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Review

Antibacterial Properties of Natural Compounds Extracted from Plants Compared to Chemical Preservatives against *Salmonella* Spp-A Systematic Review

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Abstract: Due to consumer awareness of the chemical preservatives hazards, public reception the need for medicinal plants is growing recently. In most countries contamination of food products with pathogenic bacteria (especially *Salmonella*) are followed by health and nutritional losses. Also, due to increasing to drug resistance in pathogenic microorganisms, replacement antibiotics with the natural antimicrobial compounds from plants are convenient and useful. In this review article, anti-bacterial effects of Iranian indigenous medicinal plants against *Salmonella* (during 2000 to 2016) have been investigated. This article reviewed data from 269 articles originating from WHO, Civilica, Magiran, SID, Elsevier, Science direct and PubMed etc., using the keywords essential oil, *salmonella*, antimicrobial activity, antibiotic alternative. These findings suggest that antibacterial activity of the Iranian indigenous medicinal plants against *Salmonella* was remarkably better than chemical drugs. Replacement of synthetic antibiotics with antimicrobial substances of plant origin is more essential.

Keywords: Essential oil, *Salmonella*, Antimicrobial activity, Antibiotic alternative

1. Introduction

Salmonella, the most important foodborne zoonotic bacterium, as foodborne illness caused by Salmonella in recent decades has been considerable public health. A lot of studies and researches deal with the prevalence of Salmonella in animals, food, humans and the environment (Hansen et al., 2016). There are more than 1,200 types of salmonella detected in the world. All of them are potentially dangerous to people (Sefidkon et al., 2009).

Salmonellosis is one of the most common food-related illnesses caused by eating large amounts of living cells (Burt, 2004; Oueslati et al., 2016). Salmonella grow and were detected in a variety of food such as cheese, milk, eggs, meat, poultry, sweets, cakes and pastries at which lead to food infection (Razavi-Rohani and Griffiths, 1994; Oueslati et al., 2016). Salmonellosis is the most widespread foodborne illness. More than 20,000 cases are reported by the Center for Disease Control annually. This is probably only a small percent of the cases that occur each year actually (Oueslati et al., 2016; WHO, 2013). With considering to the occurrence of drug resistance in microorganisms, research for natural extracted antimicrobial compounds as replacement for the chemical drugs is very important. In this context, the use of medicinal antimicrobial compounds has attracted much attention. These compounds increased the shelf life of food via antimicrobial properties and also effective in improving the flavor characteristics. Also, the studies on the inhibitory effects of medicinal herbs against Salmonella in comparison with the chemicals components have been assessed.

2. Review on Recent Studies

In this review article, anti-bacterial effects of Iranian indigenous medicinal plants against *Salmonella* (during 2000 to 2016) have been analysized. This article reviewed data bases such as WHO, Civilica, Magiran, SID, Elsevier, Science direct and PubMed based on the keywords essential oil, *salmonella*, antimicrobial activity, antibiotic alternative were collected.

Dangerous bacterial infections are responsible for many deaths each year. The use of drugs for controlling infections in food due to extreme drug-resistant microorganisms is faced with a problem today so this is the reason why the search for new antibacterial compounds must be implemented. Herbal medicine is a very ancient healing art that used both cognitive and intellectual awareness as well as focus on results and antibacterial activity was reported. As it can be seen in Tables 1 to 7, the antibacterial properties of various medicinal plants are being extensively assessment all over the world (Bonjar, 2004; Lewis et al., 2006; Mahmoudi et al., 2012). Studies on Allioideae, Lamiaceae, Anacardiaceae, Asteraceae, Apiaceae family have been shown the anti-bacterial effects of these plants

against *Salmonella;* However, further studies are needed on the identification and isolation of active compounds extracted from medicinal plants as a medicinal drug.

Table 1. Antibacterial activity of *Allioideae* family against *Salmonella*

No	Plant name (Scientific name)	Effective ingredients	Results	Methods
1	Garlic (*Alliums stadium*)	Allicin	In culture medium brain heart agar dose in 10 mg/kg garlic extract was less effective in reducing the amount of *Salmonella typhimurium* colonies, but dose 40 mg/kg was more effective. Garlic cannot be effective in the early days, but in the next few days, especially with high doses significantly decreased due to frequent consumption of garlic can be seen in the colony (Jafari et al., 2003).	Proliferation in vivo
	Garlic (*Alliums stadium*)	Allicin	In Culture medium brian hart agar (BHA) was obtained minimum inhibitory concentration of garlic extract against *Salmonella typhimurium* (UUCC 101) 12/50 mg/ml and minimum bactericidal concentrations of this extract 25 mg/ml. However, the amount of MBC[1] and MIC[2] of garlic tablet extract against this bacteria were obtained respectively, 80 and 40 mg/ml thus results indicate garlic extract was much stronger than garlic tablet extract (3.3 times more) (Aliporyeganeet al., 2008).	Standard tube
	Garlic (*Alliums stadium*)	-	In culture medium mueller hinton broth (MHB) was obtained the amount of MIC and MBC of garlic extract against *Salmonella typhi* (PTCC1609) and *Salmonella paratyphi* A (PTCC 1230) 20 mg/ml (Amin and Kapadnis, 2005).	Dilution in broth
	Garlic (*Alliums stadium*)	Diallyl disulfide, Trisulfide, methyl 2-propenyl, Trisulfide, di-2-propenyl, Disulfide, methyl 1-propenyl and Dimethyl trisulfide	The amount of MIC and MBC Garlic essential oils against *Salmonella typhimurium* (ATCC 13311) at pH=6 and temperature 8°C was obtained respectively, 2400 and 4800 µg/ml and in pH=6 and temperature 15°C the amount of MIC 9600 µg/ml and ineffective in pH=3.7 and temperature 35°C (Mahmoudi et al., 2013).	Broth microdilution
5	Shallot (*Allium cepa var. aggregatum*)	-	In culture medium MHB was obtained the amount of MIC and MBC shallot extract against *Salmonella typhi* (PTCC 1609) and *Salmonella Paratyphi* A (PTCC 1230) respectively, 10 mg/ml and 20 mg/ml (Amin and Kapadnis, 2005).	Dilution in broth
6	Onion (*Allium cepa*)	-	In culture medium MHB was obtained the amount of MIC and MBC onion extract against *Salmonella typhi* (PTCC 1609) and *paratyphi* A (PTCC 1230) more than 20 mg/ml (Amin and Kapadnis, 2005).	Dilution in broth

