats in each group. First, distilled water was given orally to the control group. Diethyl ether was used to anesthetize the animals following each treatment, fixed liver was taken for sectioning. Experimental design was approved by College of Science/ Basrah University. Twenty male adults healthy Two groups of rats were created.: Group 1 represented Control rats (n= 10) no treatment and Group 2: The animals were dosed orally with a concentration of 50mg/kg atenolol for thirty days (n=10).

F. Preparation of tissues

Tissue samples were fixed in equivalent formaldehyde solution (10%), then washed with tap water. The samples were then dehydrated by being passed through serious of ethanol from 30% up to 100%. Xylene was then applied for 30-40 minutes to clear the samples from ethanol. The tissues were subjected to paraffin infiltration using melted paraffin wax inside the oven at 60 ºC for one hour. and the tissue samples were transferred from the oven inside these molds which were then cooled to room temperature. The tissue sections were stained by using hematoxylin for one minute then in alcoholic eosin 1% [29].

III. Results and Discission

A. Chemical composition of the essential oil

Essential oils extracted by hydro-distillation from *C. zeylanicum* bark are light yellow in color and have a pungent odor at room temperature. The essential oil content of the bark extract of *C. zeylanicum* was determined by GC-MS as summarized in (Table 1). The structures of the major compounds are shown in (Figure 1). The results that the existence of 27 components in C. zeylanicum is demonstrated by GC/MS. phytochemical constituents). The chemical components of *C. zeylanicum* bark are essential oil which include Cinnamaldehyde (2-Propenal, 3-phenyl-) 46 %, followed by 9-Methoxybicyclo[6.1.0]nona-2,4,6-triene (31.31%), alpha.-Muurolene (7.14%),. tau-Muurolol (1.34%) and Copaene (1.63%) (Table 1). Our results associated with some research by found eight compounds Cinnamaldehyde, (E)-, tau.-Muurolol, Cubenol, Copaene, Naphthalene, 1,2,3,5, 6, 8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-, Benzenepropanal, while we associated with [30] cinnamaldehyde (73.345%, Benzaldehyde, Borneol and Copaene. Our studied similar with Gotmare and Tambe (2019) three compounds cinnamaldehyde, Benzenepropanal and Benzaldehyde. Also found Trans-cinnamaldehyde (91.56%), cis-cinnamaldehyde (1.28%), eucalyptol (1.26%), Benzenepropanol (0.76%) ,α-Muurolene (0.62%) and α-Cubebene, some researchs indicates that the main constituent of cinnamon bark oil is cinnamonaldehyde, on contrast the primary constituent of cinnamon leaf oil is eugenol [2].

The principal compound of *C. zeylanicum* is called 2-Propenal, 3-phenyl-, cinnamaldehyde, trans-cinnamaldehyde (Cin), and cinnamic acid, Cinnamal and cinnamic aldehyde [17]. Numerous researchers concluded that cinnamaldehyde is the main chemical component of cinnamon oil [17,31], Our findings support [32] recollection that 49.9% of cinnamon barks are essential oil.

The percentage of Cinnamaldehyde differ between the researchers, [33] showed the percentage of Cinnamaldehyde (91.82%) in India. In Malysia [34] reported trans-

cinnamaldehyde (84.97%) and Borneol (1.03%). While [35] recorded Trans-cinnamaldehyde (87.013%) in Ethiopia. it is found (45.13% and 64.84%) in Egypt [36, 37]. [38] reported that E-cinnamaldehyde has 88.2%. B-phellandréne (1.19%), E-cinnamaldehyde (85.77%), Z-cinnamaldehyde (3.22%), linalool (3.70%), and Eugenol (0.48%) [39].

Researchers have different estimates of how many chemical components are present in cinnamon essential oil. It was 4% of the essential oil, which is predominantly composed of 60-75% cinnamaldehyde [24]. [4] reported that C. zeylanicum consists of 38 components, the majority components (68.41%) was Cinnamaldehyde, followed by benzaldehyde. While [33] discovered that cinnamaldehyde made up about 91.82% of the composition of cinnamon oil extract, with eight compounds having small percentage. Cinnamic aldehyde was discovered to be the primary component in the essential oil extract when GC-MS analysis of *C. zeylanicum* essential oil was performed [40]. Cinnamaldehyde content in C. zeylanicum extracted was 90% [28]. While [41] identified thirty compounds. Other constituents include cinnamyl acetate, cinnamyl alcohol, eugenol, linalool, cuminaldehyde, and pinene [42].

