Chapter

Efficacy of Plant Antimicrobials as Preservative in Food

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Abstract

Safe and hygienic food is a requirement for a healthy society. The problem of food-borne outbreaks has built a challenge against the food and health regulatory authorities to control the pathogenic microorganisms. Chemical preservative has created some health problems in foods, so the recent trend is towards the use of natural antimicrobials in foods. Plants are valuable source of bioactive molecules exhibiting antimicrobial activities. The plant antimicrobial compounds have diverse chemical nature such as alkaloids, phenolics, terpenes, terpenoids, flavonoids, essential oil, etc. Many plant antimicrobials possess antimicrobial activity against pathogens and spoilage microorganisms. But variation in effectiveness of these compounds against microorganisms in laboratory system and in real food systems is major determinant in their food use. Several plant extract or purified compounds are part of human diet since thousands of years. Although some plant compounds enjoy the status of generally recognised as safe (GRAS), typical toxicological information of their use in food is not available. So the improvement in cost-effective isolation and toxicological information of these compounds is helpful in their use as biopreservative in foods.

Keywords: biopreservative, antimicrobial, essential oil, flavonoids

1. Introduction

Food preservation is dominant features in all food sectors and mainly comprises curbing the rise of microorganisms that increase the health-related issues in consumers [1]. The food attributes that attract the attention of the consumer are freshness and their naturalness and minimal processing. The perception of naturalness drives the consumer towards the food without chemical preservatives [2]. Modernization coupled with the change in the life style of the consumer shifts them towards the use of ready-to-use food. Thermal processing, drying, freezing, refrigeration, irradiation, modified atmosphere packaging (MAP) and addition of antimicrobial agents or salts are some conventional methods to prevent the growth of microbes in foods [1, 3].

Thermal processing is commonly applied in food industry to inactivate the microorganisms and enhance shelf life of food. However, pasteurisation reduces the level of some bioactive compounds such as anthocyanin pigment, carotenoids and vitamin c that has been reported in several fruits. Emerging nonthermal technology like high hydrostatic pressure (HHP), ultraviolet, ozone processing, pulsed electric fields and ultrasound has promising role in maintaining the nutritional and sensory quality of food. Dense phase carbon dioxide (DPCD) technique is generally employed for liquid foods. Pressure used in DPCD damages the tissues of the fruits [3–5].

The high intensity and longer duration time used in PEF affect the nutritional quality of foods. [6]. High dosage of ozone processing used for decontaminating food surface alters the sensory quality of the food. Nonetheless, the main limitation of applying UV-C light in food is its penetration, so it is only effective for the surface decontamination of food [7].

Besides, these some chemical preservatives such as sodium benzoate, potassium sorbate and nitrites have been used commercially in fruit juices, dairy products, confectionary, meat and meat products, etc. Nitrites and nitrates are applied in meat industry to inhibit the growth of the microorganisms, retain the red colour of the meat and reduce the oxidation of lipid. However, blue baby syndrome occurs in children owing to the presence of high amount of nitrites in their blood [8]. Some chemical preservatives such as sodium benzoate and potassium sorbate used in fruit juice industry have also constraints like benzoic acid that is converted into benzene in foods, and *S. cerevisiae* and *Pichia anomala* are able to decarboxylate sorbic acid to 1,3 pentadiene which cause kerosene-like off-odour. *Schizosaccharomyces pombe* may produce off-flavours in the presence of sulphite. Due to growing evidences about the harmful effects of chemical preservatives, there is continuous pressure to reduce the amount of added preservative in foods [9–12].

To avoid the health risks associated with the consumption of foods, natural antimicrobial compounds like bacteriocins, chitosan-fermented ingredients and plant antimicrobials provide another alternative for preserving food. Spices and herbs are used in food since the ancient time not for flavouring but also for the preservation. Plant extracts, essential oil and peptides exhibit a broad-spectrum activity. The antimicrobial and antioxidant properties of plants are attributed to secondary metabolites such as phenylpropanoids, terpenes, flavonoids and anthocyanins [3, 11, 13-14]. Several studies have been conducted around the globe to prove the efficacy of plant products, and various compounds isolated from these plants are secondary metabolites which possess antimicrobial and medicinal properties [3, 11, 13, 15, 16]. The main purpose of this review article is to examine application of plant antimicrobials in food and their chemical diversity and limitation.

