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BIOACTIVE SUBSTANCES, ANTIBACTERIAL AND ANTIOXIDANT ACTIVITIES OF MANGO KERNEL, OLIVE AND CORIANDER LEAVES

A.Z.M. Badee[1], R.K. Moawad[2]*, M.M. ElNoketi[1] and M.M. Gouda[2]

[1]Food Science Department, Faculty of Agriculture, Cairo University, Egypt.
[2]Food Technology Department, National Research Centre, Dokki, Egypt.

Abstract

There is a great interest in the discovery of novel natural bioactive compounds. The primary aim of the study was to investigate the antioxidant and antibacterial activities of mango seed kernel (MSK), olive leaves (OL) and coriander leaves (CL) extracts. All plants were extracted with 80% methanol and the extracts were used to determine total phenolic and flavonoid contents by Folin-Ciocalteu reagent and aluminum chloride methods. The antioxidant capacity was studied through the evaluation of DPPH radical-scavenging activity and ABTS radical scavenging assay. Polyphenol profile of investigated extracts was determined by HPLC assays. The antimicrobial activity was analyzed using the well diffusion method, where zones of inhibition were used as indicators of antimicrobial activity. The results showed that the highest phenolic content (29.84GAE/g) was shown in MSKE followed by OLE (16.43) then CLE (6.87), while total flavonoids were 22.08, 56.70 and 21.83 (mg CE/g) for the three extracts, respectively. The results also indicated that, the highest DPPH (92.00%) was recorded for MSKE, followed by OLE and CLE, respectively. The ABTS was highest for MSKE (94.54%), followed by OLE then CLE. All the plant extracts effectively inhibited the growth of pathogenic strains used in the study. HPLC analyses revealed that, the most abundant phenolic component is methyl gallate, naringenin and ellagic acid for MSKE, OLE and CLE, respectively. The results indicated that the Egyptian local plants tested may be potential sources for isolation of natural antioxidant and antimicrobial compounds for use in foods to replace synthetic additives.

Key words: antibacterial activity, antioxidant property, phytoconstituents, DPPH, coriander leaves, olive leaves, mango seed kernel.

Introduction

Lipid oxidation and microbial proliferation are the major factors resulting in losses in food quality. The use of natural antimicrobial and antioxidant compounds is important not only in the preservation of food but also safe for human consumption. Recently, investigation of natural plant products for the discovery of active compounds has also developed in finding natural occurring antioxidant and antimicrobial agents for use in foods to replace synthetic additives, due to their carcinogenicity (Odeja *et al.,* 2016). Among the plants rich in antioxidant and antimicrobial compounds the OLE, CLE and MSKE.

Olive leaf (*Olea europaea* L.) is the by-product of the olive oil industry, which can be used in the food industry for improving the nutritional value and functionality. Leaves from olive tree, are rich in biophenols (BPs), such as oleuropein, verbascoside, ligostroside, tyrosol, demethyoleuropein or hydroxytyrosol (Al-Rimawi, 2014 and Hukerdi *et al.,* 2018). Olive leaves extract has been shown several biological activities such as antioxidant, antimicrobial, antiviral, anticancer and cardio protective properties (Ivanov *et al.,* 2018, Ayoub *et al.,* 2019 and AlShaal *et al.,* 2019).

Mango (*Mangifera indica* L.) is one of the most important tropical fruits in the world. Mango seed kernels (MSK) are rich sources of phenolic compounds and flavonoids such as gallic acid, ellagic, pyrogallol, chlorogenic, catachin, mangiferin, protocatechuic, cinnamic, catechol. It also contained myricetin caffeine, coumaric, sinapic acid, ferulic acid, salicylic, kaempferol quercetin and tannin, which showed potent tyrosinase inhibitor, antioxidant activity and chelating activity(Abdel-Aty *et al.,* 2018 and Melo *et al.,* 2019). MSKE showed good antibacterial activity against pathogenic bacteria (Ahmed, 2015; Bernal-Mercado *et al.,* 2018 and Raju *et*

***Author for correspondence :** E-mail : rk_moawad@hotmail.com

al., 2019). MSKE is a suitable by-product that could represent a valuable input into functional foods production.