Climate, soil, harvest season, drying technique, storage conditions, and even the specific portion of the plant tissue are examples of environmental variables. The amount of essential oil in cinnamon species (*Cinnamomum burmannii*) differs between the tree age of plant [20]. Different agricultural dates, origins, vegetable states, plant growth seasons, and market storage conditions can all affect the composition of essential oils [43,44]. Although there were discrepancies between the present study and past studies in the number of essential oils, the analytical results were compatible with earlier publications [45]. This may be brought on by various cultivars and extraction techniques. It could be because the microwave's heating effect caused the essential oil's cinnamic aldehyde to change into 2-methoxycinnamaldehyde [30].

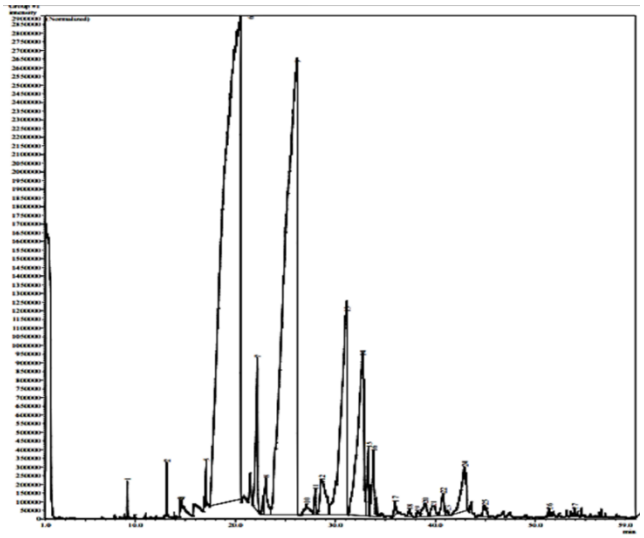

Figure (1) Chromatogram of essential oil of *C. zeylanicum* bark.

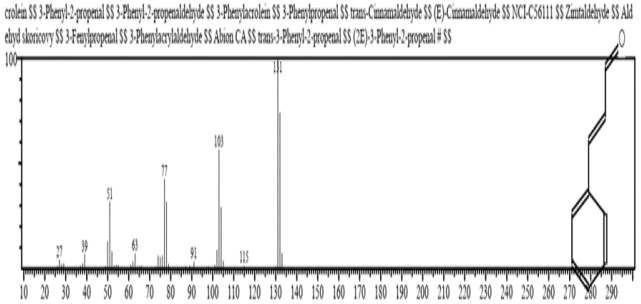

Figure (2): A typical gas chromatogram of the 2-Propenal, 3-phenyl-

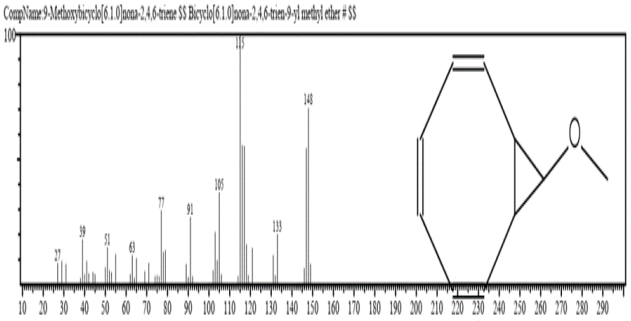

Figure (3): A typical gas chromatogram of the 9-Methoxybicyclo[6.1.0]nona-2,4,6-triene

