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Coriander seed (*Coriandrum sativum*) essential oil: determination of chemical composition, antioxidant capacity and antimicrobial activity

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ABSTRACT

In today's food industry, investigating bioactivity of different plant extracts and essential oils as natural additives and quality enhancers plays a great role for responding to food related health issues and the need of safe products with improved overall quality according to consumer's diverse taste. In present study, chemical composition along with the antioxidant and antimicrobial properties of the coriander essential oil were investigated. According to the gas chromatography-mass spectrometry (GC-MS) outputs, Linalool identified as the major component (52.40%) in the essential oil. Total phenol and flavonoid estimated about 75.60 mg GAE/g and 715.33 mg QE/g essential oil while antioxidant capacity of the substance evaluated and showed that unlike ABTS assay, essential oil in DPPH assay reached a higher level of radical scavenging slightly more than %50 (%51.95) at same concentration of 1000 ppm. The smallest and largest diameters of inhibition zones at disk diffusion agar method belonged to *Shigella dysenteriae* (14.10 mm) and *Bacillus cereus* (24 mm). Minimum inhibitory concentrations (MIC) against *Escherichia coli, Shigella dysenteriae, Salmonella typhi, Staphylococcus aureus, Listeria monocytogenes* and *Bacillus cereus* estimated 4, 8, 4, 2, 2 and 2 mg/mL while minimum bactericidal concentrations (MBC) 256, 512, 256, 256, 128, 128 mg/mL respectively. Based on the overall results, coriander seed essential oil at certain concentrations could have a high potential as a safe food additive and a strong preservative for application in the industry.

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1- Introduction

Improving the quality of food in different aspects, such as sensory and health, has been one of the concerns of humans in every period of time. Over the years, many additive substances have been introduced to people and caused problems for various reasons and have been restricted and removed from the food industry. Nowadays, engineers and researchers are trying to find or produce healthy additives without causing sensitivity and allergy with proper healing and preservation properties, according to people's demand in consuming edible products with natural beneficial compounds. Since ancient times, fresh or dried herbs were added to foods and drinks as spices to improve taste, aroma and increase shelf life. Also, plants, having many biological compounds, can have many applications in different fields of food industry. Essential oils are one of these improving additives used in various industries [1 & 2].

Essential oils, liquids with short carbon chains, are volatile. These aromatic oils are obtained by different methods such as distillation and solvent extraction from different parts of plants, which are a rich source of biological compounds, and usually used as additives to improve the aroma of products in the chemical, health and pharmaceutical industries. Of course, today, the use of herbal essential oils in medicines as the main anti-disease composition has become very popular and a new way to deal with various issues in today's society. Essential oils are also known as antimicrobial, antiviral and insecticidal agents. Essential oils are complex mixtures of low molecular weight volatile organic compounds. The constituent compounds of essential oils are mostly composed of terpenoids, which are phenolic compounds, which these terpenoids are the main cause to their various antimicrobial properties [3 & 4].

The *Coriandrum sativum* L. herbaceous plant from the Umbelliferae family, or Coriander, also known as Chinese Geoffrey, is an annual aromatic plant. It is believed that the root of this plant is the Mediterranean and the Middle East, but its main origin is still unknown and some consider it a weed among plants. This plant is one of the first spices consumed by humans and used as a seasoning in foods today. Each part of this plant has its own chemical composition, properties and nutrition value. In fact, this plant has been used in traditional medicine and food since the past. Many properties of this plant have been mentioned and investigated in different studies, to name a few: properties of soothing wounds and oral inflammation, prevention and treatment of digestive disorders such as stomach bloating, indigestion and nausea with liver irritation. And the secretion of digestive enzymes, urination, as well as the treatment of diabetes and the reduction of blood glucose levels are among the properties of coriander. In addition to the mentioned cases, the antimicrobial activity of this plant is influenced by all the bioactive components of its constituents, which causes resistance against food-borne bacteria such as *Salmonella typhi* and is considered a treatment for dysentery [5 & 6].