2. Current scenario of food-borne outbreaks

Food-borne diseases occur at a fast rate. The key concern of public health authorities are now more concerted on food pathogens and food-borne outbreaks. Due to lack of awareness, a large number of food-borne-associated incidences become unnoticed. Food-borne diseases are only reported when this pathogen cause infection in a large number of people which resulted in an outbreak. Therefore, it is essential to shrink the load of food-borne diseases through vigilant monitoring of the food-borne outbreaks and causal organism [17].

Consumption of raw foods such as fruits, vegetables, fruit juices and raw sprouts is the main cause of food-borne outbreaks. The major food-borne pathogens are *Salmonella enterica*, *E. coli*, *Clostridium perfringens*, *Staphylococcus aureus*, *Shigella* spp., *Campylobacter* spp., *Bacillus cereus*, *Vibrio parahaemolyticus*, *Clostridium botulinum* and *Listeria monocytogenes*. In the USA, norovirus is implicated in a number of food-borne outbreaks associated with consumption of salad, and millions of people are affected [18, 19]. *Salmonella* and *E. coli* are involved in multistate outbreak in the USA. *E. coli* that causes severe haemolytic diarrhoea infected 3000 people in Germany and killed 53 people. Fresh produce and water is the main source of protozoan infection [18]. *Listeria monocytogenes* was implicated in 31 outbreaks in Switzerland during 2013–2014 which is associated with consumption of ready-to-eat salad [20]. *L. monocytogenes* has also been observed where frozen corn and frozen vegetable mixes including corn, frozen spinach and frozen green bean were consumed in European countries [21]. Consumption of frozen berry was responsible for hepatitis A in Italy. Hepatitis A was found in people who travelled to Italy during 2013–2014 [22]. *Salmonella* and *S. aureus* were involved in a large number of outbreaks associated with consumption of pork or pork products in the USA during 1998–2015 [23]. Hennekinne et al. [24] reviewed the occurrence of *S. aureus* food poisoning worldwide. The major share of food-borne outbreak in Canada is related to nontyphoidal *Salmonella* spp., *Campylobacter* and *Listeria monocytogenes* [25].

3. Antimicrobial from plants

To circumvent the losses due to food-borne outbreaks, an effective method of preservation should be adopted in food factories and restaurant for controlling the food-borne outbreaks. Application of antimicrobials in foods retards the growth of spoilage microorganisms and prevents the growth of pathogenic microorganisms. Natural antimicrobial compounds are obtained from plant, animal and microbes. Lactoferrin, lactoperoxidase and lysozyme are naturally occurring antimicrobials in animals. Bacteriocins like nisin and pediocin are biopreservative from microbial origin used commercially in food. Several forms of plant products such as essential oil, plant extract either in pure or crude form and plant antimicrobial peptide have also potential to utilise as a biopreservative in food [5, 11].

3.1 Essential oil

Essential oils are oily liquids derived from several plant parts (flower, buds, leaves, fruits, twigs, bark, seed, wood and roots) belonging to angiospermic families that can be used by several industries for different purposes [26]. The essential oils are mainly investigated for their pharmacological attributes [27–30]. Food companies utilise essential oil as flavouring agent; however, antimicrobial and antioxidant aspects of essential oil make it the best candidate for food preservation [31]. Methods employed for the extraction of essential oil are steam distillation, hydro distillations, critical carbon dioxide, subcritical water, solvent extraction, hydrodiffusion and solvent-free microwave [32].

Harvesting time, types of plant, season and methods adopted for the extraction of essential oil influence the chemical diversity of the essential oil. The active groups that leverage the antimicrobial property of essential oil have been categorised into four main groups: terpenes, terpenoids, phenylpropenes, and other chemical groups [33, 34].