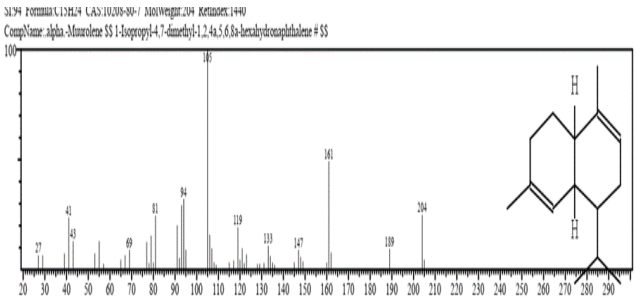

Figure (4): A typical gas chromatogram of the alpha.-Muurolene

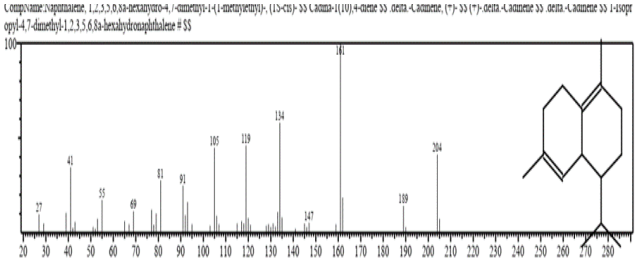

Figure (5): Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-

Table (1): Compounds Identified By Mass Spectrometry Gas Chromatography (Gc-Ms) In The Essential Oil Of *C. Zeylanicum* Bark.

Peak	Components	Retention Time	Area %
1	Benzaldehyde	9.194	0.10
2	Benzaldehyde dimethyl acetal	13.115	0.11
3	Benzenepropanal	14.455	0.04
4	Borneol	14.645	0.02
5	Cinnamaldehyde, (E)-	17.095	0.23
6	2-Propenal, 3-phenyl- or Cinnamal or cinnamaldehyde	20.506	46.46
7	Copaene	22.199	1.63
8	1,4-Methano-1H-indene, octahydro-4-methyl-8-methylene-7-(1-methylethyl)-, [1S-(1.al	23.055	0.57
9	9-Methoxybicyclo[6.1.0]nona-2,4,6-triene	26.155	31.31
10	2-Propenoic acid, 3-(2-hydroxyphenyl)-	27.105	0.29
11	2-Propen-1-ol, 3-phenyl-, acetate, (E)-	28.005	0.21
12	1-Naphthalenol, 1,2,3,4,4a,7,8,8a-octahydro-1,6-dimethyl-4-(1-methylethyl)-, [1R-(1.alp	28.633	1.18
13	.alpha.-Muurolene	31.155	7.14
14	Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-	32.729	5.95
15	Naphthalene, 1,2,3,4,4a,7-hexahydro-1,6-dimethyl-4-(1-methylethyl)-	33.315	0.69
16	Benzene, 1-methyl-4-[(1-methylethylidene)cyclopropyl]-	33.831	1.04
17	Caryophyllenyl alcohol	35.987	0.15
18	1-Hydroxy-1,7-dimethyl-4-isopropyl-2,7-cyclodecadiene	37.402	0.09
19	Illudol	38.155	0.09
20	Epiglobulol	38.954	0.32
21	Naphthalene, 1,2,3,5,6,8a-hexahydro-4,7-dimethyl-1-(1-methylethyl)-, (1S-cis)-	39.766	0.27
22	Cubenol	40.781	0.38
23	1H-Cycloprop[e]azulene, decahydro-1,1,7-trimethyl-4-methylene-	41.205	0.06
24	tau.-Muurolol	42.893	1.34
25	Cycloheptane, 4-methylene-1-methyl-2-(2-methyl-1-propen-1-yl)-1-vinyl-	44.891	0.22
26	2-Butanone, 4-(2,6,6-trimethyl-2-cyclohexen-1-ylidene)-	51.346	0.07
27	2,5,5,8a-Tetramethyl-4-methylene-6,7,8,8a-tetrahydro-4H,5H-chromen-4a-yl hydropero	53.911	0.07
			100.00

B. Histopathology of the liver

Examinations of liver sections under a light microscope for histopathology found that when compared to the control group, the rat given doses of the essential oil extract showed a number of alterations. In the section in rat liver from group treated with *C. zeylanicum* referred to dilated branch of portal duct, hepatocytes with cytoplasmic vacuolation, some hepatocytes were swollen with pyknotic, large nuclei and dilated sinusoids (Figure 6 A). As well as in the rats treated with noticed sever congestion of central vein (CV) (Figure 6 B), degeneration and sluggish of endothelial lining larger, Bile ducts hyperplasia and necrotic hepatocytes (Figure 6 C). A section of the rat liver from the *C. zeylanicum*-treated group revealed vacuolation in most hepatocytes, congested central vein, dilated sinusoid, complete degeneration of endothelial lining layer of central vein and the parenchyma tissue lost normal structure (Figure 6 D).

