Effect of Natural Antimicrobials on Foodborne Pathogens and Shelf Life: A Review

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Abstract

The emerging multi-drug resistance in food borne pathogens and consumers demand for minimally processed fresh natural foods has paved the path for natural antimicrobials to be used in food industry. Various plant materials had been used in food for their flavour and to increase the taste. Apart from these properties, these extracts and essential oils act as antioxidants and antimicrobials without affecting the quality attributes of foods. Keeping these facts, in the present review various natural extracts and essential oils have been discussed in relations to their effectiveness against foodborne pathogens, shelf life extension and spoilage microorganism.

Keywords: Food Spoilage, Food preservation, Food pathogens, Natural antimicrobial.

1. Introduction

The ever increasing demand of consumers for chemical and antibiotic free food along with the emerging multi-drug resistance in food borne pathogens has paved the path for natural antimicrobials to be used in food industry. Recently plant extracts and essential oils have received a lot of attention for use in food products due to their antioxidant and antimicrobial activities as well as flavour properties (Dhanze and Mane, 2012). Tiwari et al. (2009) reviewed antimicrobials from a range of plant, animal, and microbial sources for their potential applications in food systems. According to them natural antimicrobials can be used alone or in combination with other novel preservation technologies to facilitate the replacement of traditional approaches. Prakash et al. (2013) carried out a study to determine the antimicrobial activity of the fruit peel extracts of Maclura pomifera (Orange), Punica graminatum (Pomegranate or Anar), Musa balbisiana (Banana), Citrus limetta (Sweet lime or Mousambi), Malus domestica (Apple), Carica papaya (Papaya) and Mangifera indica (Mango) and stated that they had moderate to mild inhibiting effect on pathogenic bacteria. In this manuscript brief overview of studies on natural antimicrobial is discussed.