The mode of action of essential oil is not clearly defined till date. One particular mechanism does not justify the activity of diverse chemical groups present in the essential oil. Several researchers advocate that essential oil penetrates the bacterial cell membrane due to their lipophilic nature and disrupts the cell functioning [35–37]. Phenolic compounds alter the cell membrane permeability of the bacteria and hinder the generation of ATP and proton-motive force [38]. The hydrophobicity of essential oil displayed more activity against Gram-positive bacteria than Gram-negative bacteria which is attributed to difference in their cell structure [9]. The antimicrobial potential of essential oil is also influenced by concentration. Low concentration inhibits enzymes that are involved in energy production, and high concentration precipitates the protein. Thymol, eugenol and carvacrol inhibit ATPase activity and release of intracellular ATP and other components of cell membrane [15].

Different studies have demonstrated the effectiveness of Eos and their active compounds to control or inhibit the growth of pathogenic and spoilage microorganisms in both fresh-cut fruit and fruit juices. Literature study reveals the effectiveness of essential oil and their active compounds to retard the growth of microorganisms (**Table 1**).

The pink pepper tree (*Schinus terebinthifolius* Raddi) is a native plant of Brazil, Paraguay and Argentina. Essential oil obtained from pink pepper exhibit antimicrobial and antioxidant activity in cheese. Two percent essential oil concentration was effective in cheese for controlling the growth of microorganisms [1].

Sharafati-Chaleshtori et al. [39] studied the use of basil essential oil in beef burger reduced the growth of *Staphylococcus aureus* PTCC 1189 from 3log cfu/g to 2log cfu/g at 4°C after 24 hours. The clove oil enhanced the shelf life of red meat at 2°C for 15 days and reduced the 3.78 log cycles of bacterial count as comparison to control that contain untreated meat. Similar results were obtained in cumin oil treatment [40].

The combination of thyme EO (at 0.4, 0.8 and 1.2%) and nisin (at 500 or 1000 IU/g) decreases *Listeria monocytogenes* population below the acceptable level (2 log cfu/g) and displayed strong antibacterial activity than the individual usage of EO or nisin in minced fish meat during storage period (4°C for 12 days) [41]. Samy Selim [42] studied the effect of eucalyptus, juniper, mint, rosemary, sage, clove and thyme oils on vancomycin-resistant *Enterococci* (VRE) and *E. coli* O157:H7 in minced beef meat and observed that sage and thyme oil exhibit strong antimicrobial activity against the tested microorganism.

The combination of *Zataria multiflora* Boiss essential oil (ZEO) and grape seed extract (GSE) at a concentration of 0.1% and 0.2%, respectively, was more effective for controlling the growth of the *Listeria monocytogenes* in raw buffalo patty than individual usage of *Zataria multiflora* Boiss essential oil (ZEO) and grape seed extract and showed antioxidant activity and confirmed the synergistic effect against the tested microorganism [43]. In another study the synergistic effect of *Mentha piperita* essential oil and bacteriocin was significant to prevent the growth of microorganisms in minced beef meat as comparison to individual role [44].

3.2 Antimicrobial peptides

Plants are easily attacked by the insects, fungi and bacteria. To nullify the effect of plant pathogens, plants develop an efficient defence system with the synthesis of secondary metabolite phenols, oxygen-substituted derivatives, terpenoids, quinines, tannins and antimicrobial peptides (AMPs) [45]. AMPs are widely distributed in plants and plant parts [46] and integral part of the immune system, enzymatic network needed during metabolism, as a nutrient and a storage molecule. Antimicrobial peptides are the first line of defence during pathogen encounter with the host [47]. Over the last two decades, about 1500 antimicrobial peptides are identified in various sources such as insects, plants, microorganisms, amphibians and mammals [48]. Antimicrobial peptides are biologically active peptides that exhibit antimicrobial, antioxidant, antithrombotic, antihypertensive and immunomodulatory attributes [49–53].

Antimicrobial peptides are grouped into two types on the basis of their biosynthetic pathway. The first group comprises the peptides that are not ribosomally made (bacitracins and glycopeptides), and the second group comprises the ribosomally synthesised peptides involved in innate defence system of the body of the organisms [54]. To realise the need of the basic information of AMPs, an online antimicrobial peptide database (APD) was framed in 2003. The current version of APD was issued in 2016 comprises more than 2600 peptides from different sources [55].