The histological sections taken from the livers of animals dosed orally from the volatile oil extract of cinnamon at a concentration of 20 mg/kg showed congestion, inflammations around central vein in treated rat after 30 days and showed congestion around portal triads vein (Figure 6); as well as found necrosis and degenerations liver cells in addition inflammation of cells after 30 days, In addition. One of the mechanisms of plant extracts is the process of inhibiting the synthesis of purine and pyrimidine [46,47]. Under a microscope, liver sections were examined for histological alterations such as When compared to the control, there was greater inflammation and damage of the liver architecture [48].

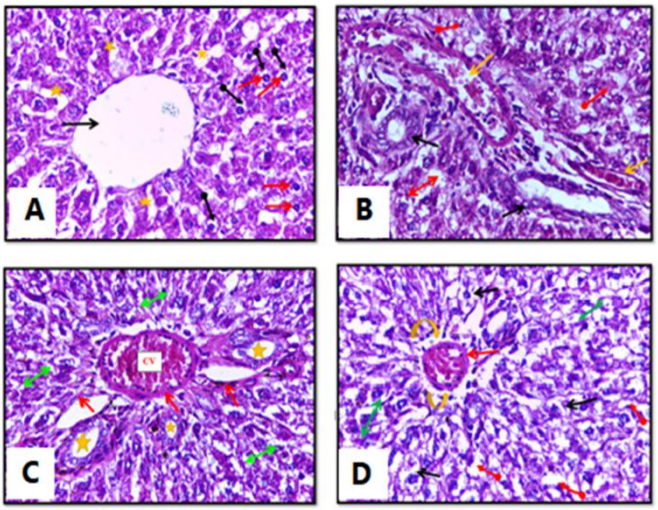

Figure –6: Photomicrographs of H and E stained liver sections from rat treated with essential oil extracts of *C. zeylanicum* (A): Section in rat liver from group treated with *C. zeylanicum* referred to dilated branch of portal duct (⟶), hepatocytes with cytoplasmic vacuolation (⟶), some hepatocytes was swollen with pyknotic, large nuclei (⟶) and dilated sinusoids (⟶). B: Section in rat liver from group treated with *C. zeylanicum* showed sever congestion in hepatic portal vein and blood vessels (⟶), hyperplasia in lining layer of bile duct (⟶), destruction of most hepatocytes (⟷) and necrotic stromal tissue(⟶). C: referred to sever congestion of central vein (CV), degeneration and sluggish of endothelial lining larger (⟶). Bile ducts hyperplasia (⟶) and necrotic hepatocytes (⟷). D: Section in rat liver from group treated with Cinnamomum showed vacuolation (⟶) in most hepatocytes, congested central vein (⟶), dilated sinusoid (⟶), complete degeneration of endothelial lining layer (⟶) of central vein and the parenchyma tissue (⟷) lost normal structure. (H&E) stain (40X).

IV. CONCLUSION

From the current investigation, it can be deduced that the main component of cinnamon bark oil is cinnamaldehyde. Consequently, cinnamaldehyde may be thought of as a component used to identify cinnamon bark oil. The liver displayed several tissue changes, including hepatocyte necrosis and the existence of steatosis foci. Histological and cellular changes in liver tissue were dramatically attenuated by *C. zeylanicum* essential oil. From this investigation, we may infer that essential oil of *C. zeylanicum* possesses hepatoprotective properties [39].

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

REFERENCES

[1] P. Ranasinghe, R. Jayawardena, and S. Pigera, "Evaluation of pharmacodynamic properties and

safety of *Cinnamomum zeylanicum* (*Ceylon cinnamon*) in healthy adults: a phase I clinical trial". *BMC Complementary and Alternative Medicine*, 17, 550, 2013.