[1] Minimum Bactericidal Concentrations
[2] Minimum Inhibitory Concentrations

Table 2. Antibacterial activity of Lamiaceae family against *Salmonella*

No	Plant name (Scientific name)	Effective ingredients	Results	Methods
1	Lavender (*lavandula stoechas*)	-	In culture medium mueller hinton agar (MHA) was obtained the zone of growth inhibition *Salmonella typhi* (ATCC 25922) under influence of alcoholic and aqueous extract of the leaves this plant with concentrations 30 mg respectively, 14/87 and 14/08 mm^3. In addition, concentration of 20 mg of alcoholic and aqueous extract had inhibitory effects and concentration of 30 mg of alcohol extract was bactericidal effect but ineffective concentration of 30 mg aqueous extract (. Khosravi and Malecan, 2004).	Disk diffusion
2	Thyme (*Zataria multiflora* Boiss)	Carvacrol	In culture medium BHI and Broth in low doses concentration of 0.03 and 0.06% of thyme has the effect of preventing the growth of *Salmonella typhimurium* No. 138. Phage type 2 (Razavilar et al., 2006).	Standard tube
3	Thyme (*Zataria multiflora* Boiss)	Carvacrol	In culture medium MHA and Broth concentrations of 0.30% this plant essential oil prevented the growth of *Salmonella typhimurium* (RITCC 2461) and was obtained the amount of MIC and MBC this plant essential oil respectively, 156/25 and 312/50 µg/ml and the amount of MIC and MBC antibiotics Flumequine respectively, 157 and 313/50 µg/ml and Oxytetracycline respectively, 470 and 930.80 µg/ml thus results showed that thyme essential oil antimicrobial effect similar to Flumequine and stronger than oxytetracycline and the average diameter of the inhibition of this essential oil with the amount of 10 micro-liter was 0/538±31/20 (Dakhili et al., 2006).	Diffusion test disk and dilution test
4	Thyme (*Zataria multiflora* Boiss)	Carvacrol, γ-terpinene and α-terpinene	Most growth of bacteria observed in the control group and the lowest growth in concentration of 0.03% this plant the essential oil (Moosavy et al., 2010).	Different concentrations of essential oils in food model
5	Thyme (*Zataria multiflora* Boiss)	-	Growth of *Salmonella typhimurium* was significantly influenced in temperature 8°C by the concentrations of combined essential oil and nisin ($P \leq 0.05$). Action inhibitory substances mentioned in temperature 8°C in concentrations higher than 0.005% of the essential oil was strong so the number of bacteria on the second day with combined concentrations of the 0.015 essential oil and 0.5 nisin, 0.03 essential oil and 0.25 nisin, 0.03 essential oil and 0.5 nisin was less than 2 log (Moosavy et al., 2008).	Different concentrations of essential oils in food model
6	Thyme (*Zataria multiflora* Boiss)	-	In culture medium MHB was obtained the amount of MIC and MBC this plant extracts against *Salmonella typhi* (PTCC 1609) respectively, 0/80 and 1/60 µg/ml (Amin and Kapadnis, 2005).	Dilution in broth
7	Thyme (*Zataria multiflora*)	Carvacrol	Thyme oil extract with concentration 0.03% would prevent the growth of *Salmonella*	Dilution in broth