Coriander plant with the ability to produce essential oil from different parts such as its leaves and seeds can also be used as an oil in food industry. Coriander essential oil containing monounsaturated fatty acid (petroselinic acid) is mainly extracted from the seeds of the plant and is more involved in the treatment of digestive diseases. With its antioxidant properties, this essential oil can be used as a preservative in various foods; In fact, this essential oil acts as a preservative in meat products by preventing lipid peroxidation. This essential oil with its almost colorless appearance and completely distinct and desirable smell is also used in aromatherapy and prevents insomnia, anxiety, convulsions and increases sexual power. The main reason for the special flavor of this herbal plant is the presence of a volatile flavoring component called linalool [7].

The purpose of this research was to identify the chemical composition of coriander seed essential oil, to determine the total phenolic and flavonoid contents and the inhibition potential against free radicals by this essential oil in a laboratory environment. Also, the potential of this essential oil to performance against pathogenic bacteria such as *Listeria monocytogenes*, *Staphylococcus aureus*, *Bacillus cereus*, *Shigella dysenteriae*, *Escherichia coli* and *Salmonella typhi*, which are all bacteria transmitted by food and cause stomach and intestinal inflammation and infection, food poisoning, diarrhea and nausea, bloody diarrhea, diarrhea and vomiting, and intestinal and stomach inflammation, respectively [8 and 9]; was investigated by various methods.

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2- Material and methods

Coriander seed essential oil was purchased from GiyahKala refinery. The experiments were carried out in the laboratories of Department of Food Science and Technology, Agricultural Sciences and Natural Resources University of Khuzestan, Mollasani, Iran.

2-1- Spectroscopy and determination of the main chemical compounds of essential oil

The chemical compounds of this essential oil (diluted with cyclohexane, sample amount 0.5 microliters) were determined by spectroscopic method and using a gas chromatograph connected to a mass spectrometer. Helium gas with a flow rate of 1 ml/min was used as carrier gas. The temperature program of the HP-5MS column was as follows: First, the temperature reached from 40 to 200 degrees at a rate of 5℃ per minute. After 1 minute, the temperature increased at a rate of 10 degrees per minute until it reached 250 degrees. It remained at this temperature for another 5 minutes, then it reached 300 degrees at a rate of 25 degrees per minute. The type of constituent compounds was reported using the normal spectrum of alkanes and the percentage of compounds was reported by calculating the area under the peaks [10].

2-2- Determining total phenolic content of coriander essential oil

Colorimetric method using folin–ciocalteu was used to measure total phenolic content. The concentration of 1000 ppm essential oil in methanol as the solvent was used for this test. After obtaining the gallic acid standard curve and the formula, 0.5 ml of sample was taken and mixed with 10% Folin solution (2.5 ml). After 6 minutes, 2 ml of sodium carbonate (7.5%) was added to the solution and after it was completely mixed, it was kept for half an hour at room temperature in a dark place. Finally, the absorbance of the obtained compound at the wavelength of 765 nm was taken by a spectrophotometer (WPA, England) and inserted into the formula [11].

2-3- Determining total flavonoid content of coriander essential oil

The total flavonoid content of the essential oil was calculated using aluminum chloride. In this test, quercein was prepared as a standard solution and its standard curve was drawn. After obtaining the standard formula, sodium nitrite with a concentration of 5% was prepared and added to the essential oil sample in the amount of 75 µl. fter 6 minutes, 10% aluminum chloride which was prepared in advance was added to the solution and mixed well. After 5 minutes, 1 ml of NaOH (1 M) solution was added and immediately the absorbance was read by a spectrophotometer at a wavelength of 510 nm [12].

2-4- DPPH assay (2,2-Diphenyl-1-picrylhydrazyl)

Evaluation of free radical scavenging against (DPPH) was done with a slight modification from the method of Hojjati et al. [13]. First, the main solution (concentration 1000 ppm) was prepared from the essential oil using methanol and subsequent concentrations were obtained from it. Then 0.1 mM methanolic solution was prepared from DPPH powder as the control sample and its absorption was taken. Different concentrations of essential oils were mixed with this solution at a ratio of 1:1 and kept in the dark for 30 minutes, then their absorbance was obtained at a wavelength of 517 nm by a spectrophotometer. The inhibition of oxidation by essential oil in different concentrations was calculated by equation (1).