Amphiphilic nature and presence of positively charged residues in antimicrobial peptide enable them to partition into bacterial membrane and alter the

Essential oil	Target microorganism	Food	Process	Effect	Reference
Thyme EO (0.6%)	*E. coli* O157:H7	Minced beef	4 °C or 10°C	Inhibitory effect at 10°C not at 4°C against *E. coli* O157:H7	[101]
Oregano essential oil	*Salmonella* enteritidis	Minced sheep meat	4 °C or 10°C for 12 days	0.9% concentration of essential oil inhibits the growth of *Salmonella* enteritidis	[102]
Thyme or marjoram EOs	*E. coli*	Minced pork	5 °C for 24 h	1 log cfu reduction of *E. coli* population after 24 hours	[103]
Thyme essential oil	Vancomycin-resistant Enterococci (VRE) and *E. coli* O157:H7	Feta soft cheese	7°C for 14 days	Reduce the bacteria growth as comparison to control	[42]
Thyme essential oil	Vancomycin-resistant Enterococci (VRE) and *E. coli* O157:H7	Minced beef meat	7°C for 14 days	Reduce the bacteria growth as comparison to control	[42]
Hydroalcoholic extracts *Lithospermum erythrorhizon*	Mesophilic Aerobic plate counts	Tomato juice	5 °C for 9 days	No significant change in microbial population as compared to control	[104]
Cuminum cyminum (cumin) seed essential oil	Spoilage moulds	Wheat and chickpea samples	Room temperature	Control the growth of moulds	[105]
Oregano and garlic essential oil	Native microflora	Chicken breast	4 °C, 13 days	Enhanced shelf life from 6 days to 13 days	[106]
Bay leaf EO	Coliforms	Tuscan sausage	7 °C, 14 days	3 log CFU/g reduction in coliform population and extend the shelf life of product for 2 days	[107]
Satureja horvatii essential oil	*L. monocytogenes*	Pork meat	4°C, 72 hours	Inhibit the growth of *L. monocytogenes*	[108]
Clove oil	Native microflora	Meat	2 °C for 12 days	Enhanced the shelf life of meat up to 15 days	[40]
Cumin oil	Native microflora	Meat	2 °C for 12 days	Enhanced the shelf life of meat up to 15 days	[40]
Thyme EO	*Listeria monocytogenes*	Minced fish	4 °C for 12 days	Reduce the populations of *L. monocytogenes* below the acceptable level (2 log cfu/g) after 6 days	[41]

Essential oil	Target microorganism	Food	Process	Effect	Reference
Eucalyptus EO	*Saccharomyces cerevisiae*	Apple and orange mixed juice	Room temperature, 8 days	Decrease the population of yeast as compared to control	[109]
Ocimum basilicum L.) Essential oil	*Staphylococcus aureus* PTCC 1189	Beef burger	4 °C for 12 days	Sensory quality of the product acceptable up to 12 days	[39]
0.1% *Zataria multiflora* Boiss essential oil (ZEO) and 0.2% grape seed extract (GSE) at a concentration of 0.1% and 0.2%	TMVC TPVC *Pseudomonas* spp. LAB and yeast populations and *Listeria monocytogenes*	Buffalo patties	8°C for 9 days	Decrease the bacterial growth of microbes	[43]
Mentha piperita essential oil	Aerobic and psychrotrophic count Enterobacteriaceae, Pseudomonas	Minced beef meat	4 °C for 21 days	Reduce the bacterial count as compared to control	[44]
Origanum elongatum essential oil	TMVC	Pomegranate juice	20°C for 16 days	Essential oil was more effective for controlling the growth of yeast and mould	[110]

Table 1.
Application of essential oil as a preservative in food.