2. Recent Works on Effectiveness of Natural Antimicrobial in Foods Systems: Indian Perspective

The extracts, juice, oils, paste and powders were used to assess their antioxidant and antimicrobial effect against various foodborne pathogens and shelf life. Rauha et al. (2000) studied the antimicrobial activity of thirteen phenolic substances and twenty nine extracts prepared from Finnish plant materials against selected microbes. Flavone, quercetin and naringenin were effective in inhibiting the growth of the organisms. Elgayyar et al. (2001) found that the basil oil had been effective against emerging food borne pathogen like E. coli O: 157:H7. Kumar and Begum (2002) showed that E. coli was highly sensitive to 80 percent ethanolic extract of Leucas aspera and moderately sensitive to Thespesia populnea extract and less sensitive to the extract of Achyranthes aspera. Singh et al. (2002) studied antibacterial activity of the essential oils extracted from the seeds of seven plant spices i.e. Anethum graveolens, Carum capticum, Coriandrum sativum, Cuminum cyminum, Foeniculum vulgare, Pimpinella anisum and Seseli indicum against eight pathogenic bacteria. They observed that the oil of C. capticum, C. cyminum and A. graveolens was very effective against all tested bacteria. Jayaprakasha et al. (2003) reported that the grape seed extract displayed antimicrobial activity against major food borne pathogen like Bacillus cereus, Staphylococcus aureus and Escherichia coli. Voravuthikunchai et al. (2004) tested antibacterial activity of aqueous and ethanolic extracts of thirty eight medicinal plant species commonly used in Thailand, against different strains of Escherichia coli, including six strains of Escherichia...
coli O157:H7, Escherichia coli O26:H11, Escherichia coli O111:NM, Escherichia coli O22; five strains of Escherichia coli isolated from bovine; and Escherichia coli ATCC 25922. Both aqueous and ethanolic extracts of Quercus infectoria and aqueous extract of Punica granatum were highly effective against Escherichia coli O157:H7. Gopanraj et al. (2005) reported that the essential oil from the rhizomes of Hedychium larsenii M. showed moderate antibacterial activity against Gram-positive and Gram-negative bacteria. Negi et al. (2005) tested the extract of Seabuckthorn (Hippophae rhamnoides L.) seeds for their anti-bacterial activity and found the MIC values of methanolic extract for Bacillus cereus, Bacillus coagulans, Bacillus subtilis, Listeria monocytogenes, Yersinia enterocolitica, to be 200, 300, 300, 300, and 350 ppm, respectively. Durai pandian et al. (2006) indicated that ten plant extracts out of eighteen plant extracts exhibited antimicrobial activity against one or more of the tested nine bacterial strains (Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Enterococcus faecalis, Escherichia coli, Klebsiella pneumonia, Pseudomonas aeruginosa, Erwinia sp and Proteus vulgaris) at three different concentrations of 1.25, 2.5 and 5 mg/disc. Among the plants tested Acalypha fruticosus, Peltophorum pterocarpum, Toddalia asiatica, Cassia auriculata, Punica granatum and Syzygium line are were most active. Mahida and Mohan (2006) examined methanol extracts of twenty two Indian plants belonging to twelve families and found them effective against more than one organism, with the results being comparable to that of antibiotics. Out of the plants tested Blumea lacera (Burm f.), Canscora diffusa (Vahl), Cassia alata L., C. biflora L., C. fistula L. (Ceasalpiniaceae), and Putranjiva roxburghii Wall (Euphorbiaceae) extracts were found to be more effective against both Gram-positive and Gram-negative bacteria. Parekh et al. (2006) screened twelve plants for their antibacterial potentiality, viz., Abutilon indicum L., Acorus calamus L., Ammania bacicifera L., Argyrea nervosa Burm. F., Bauhinia variegata L., Craetaea religiosas Forst., Hedychium spicatum L., Holarrhena antidysenterica L., Piper nigrum L., Plumbago zeylanica