Coriander (*Coriandrum sativum* L.), commonly known as Cilantro, is a herb widely used as spice, or in folk medicine, in the pharmacy and food industries (Ashika *et al.,* 2018). Coriander leaves is a good source of polyphenols and phytochemical due to its high antioxidant activity (Agrawal *et al.,* 2018 and Jangra *et al.,* 2018).. Coriander leaves extract showed good antibacterial activity against pathogenic bacteria (Farah *et al.,* 2015 and Agrawal *et al.,* 2018).. HPLC analysis revealed that camphor, rutin, apigenin, luteolin, quercetin, catechin, chlorogenic acid, caffeic acid, ferulic acid and gallic acid were the main components of coriander leaves (Anita *et al.,* 2014 and Ashika *et al.,* 2018).

Due to the increasing interest in the use of natural antioxidants and antimicrobial, this study was designed to evaluate and compare three extracts from different plant organs: mango seed kernel extract (MSKE), olive leaves extract (OLE) and coriander leaves extract (CLE), separately. Till now, there are no reports emphases on chemical composition with their biological activities. The present study was carried out in order to evaluate the proximate composition, phenolic composition (HPLC), total phenolic content (TPC),total flavonoids content (TFC), antioxidant activity (DPPH and ABTS assays), and the antibacterial activity (using the well diffusion method), of different plant organs: OLE, CLE and MSKE.

Materials and Methods

Chemicals and Reagents

Standard of phenols: gallic acid, caffeic acid; caffeine, ellagic acid, chlorogenic acid, syringic acid, ferulic acid, naringenin, propyl gallate, pyrocatechol, vanillin, coumaric acid, qurecetin, cinnamic acid, catechin and 4, 7-Dihydroxyisoflavone, butylated hydroxyl toluene (BHT), DPPH (2, 2-Diphenyl-1-picrylhydrazyl), ABTS (2, 22 -azino-bis(3ethylbenzothiazoline-6-sulphonic acid), potassium persulphate acid, Folin-Ciocalteu reagent and aluminium chloride and were obtained from Sigma Chemical Co., Germany. Methanol, ethanol, DMSO, ampicillin were purchased from El-Nasr Co., Cairo, Egypt. All other solvents and chemicals used were of analytical grade or the highest grade available.

Plant source

Fine-quality fresh green olive leaves (*Olea europaea* L.) were collected during March 2018, from the west farm of Faculty of Agriculture, Cairo University, Giza, Egypt. A ripe mango seed as by-products (waste) was collected after mango pulp processing of Zebdia variety (*Mangifera indica* L.), during the summer season of 2018, from local fruit processing units (Farghly), Giza, Egypt. The kernels were removed manually from the seeds for further extraction. Fresh coriander (*Coriandrum* sativum) leaves were collected from local market in Egypt. All the plant samples Fig. 1 were kept in polyethylene bags at 4±1°C until extraction.

Extraction

Olive leaves; coriander leaves and mango seed kernels were cleaned from extraneous matter and properly washed then dried in hot air-oven for 24 h at 40°C. The dried leaves and kernels were milled with grinder into a powdery form and kept separately in a closed dark glass bottle and stored at 4°C until further analysis.

According to the extraction method of El Anany(2015), one hundred gram of OL, CL and MSK powder were extracted overnight with 1000 ml of 80 % methanol solution in a shaking incubator (100 rpm) at room temperature. Then the extracts were centrifuged at 3500 rpm for 15 min. The supernatants were filtered through a Whatman No.1 filter paper, then extract solutions were concentrated to dryness in a rotary evaporator (Eyela, Rikakikai, Tokyo, Japan), at 40°C and complete the drying of extract in oven overnight at 40°C to form powder, which was stored separately at -20^{0}C untilfurther use. The extraction yield of each sample was calculated and reported as a percentage (g d wt. extract/ 100 g d wt. sample).

Fig. 1: *Coriander leaves.* *Mango seed kernel* *Olive leaves*

Determination of total phenolic and flavonoid content

The total phenolic and flavonoid contents of the MSKE, OLE and CLE were quantified by spectrophotometric (Thermo Fisher Scientific, Genesys, Madison, USA) measurement of the absorbance according to the Folin Ciocalteu and by using the aluminum chloride methods, respectively, as reported by Bakari *et al.,* (2017).