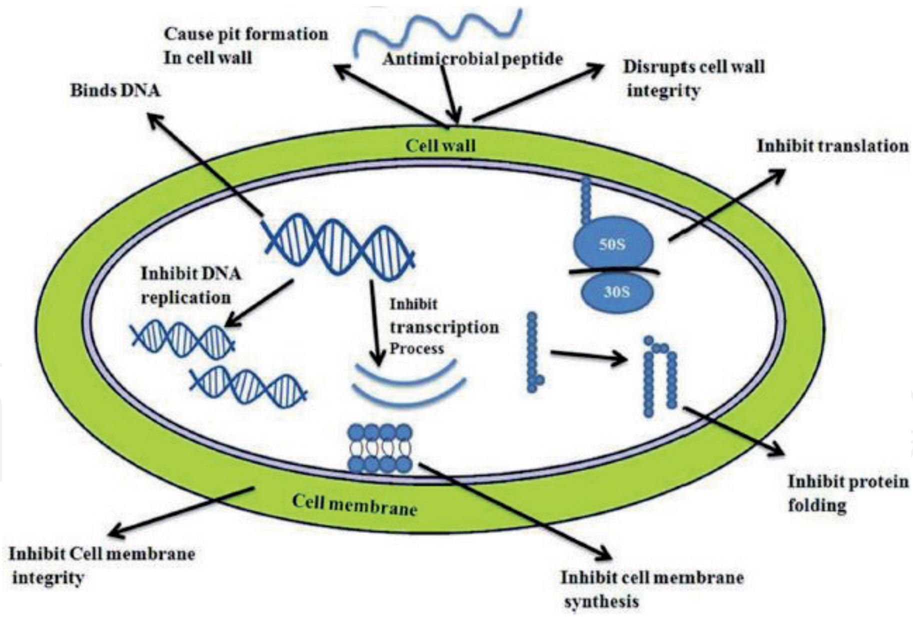

Figure 1.
Mechanism of action of antimicrobial peptide (adapted from [53]).

membrane permeability [56]. Antifungal property of AMPs lies in the attack of peptide on chitin, component of fungal cell wall, which hinders its synthesis and changes the membrane permeability (**Figure 1**) [46, 57]. AMPs bind the glycosaminoglycan moiety of cell membrane and prevent the virus-cell interaction as evident by the cationic lactoferrin peptide [58]. Bacterial antimicrobial peptides, such as bacteriocins, have been used in food preservation over many years [59].

The first antimicrobial peptide identified in plant is purothionin, which displays antimicrobial activity against *Pseudomonas solanacearum*, *Xanthomonas phaseoli* and *X. campestris*, *Erwinia amylovora*, *Corynebacterium flaccumfaciens*, *C. michiganense*, *C. poinsettiae*, *C. sepedonicum* and *C. fascians* [58]. The main groups incorporate thionins (types I–V), defensins, cyclotides, 2S albumin-like proteins and lipid transfer proteins [60, 61] along with knottin peptides, impatiens, puroindolines, vicilin like, glycine-rich, shepherins, snakins and heveins [62, 63] based on their sequence similarity, Cys motifs and distinctive disulphide bond patterns which, in turn, determine their tertiary structure folding [46].

3.2.1 Thionins

Thionins are cationic peptide comprised of 45–48 amino acids with 3 to 4 disulphide bond. Previously it was considered as toxic compound. Microbial attack on plant elicits the expressions of thionins, which belong to the release of the hormone methyl jasmonate. α-Purothionin was isolated from the endosperm of wheat. Crambin, viscotoxins, apratoxin A, α-/β-purothionins, α-/β-hordothionins, hellethionin-D, *Pyrularia pubera* thionin (Pp-TH) and *Tulipa gesneriana* bulb-purified AMPs (Tu-AMPs) belong to thionins [46]. Thionins from wheat flour showed antibacterial activity against food pathogen *Listeria monocytogenes* and *Listeria ivanovii* in vitro with MIC of 2 μg/mL [64].

3.2.2 Defensins

Plant defensins are cationic peptides comprising 45–54 amino acids with 4 to 5 disulphide bonds [65]. They exhibit several biological functions such as antifungal, antibacterial, α-amylase and trypsin inhibitory activity [46]. Firstly, they were recognised as γ-thionin from wheat and barley grains. Plant defensins are found in wide variety of plants [66, 67]. Defensins attach to glucosylceramides which are present on the fungal cell membrane resulted into the insertion and repulsion between defensins owing to their positive charges which disrupt the cell membrane [68]. γ-Hordothionin, PhD1 from *Petunia hybrida* and defensins 1 and 2 from *Vigna radiata* belong to defensins [69].

Plant defensins exhibit lower antibacterial activity against *Listeria monocytogenes* and *Listeria ivanovii* [64]. Defensin KT43C from cowpea seeds delays the growth of yeast in dough for about 2 days [67].