			(Hammer et al., 1999).	
8	Thyme (*Zataria multiXora* Boiss.)	Carvacrol and Thymol	In culture medium MHA obtained the amount of MIC and MBC against *Salmonella typhimurium* (ATCC 14028) 500 ppm and measured inhibition zone diameter 16/02 mm (Boroumand et al., 2013).	Disk diffusion
9	Thyme (*Zataria multiXora* Boiss.)	Carvacrol, Thymol, γ-terpinene, P-cymene and -αterpinene	In culture medium MHA concentrations of 1, 2.50 and 5% this plant essential oil were measured inhibited the growth of *Salmonella Paratyphi* A (PTCC 1230) respectively, 0, 9/30 and 15/60 mm (Sadeghzadeh et al., 2006).	Disk diffusion
10	Thyme (*Zataria multiXora* Boiss.)	Carvacrol, Thymol, γ-terpinene, P-cymene and -αterpinene	In culture medium MHA concentrations of 1, 2.50 and 5% essential oil this plant were measured inhibited the growth of *Salmonella Paratyphi* B (PTCC 1231) respectively, 0, 9/30 and 15/60 mm (Sadeghzadeh et al., 2006).	Disk diffusion
11	Thyme (*Zataria multiXora* Boiss.)	-	In culture medium MHA was obtained the amount of MIC and MBC for *Salmonella typhi* respectively, 0/80 and 1/60 mg/ml (Fazeli et al., 2007).	Disk diffusion
12	Thyme (*Zataria multiXora* Boiss.)	Carvacrol, Thymol, γ-Terpinene, P-Cymene, -αTerpinene, α-Pinene and α-Thujene	The amount of MIC and MBC this plant essential oil against *Salmonella typhimurium* (ATCC 13311) at pH=6 and temperature 35°C was obtained respectively, 1200 and 4800 µg/ml and in pH=3.7 and temperature 8°C respectively, 300 and 600 µg/ml (Mahmoudi et al., 2013).	Broth microdilution
13	Thymus vulgaris (*Thymus vulgaris* L.)	β-caryophyllene, p-Cymene-3-ol, -γterpinene p-cymene and Thymol	In the culture medium MHB was obtained the amount of MIC and MBC for *Salmonella typhimurium* (ATCC 1408) respectively, 1/56 and 3/12 mg/ml and the amount of MIC and MBC for *Salmonella typhimurium* (LT2 DT104) 1/56 mg/ml (Miladi et al., 2016).	Standard tube
14	Thymus vulgaris (*Thymus vulgaris* L.)	-	Analyzing of data showed number of *Salmonella enteritidis* PT4 in sauce samples containing different percentages extract statistically significant difference was observed with the control sample while samples containing 0/10 and 0/20% extract had the same effect on *Salmonella enteritidis* (Zabetian Hoseini et al., 2010).	Different concentrations of essential oils in food model
15	Thyme (*Thymbra spicata*)	Carvacrol and Thymol	In the culture medium MHA the amount of MIC and MBC this plant essential oil against *Salmonella typhi* obtained 60 µg/ml and the average of diameter of growth inhibition zone measured 35 mm and the diameter of growth inhibition zone for antibiotics gentamicin, kanamycin and Ciprofloxacin measured respectively, 22/70, 27/70 and 12 mm thus results showed this plant essential oil more effective than antibiotics (Sabzali et al., 2015).	Disk diffusion
16	Mentha (*Mentha longifolia* L.)	Carvacrol, Thymol γ-Terpinene, α-Pinene and *trans*-Caryophyllene	The amount of MIC and MBC this plant essential oil against *Salmonella typhimurium* (ATCC 13311) at pH=6 and temperature 35°C was obtained respectively, 9600 and 4800 µg/ml and in pH=7/30 and temperature 15°C respectively, 19200 and 1200 µg/ml (Mahmoudi et al., 2013).	Broth microdilution
17	Mentha	Pulegone,	The amount of MIC this plant essential oils	Disk diffusion

	(*Mentha longifolia Hudson*)	cis-Piperitone, epoxide, Menthone, Isomenthone and Carvone	against *Salmonella enteritidis* (IK27) was obtained 61/30 µg/ml and diameter zone inhibition growth measured 8 mm (Azizkhani and Ataee, 2012).	
18	Mentha (*Mentha piperita*)	Mentone, Menthol, Neomenthol, Menthyl acetate and 1,8-Cineole	In the culture medium MHA was obtained the amount of MIC essential oil *Mentha piperita* against *Salmonella typhi* (PTCC 1639) 250 ppm (Kazem Alvandi et al., 2010).	Disk diffusion
19	Marjoram (*Origanum vulgare* L.)	γ-Terpinen, Thymol, Carvacrol and α-Terpinine	In the culture medium MHA and broth concentrations of 1% essential oil this plant prevents from the growth of *Salmonella typhimurium* (ATCC 2461) (Dakhili et al., 2005).	Disk test diffusion and dilution test
20	Marjoram (*Origanum vulgare* L.)	Carvacrol	2% of the essential oil this plant was prevented the growth of *Salmonella typhimurium* (Hammer et al., 1999).	Agar dilution and broth micro dilution
21	Marjoram (*Origanum vulgare* L.)	-	In the culture medium MHA) was obtained the amount of MIC and MBC of aqueous extract *marjoram* against *Salmonella typhi* (PTCC1609 1/25 mg/ml (Shariat et al., 2013).	Standard tube
22	Salvia (*Salvia suffruticosa* Montbr)	-	In the culture medium MHA concentrations of 50 micro-liter of this plant essential oil, created diameter zone inhibit the growth the amount of 13 mm for *Salmonella typhi* (PTCC 1185) (Chalbian et al., 2003).	Measure the diameter of the inhibitory zone with method wells
23	Satureja (*Satureja montana* L.)	α-thujene, α-pinene, -γ terpinene, p-cymene and Carvacrol	In the culture medium MHB was obtained the amount of MIC and MBC for *Salmonella* typhimurium (ATCC 1408) and *Salmonella* typhimurium (LT2 DT104) 0/78 mg/ml (Miladi et al., 2013).	Standard tube
24	Satureja (*Satureja mutica*)	Myrcene, α-terpinene, p-cymene, gamma-terpinene, thymol and carvacrol	In the culture medium MHA concentrations of 2.50% and 5% essential oil this plant against *Salmonella paratyphi* A (PTCC 1230) an average diameter inhibition zone created respectively, 8 and 10 mm (Miladi et al., 2013).	Disk diffusion
25	Satureja (*Satureja edmondi*)	p-cymene, gamma-terpinene, trans-sabinene hydrate, a-terpineol and thymol	In the culture medium MHA concentrations of 2.50% and 5% this plant essential oil against *Salmonella paratyphi* A (PTCC 1230) an average diameter inhibition zone created respectively, 7 and 11 mm (Miladi et al., 2013).	Disk diffusion
26	Satureja (*Satureja Bakhtiarica*)	p-cymene, linalool, gamma-terpinene, borneol and thymol	In the culture medium MHA concentrations of 2.50% and 5% this plant essential oil against *Salmonella paratyphi* A (PTCC 1230) an average diameter inhibition zone created respectively, 8 and 11 mm (Miladi et al., 2013).	Disk diffusion
27	Satureja (*Satureja mutica*)	Myrcene, α-terpinene, p-cymene, gamma-terpinene, thymol and carvacrol	In the culture medium MHA concentrations of 2.50% and 5% essential oil this plant against *Salmonella paratyphi* B (PTCC 1230) an average diameter inhibition zone created respectively, 8 and 12 mm (Miladi et al., 2013).	Disk diffusion
28	Satureja (*Satureja edmondi*)	p-cymene, gamma-terpinene, trans-sabinene hydrate, a-terpineol and thymol	In the culture medium Mueller-Hinton agar concentrations of 2.50% and 5% essential oil this plant against *Salmonella paratyphi* B (PTCC 1230) an average diameter inhibition zone created respectively, 6 and 12 mm (Miladi et al., 2013).	Disk diffusion
29	Satureja	p-cymene, linalool,	In the culture medium MHA concentrations of	Disk diffusion