Antioxidant activity (DPPH and ABTS) free radical assays

The antioxidant capacity of MSKE, OLE and CLE tested using DPPH free radical scavenging was evaluated by the method described by Cheurfa and Allem, (2016). Total antioxidant activity of MSKE, OLE and CLE was measured in vitro with ABTS assay, and this procedure followed the method described by Ben Nejma *et al.*, (2017), with slight modifications. Each method was replicated three times.

HPLC analysis of phenolic compounds

The high performance liquid chromatography (HPLC) analysis was carried out for MSKE, OLE and CLE according to Kim *et al.,* (2006). The separation and determination were performed on Agilent 1260 series -C18 column (4.6 mm × 250 mm i.d., 5 µm). The column was eluted by water (solvent A) and 0.02% tri-floro-acetic acid in acetonitrile (solvent B) at a flow rate of 1 ml/min. The obtained peaks were monitored simultaneously at 280 nm. Commercial phenolic compounds were used as standards.

Antibacterial screening

Antibacterial activity of methanolic extract of MSK, OL and CL was tested by agar diffusion method against six bacterial species (*Bacillus subtilis, Streptococcus faecalis, Neisseria gonorrhoeae, Pseudomonas aeruginosa, Staphylococcus aureus and Escherichia coli*); which were selected on the basis of the size of the halo formed and their possible occurrence in food products. Muller Hinton agar medium was poured in 90 mm petri dishes and allowed to solidify. 100 µL of specific bacterial culture was spread uniformly on the agar surface. Wells were made by using sterile cylinder of 6mm diameter, soaked with 10 µL (100 mg/mL) of each extract separately. Ampicillin (0.020 mg/mL DMSO), was used as positive control and (disks with 10µL DMSO) as negative control. Agar plates were incubated at 37°C for 24-48 h and zone of inhibition was measured (Daoud *et al.,* 2015).

Statistical Analysis

Results were expressed as means and standard deviation (M±SD) from triplicate determinations. Analysis of variance (ANOVA) was performed to compare MSKE, OLE and CLE. Significant differences were defined as $P<0.05$; according to PC-STAT, (1985).

Results and discussions

Proximate composition

The proximate composition of raw fresh MSK, OL and CL is presented in Table 1. From which it is apparent that MSK provided the highest total protein content (8.5%), followed by OL (4.36%) and CL (4.05%). The moisture content of CL, OL and MSK was found to be 86.71, 43.18 and 7.65%, respectively. MSK had remarkably higher fat (11.14%), compared to OL (5.84%) and CL (0.95%). The ash content was 5.27, 2.35 and 1.90% for OL, MSK and CL, respectively. The carbohydrate content was the highest in MSK (70.36%), moderate for OL (41.35%) and CL revealed the lowest content (6.39%).

The proximate composition is within the normal limits for the species and is in agreement with those found in the MSK literature by El-Kady *et al.,* (2016) Abdelaziz, (2018) and Das *et al.,* (2019). The proximate results are also close to those reported for OL by Hukerdi *et al.,* (2018) and AlShaal *et al.,* (2019). The proximate composition of coriander leaves was in line with Hukerdi *et al.,* (2018) and AlShaal *et al.,* (2019). However, slight differences in proximate composition may be due to the differences in the season, geographical location, species and variety.

Extraction yield

Methanolic extraction yields of MSK, OL and CL

Table 1: Proximate composition and extract yield of MSK, OL and CL (On fresh wt. basis).

Constituents	MSKE	OLE	CLE
Moisture%	7.65±0.18^{c}	43.18±0.27^{b}	86.71±0.35^{a}
Protein%	8.50±0.15^{a}	4.36±0.14^{b}	4.05±0.17^{c}
Fat%	11.14±0.12^{a}	5.84±0.16^{b}	0.95±0.19^{c}
Ash%	2.35±0.23^{b}	5.27±0.18^{a}	1.90±0.14^{c}
Total carbo-hydrates%	70.36±0.17^{a}	41.35±0.12^{b}	6.39±0.15^{c}
Extract yield % (gm/100gm)	16.00±0.13^{b}	17.86±0.17^{a}	10.00±0.11^{c}

All values reflect the mean and standard deviation are mean of triplicate determinations.

[Total Carbohydrates = 100 - (Moisture + Protein + Intramuscular-fat + Ash].