3.2.3 Hevein-like peptides

Hevein-like peptides contain 29–45 amino acids with 3 to 5 disulphide bonds rich in Gly. It comprises conserved chitin-binding motif that distinguishes it from other peptides. Hevein was first observed in the latex of the rubber tree *Hevea brasiliensis*, displayed antifungal activity in vitro. IWF4 from *Beta vulgaris*, Ac-AMP1 from *Amaranthus caudatus*, EAFP1 and EAFP2 from the bark of *Eucommia ulmoides*, PMAPI from paper mulberry, WjAMP1 from the leaves of *Wasabia japonica* L and vaccatides vH1 and vH2 from *Vaccaria hispanica* are under hevein-like peptides [61, 70]. Hevein is effective against Gram-positive bacteria and fungi, but it shows some allergic reaction creating a hurdle in the use of it as a biopreservative [71].

3.2.4 Knottin-type peptides

Plant knottins contain 30 amino acids and comprises inhibitors of α-amylase, trypsin and carboxypeptidase families as well as cyclotides. They perform several functions like enzyme-inhibitory, cytotoxic, antimicrobial, insecticidal and anti-HIV activities [72, 73]. Initially, it was identified as protease inhibitors [74]. Linear knottins are observed in plants as well as in fungi, insects and spiders also. However, cyclotides and their acyclic variants are only found in plants [75]. They exhibit antibacterial as well as antifungal activity [64].

3.2.5 Lipid transfer protein (LTP)

LTPs consist of 70 and 90 amino acids cationic proteins with 8 Cys residues. They are implicated in lipid transfer activity between the membranes in vitro. Hydrophobic cavity covered by four helices is the common structural feature in all LTPs [76]. They are identified in several plants such radish, barley, maize, Arabidopsis, spinach, grapevine, wheat and onion [61].

3.2.6 Snakin

Snakin-1 and snakin-2 consist of 63 and 66 amino acid long residues, respectively, which are identified in potato tubers [77]. Snakin showed strong antibacterial activity against *Listeria monocytogenes* and *Listeria ivanovii* [78].

3.3 Plant extracts

Spices and herb are used as flavouring agents as well as a preservative since the ancient time. Plant parts are used as spice like leaves (mint, rosemary), flower (clove), bulb (garlic, onion) and fruit (cumin, red chilli). They enjoy the status of GRAS [79]. Factors that affect the antimicrobial efficacy of a compound incorporate target microorganism, initial microflora of the food and environmental factors. The chemical nature of the phytochemicals determines its activity against microorganisms. Plant extracts are widely used in the food industry, and antimicrobial nature of the plant extract is influenced by its phytochemicals [13, 34, 64]. Phenolics, phenolic acids, quinones, saponins, flavonoids, tannins, coumarins, terpenoids and alkaloids are the major classes of chemical constituents that influence the antimicrobial and antioxidant activity as well as flavours of the plant. The hydroxyl group of the phenolic compounds imparts its antimicrobial activity. OH group interferes with the function of the cell membrane and shifts the electrons that act as proton exchangers, disintegrates proton-motive force, inhibits ATP synthesis and causes cell death [80].

Clove exhibits antibacterial activity against *Escherichia coli*, *Listeria monocytogenes*, *Salmonella enterica*, *Campylobacter jejuni* and *Staphylococcus aureus* [81] and antifungal activity against *Candida albicans* and *Trichophyton mentagrophytes* [82]. The antimicrobial activity of the clove is owing to the presence of eugenol [11]. Cinnamaldehyde, cinnamyl alcohol and eugenol confer the antimicrobial activity of cinnamon. Cinnamaldehyde exerts its action on bacteria via inhibiting their cell wall synthesis, impairing cell membrane function and affecting the synthesis of nucleic acids [83]. Phenolic compounds of black pepper damage the bacterial membrane and affect the antimicrobial activity. In addition to antibacterial activity, antifungal activity of black pepper was also observed against the *Fusarium graminearum* and *Penicillium viridicatum* [84]. Carnosic acid and phenolic compounds influence the antimicrobial and antioxidant activity of rosemary plant [85] (Almela et al., 2006). Polyphenolic compounds such as 6-gingerol present in ginger confer the antimicrobial and antioxidant activity of the ginger [86]. Carbazole alkaloids and coumarins influence the antimicrobial activity of curry leaves [87]. Raisin extract in wheat at a concentration of 7.5% is effective for control of spoilage mould and enhances the shelf life of bread; however, this result does not significantly differ from the positive control (0.24% propionate) [88].