	(*Satureja Bakhtiarica*)	gamma-terpinene, borneol and thymol	2.50% and 5% essential oil this plant against *Salmonella paratyphi* B (PTCC 1230) an average diameter inhibition zone created respectively, 9 and 11 mm (Miladi et al., 2013).	
30	Satureja (*Satureja hortensis*)	Carvacrol	The amount of MIC and MBC of this plant essential oil against *Salmonella typhimurium* (ATCC 14028), was obtained respectively, 125 and 500 µg/ml (Mahboubi and Qazian bidgoli, 2009).	Standard tube and disk diffusion
31	Satureja (*Satureja hortensis*)	-	Disk diffusion method extracts of the plant growth were obtained inhibition zone diameter against *Salmonella typhimurium* (ATCC 13311) in concentration of 10%, 24 mm and in concentration of 5%, 20 mm and in agar well method in concentration of 10%, 22 mm and in concentration of 5%, 19 mm (Valizadeh et al., 2014).	Disk diffusion and agar well
32	Origanum vulgare (*Menth Longifolia*)	Menthone, 1,8-Cineole Linalool, Pulegone and Thymol	In the culture medium BHI was obtained the amount of MIC and MBC of this plant essential oil in concentration of 600 ppm against *Salmonella typhimurium* (phage type II 138), at pH=5 respectively, 300 and 600 µg/ml and at pH=7 was ineffective and combined with nisin concentration 5 mg/ml at pH=5, the amount of MIC and MBC was obtained respectively, 150 and 600 µg/ml and at pH=7 were ineffective thus results showed the synergistic effect of nisin with oregano is low (Rahnama and Asghri, 2013).	Disk diffusion
33	Rosemary (*Rosmarinus o fficials*)	alpha-Pinene, Camphene, 1,8-Cineole, Camphor, Ocimeonene and Camphene	In the culture medium BHI were obtained the amount of MIC and MBC rosemary essential oils with concentrations 600 ppm against *Salmonella typhimurium* (phage type II 138) at pH=5 respectively, 75 and 150 µg/ml and at pH=7 was obtained respectively, 150 and 300 µg/ml and combined with nisin concentration 5 mg/ml and at pH=5 the amount of MIC and MBC was obtained respectively, 38 and 78 µg/ml and the amount of MIC and MBC at pH=7 respectively, 75 and 150 thus results indicating effect rosemary is synergistic with nisin (Mohammadpour Vashvaei et al., 2015).	Disk diffusion
34	*Teucriumpolium*	-	The result of plant extracts showed the highest amount of MIC concentration of 10 mg/ml (Teymouri et al., 2014).	Disk diffusion
35	Poleigamander habitat of jahrom (*Teucriumpolium* L.)	α-pinene, Sabinene 1,8-Cineole, Caryophyllene oxide and Aromadendrene	In the culture medium MHA was obtained the amount of MIC this plant essential oil against *Salmonella typhimurium* 15 mg/ml and measured diameters of growth inhibition 9 mm (Teymouri et al., 2014).	Disk diffusion
36	Germander (*Teucrium polium* L)	α-pinene, β-Caryophyllene, β-pinene, Germacrene-B and Limonene	Diameter inhibition zone of this plant essential oil against *Salmonella typhi* (PTCC 1185) was measured 35 mm while affected the antibiotic gentamicin 14 mm thus results showed that the essential oil of Germander was effective more than antibiotic gentamicin (Esmaeili and Amiri, 2008).	Disk diffusion