There is no significant difference ($P>0.05$) between the values having the same superscripts in the same column.

are given in Table 1. After extraction, olive leaves provided higher yield (17.86%) than MSK (16.00%) and coriander leaves (10.0%). The variation in the yields of plant organs might be ascribed to the different availability of extractable components, resulting from the different chemical composition of plants. Similar results were achieved for olive leaves by other authors (EL Kateb *et al*., 2015; Bakari *et al*., 2017 and AlShaal *et al*., 2019); for coriander leaves by Ahmed *et al*., (2018) and Jangra *et al*.,(2018); for MSK through the researches of (Namngam *et al*., (2018) and Melo *et al*., (2019).

Total phenolic content (TPC)

Phenolic compounds are widely distributed in plants and have gained much attention, due to their antioxidant activities and free radical scavenging capacities, which potentially have beneficial implications for health (Petti and Scully, 2009). *In vitro*, antioxidant activity of the extracts table 2 showed that MSKE was too rich with polyphenols in terms of TPC the values were 29.84, 16.43 and 6.87 (mg gallic/g dw) for MSKE followed by OLE then CLE, respectively. A great different of total phenolic contents were reported in other plant organs (Chahal *et al.,* 2017 and AlShaal *et al.,* 2019). These differences in phenolic contents might be due to plant cultivars, geographical location, extraction conditions and used different standard equivalents.

It was also found that, seed kernel extract of all cultivars contained higher total polyphenol content than the flesh and peel, which indicated that seed kernel would be important reservoir of phenolic compounds (Pinsirodom *et al.,* 2018). The amounts of phenols determined in MSKE in the present study are in good agreement with Abdel-Aty *et al.,* (2018); Abdelaziz, (2018) and Raju *et al.,* (2019).. Similarly, the total phenolic content in OLE was recorded to be 16.43 (mg gallic/g dw), which was in line with Bakari *et al.,* (2017); Hukerdi *et al.,* (2018) and Ayoub *et al.,* (2019), who studied the total phenol contents from OLE. In the present study, it was reported that total phenols content for coriander leaves was 6.87 (mg gallic/g dw), Some other research workers (Pillay, 2017; Ashika *et al.,* 2018 and Jangra *et al.,* 2018) have also reported similar findings. The coriander leaves have higher amounts of phenolic compounds than the seeds (Farah *et al.,* 2015).

Total flavonoids content (TFC)

The selection of extraction conditions is very important when we research natural phenolic compounds (Felhi *et al.,* 2017). All amounts were reported in table 2 and values showed a great variations in various studied plants. The olive leaves extract exhibited the highest level of TFC (56.70 mg CE/g) as compared to MSKE (22.08 mg CE/g) and CLE (21.83 mg CE/g). The above results showed that all organs contained a considerable amount of TFC level. The present results are in agreement with the previous ones (Bakari *et al.,* 2017; Hukerdi *et al.,* 2018 and Ayoub *et al.,* 2019), who studied the total flavonoids contents from OLE. The results strongly show that total flavonoids contents from MSKE are similar to those reported by other authors (Abdel-Aty *et al.,* 2018; Abdelaziz , 2018 and Raju *et al.,* 2019).. The amounts of flavonoids determined in CLE in the present study are in good agreement with other works (Pillay, 2017; Ashika *et al.,* 2018 and Jangra *et al.,* 2018), who studied the total flavonoids contents from coriander leaves.

Antioxidant activity

Antioxidant properties of different plant extracts and pure compounds can be evaluated using various *in vitro* assays. In this study, 2, 2 -diphenyl-1-picrylhydrazyl (DPPH) and ABTS method were used for evaluating the ability of samples for scavenging free radicals.

DPPH assay

Scavenging activity was measured by the decrease in absorbance as the DPPH radical received an electron or hydrogen radical from an antioxidant compound to become a stable diamagnetic molecule (Cheurfa and Allem, 2016). The scavenging ability of the MSKE, OLE and CLE samples (leaves and kernel) on DPPH free radical was shown in table 2. The results showed a dose dependent scavenging power. Especially, the scavenging ability of MSKE increased from 56.61% to 92.00 %, at 200 ppm, indicating that it has generally better scavenging ability, even than BHT (88.45%). DPPH of OLE increased from 43.00 to 79.71%, while the value increased

Table 2: Total phenolics content, total flavonoids, DPPH% and ABTS% assay.