$[(A_{control}-A_{sample})/A_{control}] \times 100$ Equation 1

2-5- ABTS assay (2,2'-azino-bis(3-ethylbenzothiazoline-6-sulfonic acid))

The percentage of free radical inhibition ($ABTS^{+}$) by coriander essential oil was determined with slight changes from the method of Kaparakou et al. (2021). The solution of this free radical with a specific concentration was obtained using distilled water. Next, 2.45 mM of potassium persulfate was prepared, and these two solutions were mixed with a ratio of 1:2 respectively; then kept in a dark place for 16 to 24 hours. On the next day, the obtained cationic solution was diluted with methanol until it gave an absorbance equal to 0.7 ± 0.02 (control solution). Then, it was combined with different dilutions of the essential oil that had been prepared in a ratio of 1:1, and after 6 minutes, the absorption of the samples was taken at a wavelength of 734 nm. The percentage of radical inhibition was reported by using equation 1 [14].

2-6- Estimating the inhibitory potential of essential oil against pathogens

of 6 foodborne pathogens including *Escherichia coli* 12435ATCC, *Shigella dysenteriae* 13313ATCC,

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Salmonella typhi 65154ATCC, *Staphylococcus aureus* 14154ATCC, *Listeria monocytogenes* 19115ATCC and *Bacillus cereus* 10876ATCC to determine the antimicrobial power of the essential oil obtained from coriander seeds by 4 different methods: disc diffusion agar, well diffusion agar, minimum inhibitory concentration and minimum bactericidal concentration.

2-6-1- Preparing foodborne pathogenic bacteria

To perform microbial tests, fresh cultures of pathogenic bacteria were needed. Standard suspensions of the included bacteria were prepared using 0.5 McFarland standard (1.5 x 108 CFU/mL). This standard suspension was prepared using a spectrophotometer at a wavelength of 625 nm at an absorbance between 0.08 and 0.13 [15].

2-6-2- Disc diffusion agar assay

Blank discs were immersed in essential oil for 15 minutes. After surface culture of bacterial suspension on MHA medium, discs containing essential oil were placed on the surface of the agar with a specified distance from each other and the wall of the Petri dish. After 24 hours in a 37°C incubator, the diameters of the inhibitory zones around the discs were measured; reported in millimeters and compared to each other [16].

2-6-3- Well diffusion agar

To determine the inhibitory effect of this essential oil on the growth of pathogens used by the well diffusion method, first, 100 µl of the suspensions were cultured on Mueller Hinton agar medium, then wells were created on the agar using a glass pasteur pipette. Then, 20 µl of sterilized essential oil was injected into the wells. One well was taken as a control and filled with distilled water. After 24 hours of incubation at 37°C, the inhibition zones formed around the wells was measured and reported [17].

2-6-4- Minimum inhibitory concentration

The serial dilution method was used to perform this microbial test. First, the initial concentration was prepared mixing Müller-Hinton broth culture medium, essential oil and 5 ml of dimethylsulfoxide (DMSO). Other sequel concentrations obtained by adding 5 mL of MHB to each one of them. 100 µl of each concentration was taken with a sampler and transferred into the wells of a 96-well plate. Then 20 µl of the prepared suspensions was added to each dilution so that each row contained different concentrations of the essential oil containing bacteria. A positive and a negative control was considered in each row. The negative control was the mixture without antibacterial agent and the positive control was the mixture without bacteria. After incubation for 24 hours at 37°C, the 96-well plate was removed from the incubator to add color reagent to the houses. A 5% solution of 2,3,5-Triphenyl-tetrazolium chloride (TTC) as color reagent was added (20 µl) to the and transferred to the incubator again for 30 minutes. The first well without preserving red color was selected as the minimum concentration that inhibited bacterial growth [18].