[2] S. Gotmare, and E. Tambe, "Identification of chemical constituents of Cinnamon bark Oil by GCMS and comparative study garnered from five different countries", *Global Journal of Science Frontier Research*. 19(1), 35-42, 2019.

[3] S.M. Blevins, M.J. Leyva, J. Brown, J. Wright, R.H. Scofield, and C.E. Aston,"Effect of cinnamon on glucose and lipid levels in noninsulin-dependent type 2 diabetes. Diabetes Care", 30 (9), 2236–2237,2007.

[4] B. Uma, K. Prabhakar, and S. Rajendran, "Sarayu, Studies on GC/MS Spectroscopic Analysis of some Bioactive Antimicrobial Compounds from *Cinnamomum zeylanicum". Journal of Medicinal Plants*. 8(31),125-131, 2009.

[5] K.I. Al-Zubaidy, " Cinnamon's antibacterial activity on the bacterial isolates from urinary tract infections". *World Journal of Pharmaceutical Research*. 6(17),81-91, 2017.

[6] M. Y. Ghan, and M. A. Elsaiegh, " Efficiency of some vegetative powders and storage method in controlling the Great wax moth *Galleria melloella* L". *NTU Journal of agriculture and veterinary science*. 1(1), 38-41, 2021.

[7] J. M. Kalaf, "Testing the Effect of Some Botanical Oils on Some Aspects of the Life Performance of Lesser Grain Borer Rhyzopertha Dominica (F.) (Coleoptera: Bostrichidae)". *Annals of R.S.C.B* 25(6), 12008-12016,2021.

[8] M.F. Hameed, K S. Saud, and A. D. Al-Maliki, "Estimation of antimicrobial efficacy of phenolics characterized from Iraqi *Cinnamomum cassia* cortex". *Journal of Pharmacognosy and Phytochemistry,* 11(5), 01-06,.2022.

[9] J. Malik, K., Munjal, and R. Deshmukh, "Attenuating effect of standardized lyophilized *Cinnamomum zeylanicum* bark extract against streptozotocin-induced experimental dementia of Alzheimer's type". *Journal of Basic and Clinical Physiology and Pharmacology*, 26 (3), 275–285, 2015.

[10] A.A. Jawad, "Ethological studies in assessing the anti-Aggressive effect of some Iraqi medical plants in Laboratory mice. A thesis in physiology", College of education, Basra University.1997.

[11] Y. Arafat, A. Altemimi, S.A. Ibrahim, and L.S. Badwaik, "Valorization of Sweet Lime Peel for the Extraction of Essential Oil by Solvent Free Microwave Extraction Enhanced with Ultrasound Pretreatment". *Molecules*. 25, 4072, 2020.

[12] T.W. Hu, Y.T. Lin, and C. K .Ho," Natural variation of chemical components of the leaf oil of *Cinnamomum osmophloeum* Kaneh". *Bull. of Tai. For. Rese. Inst New Seri.* 78 ,18, 1985.

[13] M.L. Silva, M.A. Bernardo, J. Singh and M.F. Mesquita, "Beneficial Uses of Cinnamon in Health and Diseases: An Interdisciplinary Approach". In The Role of Functional Food Security in Global Health; Academic Press: Cambridge, MA, USA, 565–576, 2019.

[14] T. Hussain, B. Tan, G. Murtaza, G. Liu, N. Rahu and M. Saleem Kalhoro, "Flavonoids and type 2 diabetes: Evidence of efficacy in clinical and animal studies and delivery strategies to enhance their therapeutic efficacy ". *Pharmacol. Res*. 152: 104629, 2020.

[15] N. Jamali, M. Jalali, and J. Saffari-chaleshtori," Effect of cinnamon supplementation on blood pressure and anthropometric parameters in patients with type 2 diabetes: A systematic review and meta-analysis of clinical trials". *Diabetes Metab. Syndr. Clin. Res. Rev*., 14, 119–125, 2020.

[16] M.A. Bernardo, M.L. Silva, ″ Effect of cinnamon on postprandial glucose concentration". *J. Diabetes Res*., 564, 56–89, 2015.