Samples	DPPH%				ABTS%				Total phenolic	Total flavoniods
	50ppm	100 ppm	200ppm	400 ppm	50 ppm	100 ppm	200 ppm	400 ppm	mg GAE/g	mg CE/g
MSKE	56.61	74.3	92.00	-	58.03	78.38	94.54	-	29.84	22.08
OLE	43.00	50.41	59.59	79.71	47.5	56.00	64.5	82.10	16.43	56.70
CLE	14.75	28.65	36.26	65.17	16.50	32.04	39.53	67.10	6.87	21.83
BHT	57.53	75.5	88.45	-	59.4	79.43	91.00	-	-	-

All values reflect the mean and standard deviation are mean of triplicate determinations.

from 14.75 to 65.17 % in CLE, at 400 ppm, respectively table 2.

Similar results are found in MSKE literatures by (El-Kady *et al.,* 2016 and Umamahesh *et al.,* 2019). Our results table 2 are in contrast with the study of Bakari *et al.,* (2017); AlShaal *et al.,* (2019) and Ayoub *et al.,* (2019), for DPPH of OLE. The coriander leaves showed stronger antioxidant activity than the seeds (Wangensteen *et al.,* 2004). The obtained results regarding the DPPH inhibition of CLE are similar to those already reported in the literature (Ahmed *et al.,* 2018 and Jangra *et al.,* 2018). Usually, higher total phenol and flavonoids contents lead to better DPPH scavenging activity (Felhi *et al.,* 2017). As known, polyphenols have a metal chelating potential and their redox properties can be justified by their chemical structure (Schvab *et al.,* 2015). For this reason, the high polyphenolic content in MSKE, OLE and CLE may explain the high antioxidant activity.

Scavenging activity of ABTS• + free radical

The principal objective of this test is to measure the capacity of different substances to scavenge the ABTS.+ radical cation. The results showed a dose dependent scavenging ABTS.+ radical cation. As shown in table 2, the scavenging ability of MSKE was 94.54 %, which was more than BHT (91.00%) at 200 ppm, indicating that it has generally better scavenging ability. ABTS of OLE was 82.10%, while the ABTS value in CLE was 67.10 %, at 400 ppm, respectively table 2. It is obvious that tested samples are effective to provide their capacity to scavenge the ABTS.+ radical cation. The results of ABTS of MSKE are within the previous studies by other authors (Nakpanich *et al.,* 2017; Abdel-Aty *et al.,* 2018 and Umamahesh *et al.,* 2019), who reported that mango seed kernel extract is a rich source of natural antioxidants.

ABTS-radical scavenging assay was selected to confirm the scavenging activity. The results exhibited that OLE had higher scavenging activity, while CLE was the weakest as same as shown in the DPPH-radical scavenging assay table 2. This is the confirmation that OLE was best extract after MSKE to scavenge free radicals among the extracts tested. Our results table 2 are in contrast with the study of Bakari *et al.,* (2017); AlShaal *et al.,* (2019) and Ayoub *et al.,* (2019), who studied ABTS of OLE. The obtained results regarding the ABTS inhibition of CLE are similar to that already reported in the literature (Harsha and Anilakumar, 2014).

Extracts from MSKE, OLE and CLE revealed a high significance level ($p < 0.05$) between ABTS• + radical and TPC. The positive and significant correlation between TPC and ABTS antioxidant activity strengthens the results observed in the DPPH scavenging method used in this study. This investigation confirms the hypothesis that an increase in total phenolic compounds will increase the antioxidant activity of extracts.

High performance liquid chromatography (HPLC)

High performance liquid chromatography (HPLC) analysis enabled us to identify 8 phenolic compounds in MSKE, 13 phenolic compounds in OLE and 12 phenolic compounds in CLE, separately Fig. 1, 2 and 3.

HPLC was used to identify and quantified the phenolic compounds that were present in the studied mango seed kernel methanolic extract, and the results are illustrated in Fig. 2. From which it is apparent that, the components assayed for mango seed kernel methanolic extract (according to their retention times), were as follows: 3.897— chlorogenic (14.64%), 5.630- methyl gallate (29.00%), 6.464 - syringic acid (5.35%), 7.267 - rutin (12.81%),8.141- ellagic (5.61%), 9.797- vanillic 12.56%), 10.010- ferulic (8.58%) and 10.334- naringenin (11.45%) were positively identified in the present study by HPLC analytical system.