2-6-5- Minimum bactericidal concentration

To determine the minimum bactericidal concentration of the essential oil, 100 µl of colorless wells (no bacterial growth) were taken and cultured on the MHA. 24 hours after incubating, Petri dishes were removed and the concentrations that were free of bacterial growth were selected and reported as MBC [19].

2-7- Statistical analysis

SPSS (version 26) software and one-way Anova statistical analysis of data were used. The comparison between average data was done by Duncan's test with a confidence level of 95%.

3- results and discussion

3-1- Determining the chemical composition of coriander seed essential oil

The main chemical compounds of coriander essential oil obtained with a gas chromatograph connected to a mass spectrometer are listed in Table 1 and the corresponding chromatogram is shown in Figure 1. According to Table 1, this essential oil mainly consists of monoterpenes and p-cymene. Linalool (L) equal to 52.4 percent was identified as the main component, which was lower than the results obtained from the research conducted by Omidi mirzaei et al. (76.75%). Depending on the different stages of maturity, there are difference in coriander seed essential oils; in such a way that the percentage of linalool is low at the beginning of the

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maturation of the seed and reaches its peak in the last stages [20].

Monoterpenes with the chemical formula of $C_{10}H_{16}$ are the secondary most produced metabolites by plants, which can be accessed mainly by extracting the essential oils of plants. These volatile hydrocarbons and their derivatives, which are responsible for the specific flavor of plants and fruits; In the past, they were used for the purpose of preserving food and also for therapeutic properties. The properties of these compounds include antimicrobial, anti-inflammatory and intestinal microflora adjustment. Also, in recent researches, anti-obesity and anti-diabetes activity of monoterpenes has been investigated and proven through balancing the metabolism in the body. Monoterpenes are found in various forms. Linalool is an aromatic alcoholic monoterpene and one of the most important and widely used monoterpenes found in plants with high biological activity. This compound induces its antimicrobial effect by disrupting the cell membrane. The non-toxicity of monoterpenes increases their potential in edibles. Despite all the mentioned properties of monoterpenes, a safe and accurate amount for consumption in foods has not yet been determined [21, 22 & 23].

An important issue is the high percentage of Cymene, a volatile and aromatic hydrocarbon in essential oil. Cymenes are known as the main components with antimicrobial activity of essential oils and extracts in aromatic plants. In the research conducted in recent years on laboratory mice, it shows its analgesic, antimicrobial and anti-inflammatory properties. Antioxidant activity and creating oxidative balance are also considered to be the characteristics of cements. Of course, the definite and safe amount for its consumption has not yet been determined. The benzene ring contained in it may be dangerous for the consumer in higher dose of consumption, although this compound is recognized as generally safe by the US Food and Drug Administration [24]. The amount of this compound in the research of Omidi mirzaei et al. was determined less (1.83%), which justifies the difference in the results of these two studies [20]. In another study, the amount of linalool in coriander essential oil was 66.07% and the amount of cymene was 6.35% [25].