[17] H.-F. Wang, Y.-K. Wang and K.H. Yih, "DPPH free-radical scavenging ability, total phenolic content, and chemical composition analysis of forty-five kinds of essential oils". *Journal of Cosmetic Science*, 59 (6), 509–522, 2007.

[18] S. A. B. Sulaiman," Extraction of essential oil from *Cinnamomum zeylanicum* by various methods as perfume oil". M.Sc. Thesis, Faculty of Chemical & Natural Resources Engineering University Malaysia Pahang. 2013.

[19] D. Mahyar, H. Shirin, and H. Hossein, "Cinnamon (*Cinnamomum zeylanicum*) as an antidote or a protective agent against natural or chemical toxicities: a review". *Drug and chemical toxiclgy* 41, 35-45, 2018.

[20] A. Fajara, G. A. Ammara, M. Hamzaha, R. Manurunga, and M.Y. Abduha,"Effect of tree age on the yield, productivity, and chemical composition of essential oil from *Cinnamomum burmannii*". *Current Research on Biosciences and Biotechnology*, 1 (1), 17-22, 2019.

[21] G.K. Jayaprakasha, L.J. Rao, and K.K. Sakariah, "Chemical composition of volatile oil from *Cinnamomum zeylanicum* Buds". *Z. Naturforsch*. 57, 990-993, 2002.

[22] ESCOP "The Scientific Foundation for Herbal Medicinal Products". 2nd Edition, Thieme, *Exeter,* 178-210, 2003.

[23] L. B. I. Gende, R. Floris, and M. J. Eguaras. "Antimicrobial activity of cinnamon (*Cinnamomum zeylanicum*) essential oil and its main components against Paenibacillus larvae from Argentine," *Bulletin of Insectology*, 61(1),1–4, 2008.

[24] M. E. Unlu, G. V. Ergene, H. S. Unlu, and N. Vural, "Composition, antimicrobial activity and in vitro cytotoxicity of essential oil from *Cinnamomum zeylanicum* Blume (Lauraceae)," *Food and Chemical Toxicology,* 48 (11), 3274–3280, 2010.

[25] R. Wang, W. Ruijiang, and Y. Bao, "Extraction of essential oils from five cinnamon leaves and

identification of their volatile compound compositions". *Innovative Food Sci. Emerging Technol*., 10, 289 – 292, 2009.

[26] B.A. Behbahani, F. Falah,Arab,F. L.. M. Vasiee, and F. T. Yazdi,"Chemical composition and antioxidant, antimicrobial, and antiproliferative activities of *Cinnamomum zeylanicum* Bark essential oil" . *Evidence-Based Complementary and Alternative Medicine* 1-8, 2020.

[27] CVMP (Committee for Veterinary Medicinal Products), "Streptomycin and dihydrostreptomycin Summary Report," (2),7, 2000.

[28] Y. C. Wong, M. Y. Ahmad-Mudzaqqir, and W. A. Wan-Nurdiyana "Extraction of essential oil from Cinnamon (*Cinnamomum zeylanicum*)". *Orient J Chem*., 30: 37 – 47, 2014.

[29] L.G. Luna, "Manual of histologic staining methods of the armed forces Institute of Pathology". 3rd Edition, McGraw-Hill, New York, 1968.

[30] T. Yu, H. Yao, S. Qi, and J. Wang, "GC-MS analysis of volatiles in cinnamon essential oil extracted by different methods". *Grasas Aceite,*, 71 (3), 372-378, 2020.

[31] A. Merck. "The Merck Index Online". Cambridge, UK: Royal Society of Chemistry, 2015.

[32] G. Singh, S. Maurya, M.P. de Lampasona, and C. A.N. Catalan, "A comparison of chemical, antioxidant and antimicrobial studies of cinnamon leaf and bark volatile oils, oleoresins and their constituents". *Food and Chemical Toxicology*, 45, 1650, 2007.

[33] N. Pooja, and K. Maninder, "GC– MS profile of volatile oils of *Cinnamomum zeylanicum* Blume and *Ocimum kilimandscharicum* Baker ex Gurke", *International Journal of Pharmaceutical Sciences Review and Research*, 19(2), 124 – 126, 2013.