The HPLC chromatogram Fig. 2 also reveal that the dominant phenolic compound was methyl gallate (29.00%), while the peak produced for syringic acid (5.35%) was low which indicated that it was found in small quantities. Such results are in close agreement with those reported by other authors (El-Kady *et al.,* 2016; Abdel-Aty *et al.,* 2018 and Bernal-Mercado *et al.,* 2018).

The components assayed for olive leaves methanolic extract (according to their retention times), were as follows: 3.115- Gallic acid (17.53%), 3.486- Chlorogenic acid (20.16%), 3.872- Catechin (7.47%), 4.962- Caffeic (0.76%), 5.418- Syringnic acid (1.48%), 5.873- Pyro catechol (2.46%), 7.829- Coumaric acid (0.21%), 8.693- Vanillin (0.92%), 9.156- Ferulic acid (0.60%), 9.629-

Table 3: Antibacterial activity of MSK, OL and CL powder (mm) of the inhibition zones.

Microorganism	Gram reaction	Inhibition zone diameter (mm/sample)			
		Ampicillin	MSKE	OLE	CLE
Bacillus subtilis	(+)	26	16	12	9
Escherichia coli	(-)	25	15	13	12
Neiss. gonorrhoeae	(-)	28	14	12	10
Pseud. aeruginosa	(-)	26	15	13	12
Staph. aureus	(+)	21	15	14	10
Strept. faecalis	(+)	27	16	12	10

All values reflect the mean and standard deviation are mean of triplicate determinations.

Standards: Ampicillin: Anti -bacterial agent at 0.02mg/ml DMSO.

Naringenin (36.74%),10.192 - Propyl gallate (10.30%), 10.664 - Querectin (1.32%), and 11.191- Cinnamic acid (0.04%) were positively identified in the present study by HPLC analytical system.

The HPLC chromatogram Fig. 3 also reveal that the dominant phenolic compound in OLE was Naringenin (36.74%), while the peak produced for Cinnamic acid (0.04%) was very low which indicated that it was found

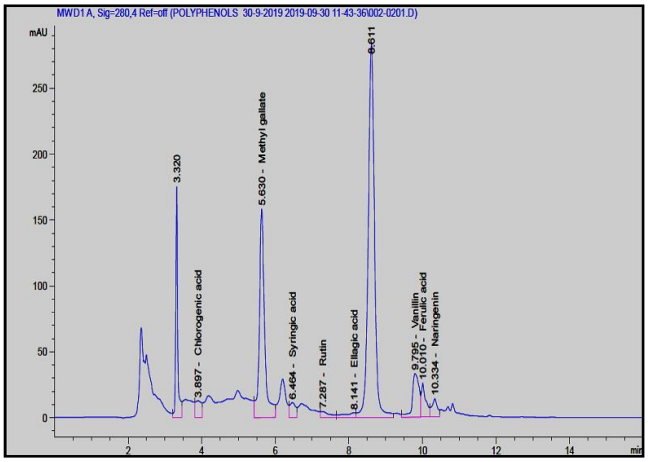

Fig. 2: HPLC analysis of MSKE.

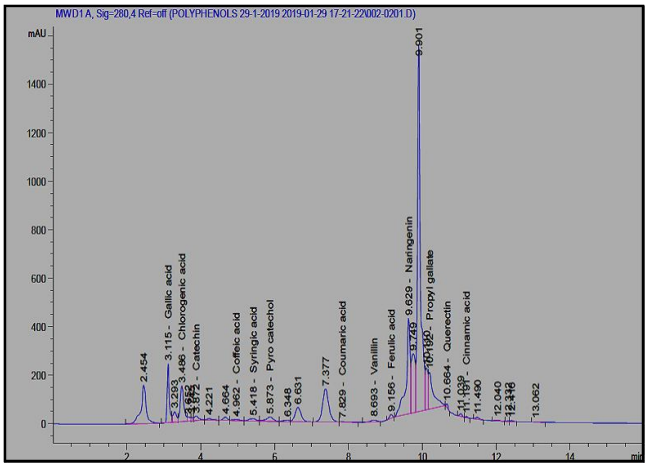

Fig. 3: HPLC analysis of OLE.