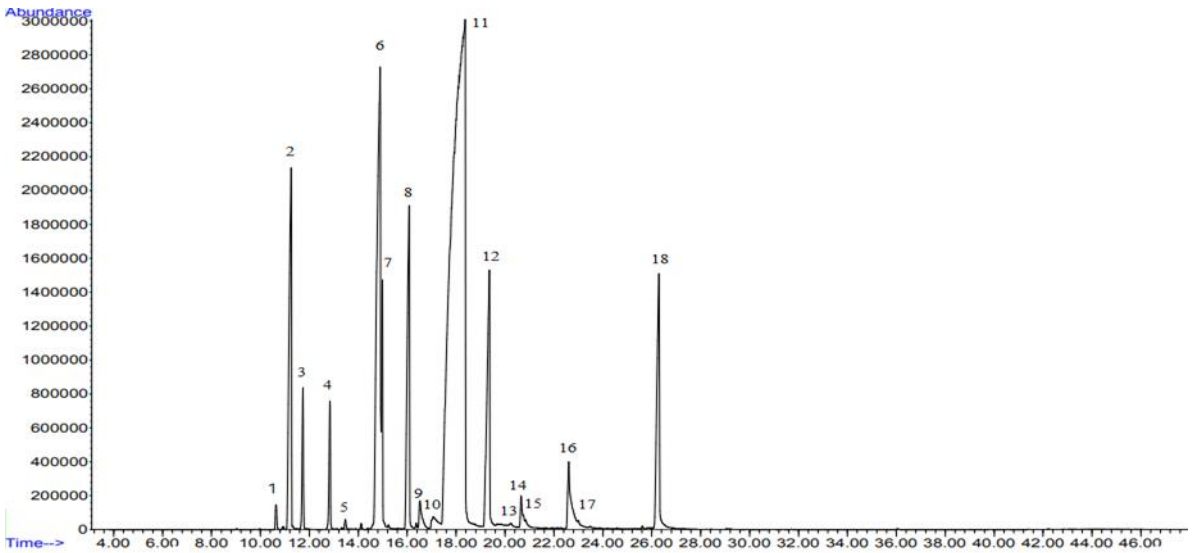

Figure 1. Chromatogram of coriander seed essential oil.

Table 1. Chemical composition of coriander seed essential oil

No	Compound	%	RT
1	Tricyclene	0.24	10.641
2	α.-Pinene	6.30	11.253

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3	Camphene	1.35	11.741
4	2-β- Pinene	1.36	12.852
5	β-Myrcene	0.12	13.474
6	Benzene	12.70	14.896
7	dl-Limonene	2.28	14.985
8	γ-Terpinene	5.55	16.074
9	cis-Linalool Oxide	0.73	16.519
11	Linalool	52.40	18.363
12	Camphor	5.72	19.363
13	dl-Limonene	0.21	20.229
14	α-Terpineol	0.62	20.662
`15	Camphene	0.27	20.84
16	trans- Geraniol	1.85	22.607
17	Geraniol	0.30	22.995
18	2,6-Octadien-1-ol	5.29	26.295

3-2- Antioxidant ability of coriander essential oil

Polyphenols are valuable plant compounds that not only change the color and flavor of food, but also have other biological benefits such as anti-cancer and antioxidant properties. In fact, there is an inverse relationship between the amount of polyphenol in the consumed feed and oxidation; In such a way that the polyphenolic groups, by accepting the electron, will disrupt the oxidative reactions inside the cell and will restore the balance [26 & 27].

The total phenolic and flavonoid content of the essential oil obtained from coriander seeds was calculated as 75.60 ± 0.01 mg of gallic acid and 715.33 ± 5.77 mg of quercetin per gram of essential oil. The mentioned values were different and higher than other studies conducted in this field, and this difference can be due to various reasons such as harvest season and grain maturity, antioxidant test method and standard curve [28]. However, the phenolic and flavonoid content of the essential oil will have a potential effect on the inhibition of free radicals. Using of the stable free radical DPPH was suggested to investigate the antioxidant properties of food, and together with the cationic radical ABTS, the overall capacity to inhibit radicals was determined and investigated through the substance's ability to transfer electrons or hydrogen [29 & 30].

The ability to inhibit DPPH and ABTS free radicals by the essential oil was investigated and the results are reported in Table 2. The highest inhibitory power at 1000 ppm concentration was equal to 51.95% for DPPH radical and 44.70% for ABTS free radical. An upward trend and a big difference in DPPH radical inhibition percentage were observed in the five subjected concentrations. Based on data at Table 2, the inhibitory effect significantly increased from 12.89% at the concentration of 200 ppm to 51.95% at the concentration of 1000 ppm; In contrast to the inhibition of ABTS, which went from 33.86% in the lowest concentration of essential oil to 44.70% in the highest concentration of essential oil, which was a difference equal to 10.84%. In a research about the characteristics of coriander essential oil and its use in the food industry; This inhibitory capacity was determined as 51.05%, which is almost equal to the percentage specified in the present study [25].