L., Psoralea corylifolia L., Sauessarea lappa Costus against five bacterial strains, viz., Bacillus cereus, Staphylococcus aureus, Klebsiella pneumoniae, Escherichia coli, Pseudomonas pseudocalicigenes. They revealed that plant extracts were more active against gram-positive bacteria than gram-negative bacteria. Chauhan et al. (2007) reported that Seabuckthorn (Hippophae rhamnoides) seeds aqueous extract possessed antibacterial activities against Listeria monocytogenes and Yersinia enterocolitica and implicated that the extract had potential for natural preservation. Sofia et al. (2007) conducted a study employing cinnamon extract and reported it to be having good inhibitory activity against Escherichia coli, Bacillus cereus and Staphylococcus aureus. Jagtap et al. (2009) found ethanol extract of brahmi leaves to be highly sensitive against the various food borne pathogens. Khan et al. (2009) stated that multidrug resistant (MDR) strains of Escherichia coli were sensitive to crude ethanolic extracts Acacia nilotica, Syzygium aromaticum and Cinnamomum zeylanicum. Sharma et al. (2009) determined the antibacterial activity of aqueous, ethanol and acetone extracts of Corriander sativum, Abutilon indicum, Boerhavias diffusa and paniculata, Plantago ovata, Bacopa monnieri, Bauhinia variegate, Flacouratia ramontchi, Embelia tserium, Euphorbia ligularia, Zinziber officinale, Terminalia chebula, Azadirachta indica, Ocimum sanctum and Cinnamonum cassia was against 33 bacterial isolates. They reported that crude extracts of the selected plants especially the acetone and ethanol extracts exhibited significant activity against UTI pathogens. Chanda et al. (2010) reported the antimicrobial activity of peels of seven fruit and vegetables against eleven microorganisms. The Mangifera indica peel showed best and promising antimicrobial activity. Gram-negative bacteria were found more susceptible than Gram-positive bacteria which contradicted the previous reports that plant extracts are more active against Gram positive bacteria than Gram negative bacteria. Sudarshana et al. (2010) recently used the ginger and garlic essential oils as decontaminants with very promising results against Staphylococcal counts, E. coli and Salmonella. Upadhyay et al. (2010) conducted a study on the antibacterial effects aqueous and hydroalcoholic extracts of Hippophae rhamnoides L. (Seabuckthorn) (SBT) and showed that leaf extracts of Seabuckthorn had growth inhibiting effect against Bacillus cereus, Pseudomonas aeruginosa, Staphylococcus aureus and Enterococcus faecalis. Michel et al. (2011) reported that crude ethanolic extract from Hippophaë rhamnoides L. (Elaeagnaceae) leaf, stem, root and seed, were active against Gram positive and negative bacteria. Verma and Chaudhary (2011) showed that the fruit extract of C. carandas in dichloromethane showed antibacterial activity against the E. coli. Arora et al. (2012) assessed antibacterial properties of crude extracts of sea buckthorn (Hippophae rhamnoides L.) pomace, seeds and leaves against seventeen foodborne pathogens. The methanolic extract of leaves exhibited a low minimum inhibitory concentration (MIC) value of 125 µg/ml against Listeria monocytogenes. Gupta et al. (2012) characterized the antimicrobial effect of six Indian tropical fruit residues against five Gram-positive bacteria and four Gram-negative bacteria. Among the...
shown by Carissa carandas and Artocarpus lachoocha. Kamaraj et al. (2012) evaluated the antibacterial properties of crude extracts from leaf and flower of Aristolochia indica, Cassia angustifolia, leaf of Catharanthus roseus, Diospyros melanoxylon, Dolichos biflorus, Gymnema sylvestre and Justicia procumbens against Gram-positive and Gram-negative bacteria including Escherichia coli. The inhibitory zone observed against E. coli was 20 mm in case of leaf methanol extract of A. indica. The MIC values of flower extract of A. Indica showed against E. coli was 24.2g/ml leaf.