Table 3. Antibacterial activity of Anacardiaceae family against *Salmonella*

No	Plant name (Scientific name)	Effective ingredients	Results	Methods
1	Sumac (*Rhus coriaria.L*)	B-caryophyllene, Thunbergene, Delta-cadinene and Caryophyllene oxide	In the culture medium nutrient broth of this plant essential oil in low concentrations (ppm 300) also has bacteriostatic effect against *Salmonella typhimurium* and this effect increased with increasing concentration so the concentration in 1000 ppm essential oil effect bactericidal (Radmehr et al., 2013).	Standard tube
2	Sumac (*Rhus coriaria.L*)	-	In the culture medium MHA was obtained the amount of MIC and MBC sumac extract against *Salmonella typhi* respectively, 0/20 and 0/80 mg/ml (Fazeli et al., 2007).	Disk diffusion

Table 4. Antibacterial activity of Asteraceae family against Salmonella

No	Plant name (Scientific name)	Effective ingredients	Results	Methods
1	Yarrow (*Achillea wilhelmsii* C.koch)	-	In the culture medium MHA concentrations of 50 micro-liter of this plant essential oil was measured inhibited the growth of the diameter the size of 13 mm against *Salmonella typhi* (PTCC 1185) (Azizkhani M, Ataee, 2012).	Disk diffusion
2	Artemisia (*Artemisia aucheri* Boiss.)	Linalool, borneol, Z-citral, geraniol, geranyl acetate and α-citral	in the culture medium MHA were achieved the amount of MIC and MBC of this plant essential oil against *Salmonella typhimurium* (ATCC 14028) 16 µg/ml and the average diameter of inhibition at concentrations of 15 micro-liters 10/50±0/70 mm and for the antibiotic gentamicin concentration 10 µg/disc the amount of 21±1/20 mm, thus *Artemisia* essential oil has antimicrobial effect less than the antibiotic (Mahboubi and Qazian bidgoli, 2009).	Disk diffusion and broth micro dilution
3	Camomille (*Matricaria Chamomilla* L.)	α-bisabolene Oxide, α-bisabolole Oxide, α-farnesene, β-farnesene and germacrene D	In the culture medium MHA was achieved the amount of MIC for *Salmonella typhimurium* (ATCC 14028) 4 mg/l and measured inhibition zone diameter 7/30 mm and the amount of MIC chloramphenicol and ascorbic acid against this bacteria respectively, 0/25 and 3/30 mg/l (Izadi et al., 2013).	Broth micro dilution
4	Parthenium (*Tanacetum Parthenium* L.)	Camphene, benzaldehyde, P-cymene, camphor and chrysanthenyl acetate	In the culture medium MHA was obtained the amount of MIC for *Salmonella typhimurium* (ATCC 14028) 1 mg/l and were measured diameter of inhibition 9/20 mm and the amount of MIC for chloramphenicol and ascorbic acid against this bacteria respectively, 0/25 and 3/30 mg/l (Izadi et al., 2013).	Broth micro dilution
5	Parthenium (*Tanacetum parthenium L.*)	Camphene, camphor, chrysanthenyl acetate (Trans), (E)-β-farnesene and α-pinene	In the culture medium MHA was obtained the amount of MIC and MBC of this plant essential oil against *Salmonella* typhimurium 0.78% and measured the average diameter of inhibition 6 mm (Saharkhiz et al., 2008).	Disk diffusion
6	Worm wood (*Artemisia absinthium*)	Beta-Thujone, Phellandrene, Sabinene and Cymene	In the culture medium nutrient broth (BHI) the amount of MIC aqueous extract, ethanol and methanol this plant against *Salmonella typhimurium* (phage type II) micro-dilution method for every three extract was obtained the most out of 10 mg/ml and for essential oil 300 ppm and measured the diameter of growth	Broth micro dilution

			inhibition of aqueous extract and ethanol were 8 mm and for methanol extract and essential oil 7 mm (Gandoumi et al., 2012).	
7	Worm wood (*Artemisia absinthium*)	-	In the culture medium nutrient agar was obtained the amount of MIC methanol extract against *Salmonella typhimurium* 13 mg/ml (Sengul et al., 2010).	Disk Diffusion
8	Worm wood (*Artemisia santonicum*)	-	In the culture medium nutrient agar was obtained the amount of MIC methanol extract against *Salmonella typhimurium* 13 mg/ml (Sengul et al., 2010).	Disk Diffusion