The antioxidant property of coriander essential oil was also calculated in another study and the concentration in which the DPPH inhibition percentage reached 50% was reported as 9 to 18 g/L [31]. But unlike the results mentioned in Table 2; The results obtained by Omidi mirzaei et al. regarding the antioxidant property of this essential oil showed that at the same concentration (900 ppm), the percentage of ABTS radical inhibition was higher than DPPH and equal to 66.60%. The DPPH radical inhibition percentage was close to the present result and equal to 53.75% [7]. The results of the antioxidant power of the essential oil were almost similar in the conducted studies. The antioxidant effect of essential oil can be due to several factors

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such as the amount of monoterpenes and polyphenols in it.

Table 2. Antioxidant activity of coriander essential oil (DPPH and ABTS)

Concentration (ppm)	Radical scavenging effect (%)	
	DPPH	ABTS
200	12.89 ± 0.24^{A}	33.86 ± 0.77^{A}
400	27.61 ± 0.72^{B}	37.75 ± 0.42^{B}
600	43.35 ± 0.87^{C}	39.44 ± 0.45^{C}
800	50.14 ± 0.29^{D}	41.49 ± 0.89^{D}
1000	51.95 ± 0.24^{E}	44.70 ± 0.70^{E}

The data shown in the table are "mean ± standard deviation" in 3 replicates. The capital letters in each column indicate a significant difference at $P< 0.05$ between radical scavenging effect of different essential oil concentrations.

3-3- Antimicrobial activity of coriander essential oil

Extracts and essential oils are rich in antimicrobial compounds such as polyphenols and terpenes. Cymene is the most important antimicrobial agent found in thyme and oregano. The amount of this substance in the tested coriander seed essential oil is significantly high, which justifies the high antibacterial, antifungal and antiviral activity. Another use of this compound is in the prevention and treatment of cough and sputum [24]. Non-observance of health and safety in the food industry and consumption of contaminated food has caused food-borne diseases in people all over the world; which has created a growing hazard to public health. One of the ways to eradicate these diseases was the use of preservatives, which due to the resistance of these types of pathogens as well as the sensitivity of these preservatives, the investigation and introduction of natural preservatives with high antimicrobial power has become one of the trending needs in the food industry.

Among the main pathogens that can be identified as responsible for infections caused by contaminated food are two bacteria, *Escherichia coli* and Salmonella [32 & 33]. The results of determining the inhibitory power of coriander seed essential oil against six pathogenic bacteria (three gram-positive bacteria and three gram-negative bacteria) by disk diffusion are reported in Table 3.

Table 3. Antibacterial effect of coriander essential oil (disc diffusion agar method)

Inhibition zone (mm)	Pathogens					
	E. coli	*S. dysenteriae*	*S. typhi*	*S. aureus*	*L. monocytogenes*	*B. cereus*
Coriander essential oil	18.20 ± 0.40^{A}	14.10 ± 0.50^{B}	16.30 ± 0.20^{C}	19.60 ± 0.50^{D}	20.80 ± 0.35^{E}	24.00 ± 0.30^{F}

The data shown are "mean ± standard deviation", with 3 replicates. Different capital letters indicate a significant difference ($p<0.05$) between the antimicrobial effect of essential oil on pathogens.

According to the results, the smallest diameter of the halo of non-growth in the agar disk method containing essential oil in the medium related to *Shigella dysenteriae* bacteria was found to be 14.10 mm. The biggest inhibition zone was related to the gram-positive bacteria *Bacillus cereus* (24 mm). The ability to inhibit bacterial growth by coriander essential oil based on well diffusion method is given in Table 4.

The results were almost the same as the disk diffusion method. In both tests, the ability of the essential oil to inhibit Gram-positive bacteria was

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higher than Gram-negative bacteria; which indicates the higher resistance of Gram-negative bacteria to this essential oil. It should be mentioned that at the well diffusion, unlike the disk diffusion, the gram-negative bacteria *Escherichia coli* showed more sensitivity to the essential oil and a greener inhibition zone appeared around it. The diameter of this halo was close to the diameter of inhibitory zones of gram positives.