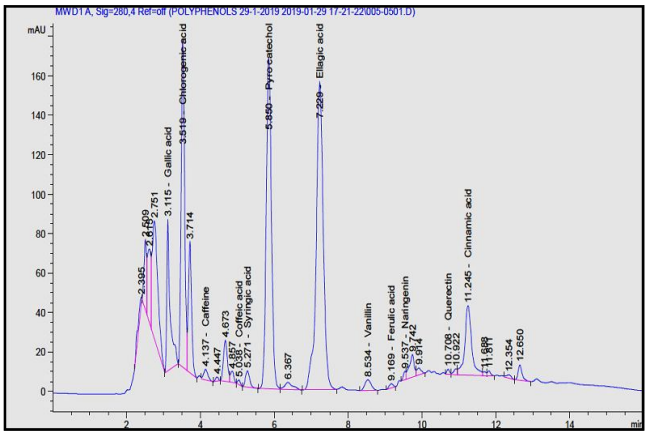

Fig. 4: HPLC analysis of CLE.

in very small quantities. Such results are in close agreement with those reported by other authors (Kotb *et al.,* 2017; AlShaal *et al.,* 2019).

The components assayed for coriander leaves methanolic extract (according to their retention times), were as follows: 3.115- Gallic acid (8.42%), 3.519- Chlorogenic acid (30.76%), 4.137- Caffeine (0.36%), 5.038- Caffeic acid (0.11%), 5.271- Syringic acid (0.69%), 5.850- Pyro catechol (15.97%), 7.229- Ellagic acid (42.81%), 8.534- Vanillin (0.64%), 9.169- Ferulic acid (0.10%), 9.537- Naringenin (0.23%), 10.708 - Querectin (0.38%) and 11.245- Cinnamic acid (1.11%) were positively identified in the present study by HPLC analytical system.

The HPLC chromatogram Fig. 4 also reveal that the dominant phenolic compound in CLE was Ellagic acid (42.81%), while the peak produced for Ferulic acid (0.10%) was very low which indicated that it was found in very small quantities. Such results are in close agreement with those reported by other authors (Anita *et al.,* 2014 and Ashika *et al.,* 2018).

Antibacterial activity

Antibacterial activity of methanolic extract of MSK, OL and CL was tested by agar diffusion method against six bacterial species (*Bacillus subtilis, Streptococcus faecalis, Neisseria gonorrhoeae, Pseudomonas aeruginosa, Staphylococcus aureus and Escherichia coli*); which were selected on the basis of the size of the halo formed and their possible occurrence in food products. All the plant extracts effectively inhibited the growth of pathogenic strains used in the study.

The antibacterial activity of MSKE, OLE and CLE was evaluated according to their IZD values against various strains and the results were compared with the activity of the standards. The obtained results revealed that MSKE recorded a large inhibition zones against tested bacteria ranging from 14 - 16 mm. Similarly, OLE indicated a large inhibition zones against tested bacteria ranging from 12-14 mm, while CLE showed a lower inhibition zones against tested bacteria ranging from 9-12 mm. The difference in the antimicrobial effects of the investigated parts of this plant species may be due to the phytochemical properties and various contents. Heleno *et al.,* (2015) reported that phenolic acids such as protocatechuic, vanillic, ferulic and caffeic acids could be used as antimicrobial agents because of the presence of carboxylic acid (COOH), two hydroxyl (OH) groups in *para* and *ortho* positions of the benzene ring and also a methoxyl (OCH3) group in the *meta* position.

Conclusion

This work emphasizes the significant difference in chemical composition between the three organs, MSKE, OLE and CLE and their significant influence on biological activities. The concentrations of phenolic and flavonoids were determined to be higher in kernel than leaves; all extracts are endowed with potent antioxidant and antimicrobial activities, especially MSKE. Antioxidant activity (DPPH and ABTS assays) was the highest in MSKE, followed by OLE then CLE. HPLC analysis indicated eight phenolic compounds were present in higher concentrations in the chromatographic profile of the MSKE; with methyl gallate was found in a highest level. HPLC analysis of OLE revealed chromatographic profile; with Naringenin was the dominant phenolic compound. Regarding CLE the dominant phenolic compound was Ellagic acid. All extracts inhibited the growth of pathogenic bacteria under investigation, with IZD ranging from 9-16 mm. In summary, findings reported that Egyptian plants (MSKE, OLE and CLE) are rich sources for bioactive compounds and can be used more in future in pharmacy and food industry. They could be a natural source of polyphenols compounds with antioxidant and antimicrobial properties.

Conflicts of interest

The authors declare no conflicts of interest.

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