Table 5. Antibacterial activity of Apiaceae family against *Salmonella*

No	Plant name (Scientific name)	Effective ingredients	Results	Methods
1	Bunium persicum (*Bunium persicum* Boiss.)	γ-terpinen-7-al, 2-caren-10-al, cuminaldehyde, γ-terpinene and P-cymene	In the culture medium MHA with concentration of 30 micro-liter of this plant essential oil against *Salmonella typhi* (1634) was created the diameter of inhibition zone 14 mm and tetracycline 11 mm thus results showed antimicrobial activity of this plant essential oil was more than tetracycline (Moghtader et al., 2009).	Disk diffusion
2	Bunium persicum (*Bunium persicum* (Boiss.) B. Fedtsch.)	γ-terpinene, p-cuminaldehyde, γ-terpinen-7-al, p-cymene and limonene	In the culture medium MHA the amount of MIC and MBC was obtained in vitro this plant essential oil against *Salmonella enteritidis* (RITCC 1624) 3 mg/ml. The amount of MIC was obtained for antibiotic chloramphenicol 0/18 mg/ml and ascorbic acid 3 mg/ml that represent the antibiotic chloramphenicol effectively more than this essential oil and ascorbic acid is equal with the essential oil (Oroojalian et al., 2010).	Broth micro dilution
3	Cumin (*Cuminum cyminum* L.)	ß-pinene, p-cymene, γ-terpinene, p-cuminaldehyde and safranal	In the culture medium MHA the amount of MIC and MBC was obtained in vitro this plant essential oil against *Salmonella enteritidis* (RITCC 1624) 3 mg/ml. The amount of MIC was obtained for antibiotic chloramphenicol 0/18 mg/ml and ascorbic acid 3 mg/ml that represent the antibiotic chloramphenicol more effectively than this essential oil and ascorbic acid is equal with the essential oil (Oroojalian et al., 2010).	Broth micro dilution
4	Cumin (*Cuminum cyminum* L.)	β-Pinene, p-Cymene, γ-Terpinene, Cuminaldehyde, α-Pinene-7-ol and	The amount of MIC and MBC of this plant essential oil against *Salmonella typhimurium* (ATCC 13311) at pH=6 and temperature 35°C was obtained respectively, 2400 and 4800 µg/ml and in pH=7/30 and temperature 35°C respectively, 600 and 1200 µg/ml (Mahmoudi et al., 2012).	Broth micro dilution
5	Cumin (*Cuminum cyminum* L.)	Cuminaldehyde, 2-caren-10-al, Gamma-Terpinene, beta-Pinene And Para-Cymene	In the culture medium BHI the amount of MIC and MBC Cumin essential oils with concentration 600 ppm against *Salmonella typhimurium* (phage type II 138) at pH=5 was obtained respectively, 150 and 300 µg/ml and at pH=7 the amount of MIC 300 µg/ml and in combination this plant essential oil with nisin concentration 5 mg/ml at pH=5 the amount of MIC and	Disk diffusion

			MBC respectively, 75 and 150 µg/ml and at pH=7 the amount of MIC and MBC both was obtained 300 µg/ml thus results indicates the synergistic effect of nisin with cumin (Rahnama and Asghri, 2013).	
6	Bunium persicum (*Bunium persicum* Boiss.)	Cuminaldehyde, γ-terpinen-7-al, α-terpinene, P-cymene and 2-caren-10-al	In the culture medium MHA of this plant essential oil was created the diameter of inhibition zone 14 mm against *Salmonella typhi* (1634) and antibiotic tetracycline 11 mm thus results showed that antimicrobial activity of this plant essential oil was more than antibiotic tetracycline (Moghtader et al., 2009).	Disk diffusion
7	Ammi (*Carum copticum* (L.) C. B. Clarke)	*P*-cymene, γ- terpinen and Thymol	In the MHA this plant essential oil against *Salmonella enteritidis* (RITCC 1624), the amount of MIC and MBC was obtained in vitro respectively, 0/50 and 1 mg/ml. The amount of MIC was obtained for antibiotic chloramphenicol 0/18 mg/ml and ascorbic acid 3 mg/ml thus results indicates the essential oil this plant effective more than ascorbic acid and activity of relatively equal to the antibiotic chloramphenicol (Oroojalian et al., 2010).	Broth micro dilution
8	Anise (*Pimpinella anisum*)	Benzene, 1-methoxy-4-(1-propenyl), Longifolene-(V4), Phenol, 2-methoxy-4-(1-propenyl) and 1,2-Benzenedicarboxylic acid, diisooctyl ester	The amount of MIC and MBC this plant essential oil against *Salmonella typhimurium* (ATCC 13311) at pH=6 and temperature 8°C was obtained respectively, 600 and 9600 µg/ml and unaffected at pH=7.30 and temperature 35°C (13).	Broth micro dilution
9	Fennel (*Foeniculum vulgare* Miller)	-	The mean diameter of inhibition *Salmonella typhimurium* (RITCC 2461) by this plant essential oil was obtained 10 micro-liters and 12/60±0/24 (16).	Diffusion test and disk dilution test
10	Wild celery Marsh parsley (*Kelussia odoratissima*)	Alpha Caryophyllene, Alpha Humulene, Trans-Geraniol, 3-isobenzofuranon and Cyclopropane	The amount of MIC this plant essential oil against *Salmonella typhimurium* (ATCC 13311) was obtained 10000 ppm (Mahmoudi et al., 2010).	Micro-well dilution
11	Peucedanum (*Peucedanum ruthenicum* M. Bieb)	Oxygenated monoterpenes, Hydrocarbon sesquiterpenes, Oxygenated sesquiterpenes and Thymol	In the Culture medium MHA antimicrobial effect this plant essential oil with concentration 2 mg/disc were measured against *Salmonella typhi* (ATCC 19430) 8 mm and the antimicrobial activity of neomycin (200 µg) 19 mm thus results indicates half of the antimicrobial activity of this plant was compared with neomycin (Alavi et al., 2006).	Disk diffusion
12	(*Oliveria decumbens* Vent.)	Thymol, *P*-cymene and γ-terpinene	In the culture medium mueller hinton by using the broth micro-dilution method was obtained the amount of MIC and MBC this plant essential oil against *Salmonella typhi* 0/50 µg/ml and by using the disk diffusion method was measured inhibition zone diameter of 10 mm (Mahboubi et al., 2008).	Broth micro dilution and disk diffusion