Table 4. Antibacterial effect of coriander essential oil (well diffusion agar method)

Inhibition zone (mm)	Pathogens					
	E. coli	*S. dysenteriae*	*S. typhi*	*S. aureus*	*L. monocytogenes*	*B. cereus*
Coriander essential oil	20.10 ± 0.60^{A}	16.50 ± 0.25^{B}	16.50 ± 0.40^{C}	21.40 ± 0.30^{C}	22.20 ± 0.50^{D}	24.60 ± 0.20^{E}

The data shown are "mean ± standard deviation" with 3 replicates. Similar capital letters indicate a significant difference ($p<0.05$) between the antimicrobial effect of essential oil on pathogens.

To determine the inhibitory and bactericidal activity of essential oil against selected pathogenic bacteria, different concentrations of essential oil were prepared; which the results of the tests were reported in Table 5. According to Table 5, coriander essential oil at the lowest concentrations had the ability to prevent the growth of pathogenic bacteria, so that at a concentration of 2 mg/ml, it was able to inhibit the growth of three subjected Gram-positive bacteria.

According to the results, the most resistant bacteria to essential oil was *Shigella dysenteriae*, which showed its lack of growth at a concentration of 8 mg/ml. Also, this essential oil showed bactericidal effect against all the pathogens. The lowest concentration of essential oil that could eliminate the resistant *Shigella dysenteriae* bacteria was 512 mg/ml of essential oil. Also, Gram-positive bacteria *Staphylococcus aureus* showed less sensitivity to essential oil than other Gram-positive bacteria in the MBC test. Ghazanfari et al. investigated the antimicrobial ability of coriander seed essential oil against a Gram-positive bacterium (*Staphylococcus aureus*) and a Gram-negative bacterium. The concentration of essential oil used in disk diffusion and well methods was equal to 300 mg/ml. The inhibitory zone diameter was reported as 10 and 15 mm, respectively. Also, the results of the MIC and MBC test of the essential oil against the bacteria were evaluated as 16 and 32 mg/ml, respectively; which is higher than the concentrations determined in the present study, while the effect of their essential oil on Gram-positive bacteria was consistent with our results [11].

In another study, the effect of this essential oil on various bacteria such as *Escherichia coli*, *Listeria monocytogenes* and *Staphylococcus aureus* was investigated by determining the lowest concentration of growth inhibition. The results were similar to previous studies and based on the higher sensitivity of gram positives against essential oil. The specified concentration of essential oil against *Escherichia coli* was reported as 50 µg/ml, 6.25 µg/ml against the pathogen *Listeria monocytogenes*, and 12.5 µg/ml against *Staphylococcus aureus* bacteria [34].

The results obtained from the evaluation of essential oil's antimicrobial activity in another study were different from our results. The diameter of the inhibition zone around the disc containing coriander seed essential oil which was exposed to *Bacillus cereus* bacteria was 30.30 mm. This value was reported as 29.20 and 23.15 mm for *Escherichia coli* and *Salmonella typhi*, respectively. However, the essential oil in the current study had growth inhibitory power at a lower concentration [20]. Due to the lower percentage of p-cymene and polyphenols measured in both studies, we can justify the reason for these differences.

The inhibition effect on the pathogen by antimicrobial agents is done by attacking the invading agent to different parts of the membrane. The difference between the membranes structure of Gram-positive and Gram-negative bacteria can be a reason for their different reactions to essential oils [36 & 37]. The antimicrobial effect of this essential oil was carried out in many studies on bacteria and fungi, and the results indicated the appropriate and strong effect of coriander on the microbial agent.

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This essential oil alone or by interacting with other antibiotics can have a significant effect on pathogens, especially gram positive bacteria. In fact, the use of this substance in combination with a suitable antibiotic can have a synergistic effect, improve the weak points and cause the development of essential oil properties and defeat the resistance of pathogens against old antimicrobial agents. The antibiotic gentamicin can be one of the candidates for combination with coriander seed essential oil with synergistic properties [36 & 37].