3. Recent Works on Effectiveness of Natural Antimicrobial in Foods Systems: Global Perspective

Most of the work on effectiveness of natural antimicrobial was directed foodborne pathogen and very less attention was provided for their effect against spoilage microorganism except recent work of Dhanze et al. (2013). However, studies on antioxidant effect were available using natural extracts, juices, oils, powder and pastes specifically in animal origin foods. In one of the study, Cutter (2000) conducted a series of experiments to determine the effectiveness of a commercially available, generally recognized as safe, herb extract against Escherichia coli O157:H7, Salmonella Typhimurium and Listeria monocytogenes associated with beef. They suggested that the use of herb extracts may afford some reductions of pathogens on beef surfaces. In another study, Ahmad and Beg (2001) observed a broad-spectrum antimicrobial activity of ethanolic extracts of twelve plants (L. inermis, Eucalyptus sp., H. antidysenterica, H. indicus, C. eaustifolia, T. belterica, T. chebula, E. officinalis, C. sinensis, S. aromaticum and P. granatum) against drug-resistant bacteria i.e. Escherichia coli, Staphylococcus aureus, Salmonella paratyphi, Shigella dysenteriae, Bacillus subtilis and Candida albicans. Sakagami et al. (2001) described that the extracts from four plant species, Limonium californicum (Boiss.) A. Heller, Cupressus lustiana Miller, Salvia urica Epling and Jussiaeae peruviana L. were effective in inhibiting verotoxin production by enterohemorrhagic Escherichia coli O157: H7 (EHEC). Delaquis et al. (2002) used essential oils by dill (Anethum graveolens L.), coriander (seeds of Coriandrum sativum L.), cilantro (leaves of immature C. sativum L.) and eucalyptus (Eucalyptus dives) against gram-positive bacteria and gram-negative bacteria and determined their antimicrobial activity. Friedman et al. (2002) reported that twenty-seven essential oils and twelve oil compounds were having bactericidal activity against Campylobacter jejuni, Escherichia coli O157:H7, Listeria monocytogenes and Salmonella enterica. The oils that were most active against E. coli were oregano, thyme, cinnamon, palmarosa, bay leaf, clove bud, lemon grass, and allspice oils. Olasupo et al. (2003) evaluated the inhibitory activity of several natural organic compounds alone or in combination with nisin against Escherichia coli. They reported that the individual natural organic compounds showed inhibitory activity against the two Gram-negatives but their combinations with nisin showed no improvement of antimicrobial activity. Burt et al. (2004) studied the antibacterial activity of essential oils (e.g. carvacrol, thymol, eugenol, perillaldehyde, cinnamaldehyde, cinnamic acid) against gram positive and gram negative bacteria including Escherichia coli O157:H7 at levels between 0.2 and 10 microl ml (-1). Gram-negative organisms were reported to be slightly less susceptible than gram-positive bacteria. Friedman et al. (2004) assessed seventeen plant essential oils and nine oil compounds for antibacterial activity against Escherichia coli O157:H7 in apple juices and reported that the ten compounds most active against E. coli were carvacrol, oregano oil, geraniol, eugenol, cinnamon leaf oil, citral, clove bud oil, lemongrass oil, cinnamon bark oil, and lemon oil. Mucete et al. (2005) reported the antibacterial activity of horseradish root extract against Escherichia coli and antifungal activity against Candida albicans and Aspergillus niger which are generally involved in food spoilage. Fu et al. (2007) stated that the essential oils from clove (Syzygium aromaticum (L.) and rosemary (Rosmarinus officinalis L.) possessed significant antimicrobial effects against many microorganisms including Escherichia coli. The MICs of clove oil ranged from 0.062 percent to 0.500 percent (v/v), while the MICs of rosemary oil ranged from 0.125 percent to 1.000 percent (v/v). Oussalah et al. (2007) evaluated twenty eight essential oils for their antibacterial properties, against four pathogenic bacteria (Escherichia coli O157:H7, Listeria monocytogenes 2812 1/2a, Salmonella Typhimurium SL 1344 and Staphylococcus aureus). Results showed that the most active essential oils against bacteria tested were Corydohymus capitatus, Cinnamomum cassia, Origanum heracleoticum, Satureja montana and Cinnamomum verum (bark). Zhang et al. (2009) reported that the combination of rosemary and liquorice spice extracts inhibited not only the growth of L. monocytogenes, but were also effective against pathogenic species of bacteria such as E. coli, Pseudomonas fluorescens and Lactobacillus sake in vacuum packaged hams and modified atmosphere packaged fresh pork chops. Tajkarimia et al. (2010) described that herbs and spices containing essential oils (EOs) when used in the range of 0.05–0.1%
demonstrated activity against pathogens, such as Salmonella Typhimurium, Escherichia coli O157:H7, Listeria monocytogenes, Bacillus cereus and Staphylococcus aureus, in food systems. Abdullah et al. (2012) showed that Mangifera indica peels were a potent antibacterial inhibitor for both Gram-positive and Gram-negative bacteria. Ait-Ouazzoua et al. (2012) evaluated the antimicrobial activity of the essential oils (EOs) of Mentha pulegium L., Juniperus phoenicea L. and Cypers longus L. from Morocco. The antimicrobial activity of these EOs has been evaluated against seven bacteria of significant importance for food hygiene. According to the results, M. pulegium showed the best bacteriostatic and bactericidal effect, followed by J. phoenicea and C. longus. Cicerale et al. (2012) described that olive oil phenolic compounds have potentially beneficial biological effects in humans and animals resulting from their antimicrobial, antioxidant and anti-inflammatory activities. Kyung (2012) reported that alliums are important for food hygiene. According to the results, Escherichia coli O157:H7 including other strains of enterohemorrhagic E. coli, Campylobacter jejuni, Listeria monocytogenes, Bacillus cereus and Staphylococcus aureus. Lee and Najiah (2009) stated that the crude extract of Citrus microcarpa showed antimicrobial activity against seven bacterial reference strains, namely, Escherichia coli (ATCC 25922), Citrobacter freundii (ATCC 8090), Aeromonas hydrophila (ATCC 49140), Pseudomonas aeruginosa (ATCC 35032), Streptococcus agalactiae (ATCC 13813), Edwardsiella tarda (ATCC 15947), and Yersinia enterocolitica (ATCC 23715) with the MIC values ranging from 7.8 to 31.3 mg mL–1. Singh and Bilal (2009) studied the antimicrobial potency of Citrus sinensis peel and oil against Escherichia coli with the formation of 17 mm wide zone of inhibition. Pandey et al. (2011) showed that ethanolic, methanolic, ethyl acetate and hot water extract of lemon fruit peels, seeds and juice displayed promising evidence of antibacterial activity against bacteria (E. coli, P. aeruginosa and S. aureus).