Table 6. Antibacterial activity of Vegetables and fruits against *Salmonella*

No	Plant name (Scientific name)	Effective ingredients	Results	Methods
1	Juice Pomegranate (*Punica granatum L. or Pomegranate*)	-	In the culture medium nutrient agar juice pomegranate with concentration 5 µl/disc created inhibitory zone 6/30±0/33 mm against the *Salmonella typhi* while antibiotic tetracycline with concentration 30 µl/disc created inhibitory zone 17/30±0/33 mm (Ghodratollah et al., 2011).	Disk diffusion
2	Perfect Pomegranate fruit extract (*Punica granatum L. or Pomegranate*)	-	In the culture medium nutrient agar perfect pomegranate fruit extract with concentration 250 µl/disc created inhibitory zone 11/70±0/33 mm against the *Salmonella typhi* while antibiotic tetracycline with concentration 30 µl/disc created inhibitory zone 17/30±0/33 mm (Ghodratollah et al., 2011).	Disk diffusion
3	Gourd (*Lagenaria siceraria Molina Standley*)	-	In the culture medium nutrient agar juice gourd with concentration 5 µl/disc created inhibitory zone 5 mm against the *Salmonella typhi* while antibiotic tetracycline with concentration 30 µl/disc created inhibitory zone 17/30±0/33 mm (Ghodratollah et al., 2011).	Disk diffusion
4	Gourd (*Lagenaria siceraria Molina Standley*)	-	In the culture medium nutrient agar gourd extract with concentration 250 µl/disc created inhibitory zone 11/70±0/33 mm against the *Salmonella typhi* while antibiotic tetracycline with concentration 30 µl/disc created inhibitory zone 17/30±0/33 mm (Ghodratollah et al., 2011).	Disk diffusion
5	Quercus (*Quercus.branti var* persica)	-	In the culture medium MHB was obtained the amount of MIC and MBC for methanol extract of this plant against *Salmonella typhi* (PTCC 1639) respectively, 2/50 and 5 mg/ml. EC^{4}_{50} was obtained for methanol extract 70/40 and for BHA 89/56 and BHT 41/73 and also the lowest EC_{50} belongs to BHT that was no significant difference with the extract of this plant (Ghaderi Ghahfarokhi et al., 2011).	Broth micro dilution
6	Quercus (*Quercus.castaneifolia var* castaneifolia)	-	In the culture medium MHB the amount of MIC and MBC for methanol extract of this plant against *Salmonella typhi* (PTCC 1639) was obtained respectively, 2/50 and 5 mg/ml. EC_{50} was obtained for methanol extract 42/84 and for BHA 89/56 and BHT 41/73 thus significant difference between the EC_{50} this plant extract with BHA was seen and the extract with regard to the scavenging of free radicals was stronger than BHA (Ghaderi Ghahfarokhi et al., 2011).	Broth micro dilution
7	Quercus (*Quercus.branti var* persica)	-	In the culture medium MHA was obtained the amount of MIC and MBC for ethanolic extract of this plant against *Salmonella typhi* (PTCC 1639) respectively, 2/50 and 5 mg/ml. EC_{50} was obtained for ethanolic extract 45/58 and for BHA 89/46 and BHT	Broth micro dilution

			41/73. Thus ethanol extract of this plant is a stronger antioxidant than BHA and was weaker than BHT (Ghaderi Ghahfarokhi et al., 2010).	
8	Quercus (*Quercus.castaneifolia var* castaneifolia)	-	In the culture medium MHA was obtained the amount of MIC and MBC for methanol extract of this plant against *Salmonella typhi* (PTCC 1639) 5 mg/ml. EC_{50} was obtained for methanol extract 25/08 and for BHA 89/56 and BHT 41/73 that indicates the methanol extract of this plant was effective than the mentioned two synthetic antioxidants (Ghaderi Ghahfarokhi et al., 2010).	Broth micro dilution
9	Walnut (*Juglans regia*)	-	In the culture medium MHA the amount of MIC and MBC ethanol extract this plant against *Salmonella typhimurium* (PTCC 1609) was obtained respectively, 1/25 and 2/50 mg/ml (Sharafati-chaleshtori et al., 2011).	Broth micro dilution

Table 7. Antibacterial activity of other plants against *Salmonella*

No	Plant name (Scientific name)	Effective ingredients	Results	Methods
1	Cinnamon (*Cinnanomum Zeylanicum*)	E-Cinnamaldehyde, Piperitenone, α-Copaene, Cinnamyl Acetate, α-Amorphene and delta-Cadiene	in the culture medium BHI the amount of MIC and MBC cinnamon essential oil with concentrations 600 ppm against *Salmonella typhimurium* (phage type II 138) at pH=5 was obtained respectively, 38 and 75 µg/ml and at pH= 7 was obtained respectively, 150 and 300 µg/ml and in combination with nisin with concentration 5 mg/ml at pH=5 the amount of MIC and MBC was obtained respectively, 19 and 38 µg/ml and at pH=7 was obtained respectively, 75 and 150 µg/ml thus results indicates the synergistic effect of nisin with cinnamon (Rahnama and Asghri, 2013).	Disk diffusion
2	Nettle (*Urtica dioica*)	-	In the culture medium MHA the amount of MIC and MBC of aqueous extract this plant against *Salmonella typhi* (PTCC1609) was obtained respectively, 1/25 and 2/5 mg/ml (Shariat et al., 2013).	Standard tube
3	Mallow (*Malva neglecta*)	-	Most growth inhibition zone against *Salmonella typhimurium* related to the suspension of silver nanoparticles with concentrations 400 ppm and aqueous extract of Mallow 209 mg/ml and the least growth inhibition zone related to the suspension of silver nanoparticles with concentrations 500 ppm and ethanol extract of Mallow with concentrations 104/50 mg/ml. The minimum and maximum growth inhibition zone for aqueous extract was obtained respectively, 17 and 3/70 mm, ethanol extract 14/60 and 12 mm, and silver nanoparticles 16 and 3/10 mm and the Estonia extract wasn't ineffective. The amount of MIC and MBC aqueous and ethanol extracts of Mallow was obtained against	Disk diffusion