Table 5. MIC and MBC of coriander seed essential oil

Bacteria	MIC (mg/mL)	MBC (mg/mL)
E. coli	4	256
S. dysenteriae	8	512
S. typhi	4	256
S. aureus	2	256
L. monocytogenes	2	128
B. cereus	2	128

4- Conclusions

In this research, at first, the chemical composition of coriander seed essential oil was determined by spectroscopy where the monoterpene linalool and p-Cymene were specified as the main compounds. Monoterpenes, as the main constituents of essential oils, play an essential role in antioxidant and antimicrobial properties. Based on the tests performed on essential oils in this study, the inhibitory effect on DPPH and ABTS free radicals was determined as 51.95% and 44.70% in the highest concentration, respectively. The total phenol and flavonoid content of the essential oil was also calculated and reported to justify its antimicrobial and antioxidant properties. The main characteristic of the essential oil was its antimicrobial properties against 6 pathogenic bacteria. Coriander seed essential oil showed a very high antibacterial activity. Based on the obtained results, it can be claimed that this essential oil in a certain concentration can have a high potential in the food industry as a safe additive and a strong preservative.

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مقاله علمی_پژوهشی

اسانس دانه گشنیز (*Coriandrum sativum*): تعیین ترکیبات شیمیایی، قدرت آنتی‌اکسیدانی و فعالیت ضدمیکروبی

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چکیده

افزودنی‌ها و بهبود دهنده‌های کیفیت مواد خوراکی نقش فراوانی در صنایع غذایی دارند. امروزه با توجه به مسائل ایمنی و سلامت غذایی و نیاز بازار به ورود محصولات خوراکی جدید متناسب با سلیقه متنوع مصرف‌کنندگان؛ بررسی خواص و معرفی گیاهان و عصاره‌های آبی و روغنی آن‌ها به روندی جدید برای پاسخ به این پیش آمد تبدیل شده است. در مطالعه حاضر، پس از تعیین ترکیبات عمده تشکیل‌دهنده، ویژگی‌های اسانس دانه گشنیز از نظر میکروبی و اکسیدانی تعیین شد. براساس طیف‌سنجی با دستگاه گاز-کروماتوگراف، لینالول با مقدار ۵۲/٤۰ ٪ به‌عنوان ترکیب اصلی سازنده اسانس مشخص شد. همچنین مقدار فنل و فلاونوئید به‌ترتیب ۷۵/٦۰ میلی‌گرم گالیک اسید و ۷۱۵/۳۳ میلی‌گرم کوئرستین در هر گرم اسانس محاسبه شد. دو روش بررسی فعالیت آنتی‌اکسیدانی DPPH و ABTS، انجام گرفت و مشخص شد در غلظت یکسان (۱۰۰۰ppm) مهار رادیکال آزاد DPPH برخلاف ABTS به حد بالاتری از ۵۰ درصد می‌رسد (۵۱/۹۵ ٪). کم‌ترین و بیشترین قطر هاله عدم رشد در روش دیسک دیفیوژن به ترتیب مربوط به باکتری *شیگلا دیسانتری* (۱٤/۱۰ میلی‌متر) و *باسیلوس سرئوس* (۲٤ میلی‌متر) بود. حداقل غلظت مهارکنندگی برای باکتری‌های *اشرشیاکلی*، *شیگلا دیسانتری*، *سالمونلا تیفی*، *استافیلوکوکوس اورئوس*، *لیستریا مونوسیتوژنز* و *باسیلوس سرئوس* به ترتیب ٤، ۸، ٤، ۲، ۲ و ۲ میلی‌گرم بر میلی‌لیتر بود. حداقل غلظت کشندگی اسانس گشنیز برای باکتری‌های مذکور به ترتیب ۲۵٦، ۵۱۲، ۲۵٦، ۲۵٦، ۱۲۸ و ۱۲۸ میلی‌گرم بر میلی‌لیتر بود. براساس نتایج به‌دست آمده می‌توان ادعا داشت که این اسانس در غلظت و دوز مشخص می‌تواند پتانسیل بالایی در صنعت غذا به‌عنوان یک ماده افزودنی ایمن و نگهدارنده قوی داشته باشد.

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