4. Recent Work on Effectiveness of Plants Extracts on Foodborne Pathogens and Shelf Life

4.1 Citrus Fruits

The effectiveness of oils and vapours of citrus fruits were evaluated for their antimicrobial activity against wide variety of spoilage and pathogenic microorganisms (Kirbaslar et al., 2009; Shahid et al., 2009; Espina et al., 2011; Saima et al., 2011; Roy et al., 2012; Settannia et al., 2012). While the acitivity was specifically tested against E. coli (Fisher and Phillips, 2006; Johann et al., 2007; Mishra et al., 2012) and reported significant antimicrobial activity against the various strains of E. coli. Fisher and Carol (2008) reported that the essential oil of citrus fruits like orange, lemon and bergamot had good antimicrobial activity against Escherichia coli O157, Campylobacter jejuni, Listeria monocytogenes, Bacillus cereus and Staphylococcus aureus. Lee and Najiha (2009) stated that the crude extract of Citrus microcarpa showed antimicrobial activity against seven bacterial reference strains, namely, Escherichia coli (ATCC 25922), Citrobacter freundii (ATCC 8090), Aeromonas hydrophila (ATCC 49140), Pseudomonas aeruginosa (ATCC 35032), Streptococcus agalactiae (ATCC 13813), Edwardsiella tarda (ATCC 15947), and Yersinia enterocolitica (ATCC 23715) with the MIC values ranging from 7.8 to 31.3 mg mL–1. Singh and Bilal (2009) studied the antimicrobial potency of Citrus sinensis peel and oil against Escherichia coli with the formation of 17 mm wide zone of inhibition. Pandey et al. (2011) showed that ethanolic, methanolic, ethyl acetate and hot water extract of lemon fruit peels, seeds and juice displayed promising evidence of antibacterial activity against bacteria (E. coli, P. aeruginosa and S. aureus).

4.2. Pomegranate

The extracts of pomegranate (Punica granatum) was found to be effective against the wide variety of micro-organism (Prashanth et al., 2001; Negi and Jayaprakasha, 2006; Opara et al., 2009; Devatkal et al., 2013). The extract of pomegranate (Punica granatum) exhibited substantial antimicrobial activity against E. coli (Meléndez and Capriles, 2006; Naz et al., 2007; McCarrell et al., 2008; Pradeep et al., 2008; Khan et al., 2011), while (Voravuthikunchai et al., 2005) reported that the ethanolic extract from Punica granatum pericarp was effective against different strains of enterohemorrhagic Escherichia coli O157: H7 including other strains of enterohemorrhagic E. coli. Fawole et al. (2012) tested antibacterial activity of methanol extracts from peels of seven commercially grown pomegranate cultivars on Gram-positive and Gram-negative bacteria (Escherichia coli and Klebsiella pneumonia). Methanolic peel extracts showed strong broad-spectrum activity against Gram-positive and Gram-negative bacteria, with the minimum inhibitory concentrations (MIC) ranging from 0.2 to 0.78 mg/ml. Nuamsetti et al. (2012) reported that Escherichia coli, Bacillus subtilis, Staphylococcus aureus and Salmonella Typhimurium were sensitive to hot water, 95% ethanol, and acetone extracts of pomegranate fruit peels and arils (with seeds), with hot-water extract of the peels being most
potent with the minimal inhibitory concentration of 207 mg/ml against *E. coli*.