			Salmonella typhimurium equal and quantities 25/20 and 104/50 mg/ml (Dost Mohamadi et al., 2012).	
4	pulegium (*Mentha pulegium* L.)	Pulegone, Limonene and -αpinene	This plant essential oil in concentration of 0/50% prevents the growth of *Salmonella typhimurium* (RITCC 2461). Average diameter inhibition of this plant essential oil were measured with the amount of 10 micro liters 17/60±0/678 and in culture medium MHA the amount of MIC and MBC of this plant essential oil against *Salmonella typhimurium* was obtained respectively, 312/50 and 625 µg/ml. The amount of MIC and MBC antibiotics flumequine was obtained respectively, 157 and 313/50 µg/ml and oxytetracycline 470 and 930/80 µg/ml and enrofloxacin 7/20 and 14/50 µg/ml and chloramphenicol 12 and 24 µg/ml, the results of this study showed that antimicrobial activity this plant more than tetracycline antibiotic and antimicrobial activity this plant less than 3 antibiotics mentioned (Dakhili et al., 2006).	Diffusion test disk and dilution test
5	Lecanora (*Lecanora mural* SP.)	-	In the culture medium MHA was obtained the amount of MIC for estonia and ethanol extract against *Salmonella typhimurium* respectively, 75/10 and 81/49 and inhibition zone diameter ethanol and estonia extract were measured respectively, 25 and 20 mm (Nasisri Semnani et al., 2014).	Disk diffusion and broth micro dilution
6	Crataegus (*Crataegus elbursensis*)	-	In the culture medium MHB was obtained the amount of MIC and MBC this fruit extracts against *Salmonella enterica* (PTCC 1188) respectively, 10 and 20 mg/ml. In concentration 500 µg/ml anti-radical activity of this fruit extract was higher than synthetic antioxidant BHT and showed a better performance in this regard (Salmanian et al., 2014).	Broth micro dilution
7	Crocus (*Crocus sativus* L.)	-	In the culture medium BHI were obtained the amount of MIC aqueous, ethanolic and methanolic extract saffron petals against *Salmonella typhimurium* (phage type II) by micro-dilution method respectively, 40 and more than and 40 mg/ml and MIC aqueous, ethanol and methanol extract saffron petals against *Salmonella typhimurium* agar by dilution method 40 mg/ml. The diameter of the inhibitory zone under the effect of aqueous, ethanolic and methanolic extracts were obtained respectively, 20, 21 and 20 mm (Gandoumi et al., 2010).	Disk diffusion and broth micro dilution
8	Cymbopogon (*Cymbopogon Olivier* Boiss Bor)	-	In the culture medium MHA concentrations of 50 micro-liter this plant essential oil created diameter the inhibitory zone the amount of 16 mm against *Salmonella typhi* (PTCC 1185) (Chalbian et al., 2003).	Disk diffusion
9	Saponaria (*Saponaria officinalis*)	-	In the culture medium nutrient agar was obtained the amount of MIC methanol extract against *Salmonella typhimurium* 12 mg/ml (Sengul et al., 2010).	Disk diffusion

3. Conclusion

Salmonellosis is one of the most important food-borne diseases in the health community. Food of animal origin, especially meat and eggs are very important in the transmission of the disease. Due to the large presence of bacteria in the environment and in human and animal digestive tract, preventing food contamination is very difficult. Thus, destruction and inhibiting the growth of bacteria in food is very important. Thermal and non-thermal methods to eliminate bacteria in the food products are very common. The use of any of these methods alone has adverse effects on the nutritional quality of food products. So today is combining different methods can be used to increase the shelf life of food products. In this regard, we can mention the use of chemical preservatives, increasing the shelf life of food using chemical preservatives has long been common. The use of these compounds has been associated with many risks such as drug resistance, allergies, cancer. So today use natural preservatives derived from plant and microbial sources are an excellent alternative (Bajpai et al., 2010; Mattson et al., 2011; Yoon et al., 2011).

According to the results obtained in this study and increasing restrictions on the use of antimicrobial chemicals such as Side effects and drug resistance, need to replace these materials with natural ingredients and essential oils is felt which could pave the way for replacement the above materials in order to protect human and animal food; and controlling diseases. Also, vegetable oil can be used in combination with other antibiotics, reducing the dose of antibiotics. Essential oil and plant extracts listed on the number of microorganisms has inhibitory effect and others have bactericidal effect. The antimicrobial activity of essential oils and extracts from these plants on a wide range of microorganisms is required studies on long the effectiveness of these essential oils and extracts of this plant as an antimicrobial compound in food models that was investigated by this review.

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