[34] N. N. Kasim, S. N. Ismail, N. D. Masdar, F. Hamid and W. I. Nawawi, "Extraction and potential of cinnamon essential oil towards repellency and insecticidal activity", *International Journal of Scientific and Research Publications*, 4(7), 1 – 6, 2014.

[35] B. Adinew, "GC – MS and FT – IR analysis of constituents of essential oil from Cinnamon bark growing in South – west of Ethiopia", *International Journal of Herbal Medicine*, 1(6), 22 – 31, 2014.

[36] G. S. El-Baroty, H. H. Abd El-Baky, R. S. Farag, and M. A. Saleh, "Characterization of antioxidant and antimicrobial compounds of cinnamon and ginger essential oils", *African Journal of Biochemistry Research*, 4(6), 167 – 174, 2010.

[37] E. M. Elgendy, H. S. Ibrahim, H. F. Elmeherry, A. G. Sedki and F. U. Mekhemer. "Chemical and biological comparative in vitro studies of cinnamon bark and lemon peel essential oils", *Food and Nutrition Sciences*, 8, 110 – 125, 2017.

[38] S. Sariözkan, G. Türk, M. Güvenç, A. Yüce, S. Özdamar, F. Cantürk, and A.H. Yay, "Effects of Cinnamon (*C. zeylanicum*) Bark oil against taxanesinduced damages in sperm quality, testicular and epididymal oxidant/antioxidant balance, testicular apoptosis, and sperm DNA integrity". *Nutrition and cancer*, 68(3), 481-494, 2016.

[39] D.E.H. Adli, M. Brahmi, K. Kahloula, W. Arabi, B. Bouzouira, M. Talatizi, and M. Slimani, "The therapeutic effect of *Cinnamomum cassia* essential oil against hepatotoxicity induced by co-exposure to lead and manganese in developing Wistar rats", *Journal of Drug Delivery and Therapeutics*. 10(5), 49-55, 2020.

[40] M. Kazemi, and S. Mokhtariniya, "Essential oil composition of bark of *Cinnamomum zeylanicum*". *Journal of Essential Oil-Bearing Plants*, 19, 786-789, 2014.

[41] D.F. Al-fekaiki, A. K. Niamah, and S. T. Al-Sahlany, "Extraction and identification of essential oil from *Cinnamomum Zeylanicum* barks and study the antibacterial activity". *J. Microbiol. Biotech. Food Sci.* 7 (3), 312-316, 2017.

[42] N. K. Dao, Chinese Cassia. In P. Ravindran, K.B. Nirmal, and M. Shylaja (Eds.), "Cinnamon and 1876 Cassia: The Genus *Cinnamomum"*, 156–184, 2004.

[43] V. N. Trajano, and E. O. Lima, "Travassos, A. E., de Souza, E. L. Inhibitory effect of the essential oil from *Cinnamomum zeylanicum* Blume leaves on some food-related bacteria". *Ciênciae Tecnologia de Alimentos*, 30, 771-775, 2010.

[44] A.R.S. Al-Hilphy, "A practical study for new design of essential oils extraction apparatus using ohmic heating". *Int. J. Agric. Sci*. 4(12):351-366.

[45] R. Li, Y. Wang, Z.T. Jiang, and Jiang, S. (2010). "Chemical composition of the essential oils of *Cinnamomum loureirii* Nees. From China obtained by hydrodistillation and microwaveassisted hydrodistillation". *J. Essent. Oil Res.* 22, 129–131, 2014.

[46] M. Al-Malak. "Histopathological and Histochemical of small intestine infected with giardiasis in human and experimental models". PHD. Thesis, 2004.

[47] D.K. Suker, and F.A. Jasim, "Liver histopathological alteration after repeated intra-tracheal instillation of titanium dioxide in male rats". *Gastroenterol Hepatol Bed Bench.* 11(2), 159-168, 2018.

[48] S.A.A. Al-Saadi, K.H. Al- Derawi, and S. Abd Alrasool, "The Effect of steroidal extract of *Nerium oleander* on the liver tissue structure of albino mice". *IOSR Journal of Pharmacy and Biological Sciences*. 12(2), 52-55, 2017.