The plants that possess antioxidant property which belong to Lamiaceae, rosemary, oregano, thyme, sage, marjoram, basil, coriander and pimento are predominant [79]. Lipid peroxidation is the main culprit in the rejection of meat and meat products. Antioxidant compound decreases the lipid peroxidation. Plant extract comprises antioxidant activity attributed to their phenolic component. Selection of solvent is an important tool for the extraction of antioxidant property of the plant. Several studies support the antioxidant activity of plants in meat. The antioxidant activity of grape seed extract in pork patties stored at −18°C for 6 months was higher than that of oregano extract, oleoresin rosemary, butylated hydroxyanisole and butylated hydroxytoluene [89]. Similar results of antioxidant activity of grape seed extract were observed in beef patties, and the freshness and sensory quality of the product were retained for 4 months at −18°C and 6 months at the same temperature [90, 91] and in frankfurters [92], restructured mutton slices at refrigeration temperature [93]. The 0.1% of clove essential oil had higher antioxidant activity in buffalo patties at 8°C for 9 days in comparison to grape seed extract [94].

4. Hurdles in plant antimicrobials as preservative in foods

Plant antimicrobial compounds have an efficacy as preservative and food ingredients. Before October 1994, food additives from plant sources are used without any regulatory test. Currently the trend has moved towards the rapid expansion of utilisation of plant antimicrobials as additive, ingredient or supplement in several health food products [95]. The US FDA and European commission approved some essential oil as food preservative. The main barrier encountered in the use of essential oil in food is the inability of the reproducibility of their activity. Although they contain diverse nature of the chemical compounds, they have different qualitative and quantitative fluctuations in the content of the compounds which influence their biological effectiveness [96, 97]. The other major obstacle that limits the use of essential oil in food is their strong aroma that alters the organoleptic property of food. Beside that the nature of the food also affects the efficacy of essential oil in food. Food is comprised of different microenvironments; hence, the concentration of essential oil is also increased that leverage the taste of the food resulting in the rejection of food [13, 98]. Strong aroma flavour of essential oil is minimised by meticulously choosing the essential oil according to the type of food. Availability of raw material and risk of the loss of biodiversity also hinder the use of plant essential oil as preservative [95, 99].

The in vitro antimicrobial activity of plants has been demonstrated in several studies. However, hardly an antimicrobial study of plant extract has been available in food. In most of the studies, the results of in vitro antimicrobial activity of plant extract differ from the antimicrobial activity observed in food. The low activity of the plant in food is attributed to involvement of crude extract in most cases, and they possess low activity in contrast to pure compounds. Crude extract which comprises of flavonoids in glycosidic form retards their effectiveness against the microorganisms [13, 100]. The presence of extracting solvent also creates a hurdle for the use of plant extracts in food [11, 13]. The application of antimicrobial peptides derived from plants in food is at its infancy stage. Lots of work have to be done to prove its potential as preservative in food.

5. Conclusion and future remarks

Plant-derived antimicrobials have promising probability to be used as preservative in food. Literature studies revealed the inefficiency of plant antimicrobial as a preservative in food systems and also have inadequate scientific reports that support their safety in food. Although food authorities around the world have issued guidelines regarding the food additives, there is lacking data related to standardisation of plant extract. There is stringent need for approval of plant antimicrobial as a preservative by the food authorities as its potential as natural preservative is proved. The method of the extraction of plant is also impediment in the passage of preservative action of plant. Development of cost-effective methods for the extraction of plant antimicrobials should be search out, so that there is no loss of original antimicrobial compound, and preservative from plant should be used on large scale. Nanotechnology approach also enhances the potential of plant antimicrobials. Most of the essential oils were incorporated into packaging system where they impart the antimicrobial activity and enhance the shelf life of food. Nanoencapsulation of plant antimicrobial will also helpful for maintaining the bioactivity of plant antimicrobial in food systems.

Conflict of interest

There is no conflict of interest between authors.

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