### 4.3. Ginger

Ginger is one of the most used condiments for preparation of various dishes in India. The antimicrobial and antioxidant activity of ginger has been reported (Habishaet *et al*., 2000). The antimicrobial activity of ginger extract was also reported against *E. coli* (Ekwenye and Elegalam, 2005; Gupta and Ravishankar, 2005; Nanasombat and Lohasuphatwee, 2005; Indu *et al*., 2006; Chen *et al*., 2008; Auta *et al*., 2011). The antimicrobial activity was also reported against *E. coli* O157:H7 (Gupta and Ravishankar, 2005; Sutherland *et al*., 2009), while Ushimaru *et al.* (2007) showed that methanolic extract (70 percent) of ginger (*Zingiber officinale*) was effective against *E. coli* with MIC (50 percent and 90 percent) equal to 6.97 mg/ml. However, Kaushik and Goyal (2011) studied the crude aqueous and organic extracts of rhizome of *Zingiber officinale* Roscoe (ginger) against *Escherichia coli* and suggested that methanolic crude and organic extracts displayed antibacterial effect but aqueous extracts were ineffective. Similarly, Gull *et al.* (2012) showed that ethanolic and methanolic extracts of ginger had significant antimicrobial effect on *Escherichia coli* isolates, but the ginger aqueous extract was only mildly effective. Pokhrel *et al.* (2012) examined the antibacterial activity of crude ethanolic extracts and essential oils of Ginger (*Zingiber officinale*) against five strains of diarrhoea causing *Escherichia coli*. They showed the *E. coli* strains were susceptible to the essential oils but not to the crude extracts.

### 4.4. Curry Leaves

*Murraya Koenigii* Linn commonly known as Meethi neem, belongs to the family Rutaceae. The curry tree is native to India and it is found almost everywhere in the Indian subcontinent including the higher levels of Himalayas. Curry leaves are found to be effective as antioxidant, antidiabetic, antibacterial, antihypertensive, cytotoxic and also in the treatment of bronchial respiratory difficulties (Dhanze, 2011). The leaves are used traditionally as spice in curry and other eatables. The effect of the curry leaves extract was observed against foodborne pathogens (Zachariah, 2009; Harika *et al*., 2010; Malwal *et al*., 2010) with significant antimicrobial activity. Ningappa *et al.* (2010) assessed the antibacterial activity of a monomeric protein isolated from *Murraya Koenigii* L. (curry leaves) and showed that it effectively inhibited *Escherichia coli*, with MIC values ranging from 13 to 24 μg/ml. Baskaran *et al.* (2011) observed that ethanol, methanol, ethyl acetate, acetone, chloroform, petroleum ether, hexane and aqueous extracts of *Murraya Koenigii* displayed antibacterial activity against the Gram-positive and Gram-negative bacteria, while *Escherichia coli* showing maximum susceptibility to acetone extract (zone of inhibition=16.20±0.20). Das and Biswas (2012) showed that ethyl acetate and dichloromethane soluble partitionate of methanolic leaf extract of *Murraya Koenigii* exhibited mild activity against *Escherichia coli* forming zone of inhibition of 9 mm to 11 mm.

### 4.5. Radish

The radish extracts was employed by various workers to find out their antimicrobial activity against foodborne pathogens (Al-Delaaimy and Ali, 1970; Abdou *et al*., 1972; Kivanc and Kunduhoegl, 1997; Jahangir *et al*., 2010). Mucete *et al.* (2005) reported the antibacterial activity of horseradish root extract against *Escherichia coli* and antifungal activity against *Candida albicans* and *Aspergillus niger* which are generally involved in food spoilage. Beevi *et al.* (2009) investigated acetone and hexane extracts derived from the root, stem, and leaf of *Raphanus sativus* for their antibacterial activity against foodborne and resistant pathogens. Of the different parts of *R. sativus* studied, root tended to be more active than the stem and leaf extracts in inhibiting the bacterial growth. Kumar *et al.* (2010) used extracts of some Indian culinary leaves (radish, curry, coriander, mint leaves etc.) to analyse them for the possible antimicrobial potential by testing them against different bacteria by using agar-disc diffusion method. Janjua *et al.* (2013) analyzed different extracts of peels of edible root of *Raphanus sativus L. var niger* for in vitro antibacterial activity against different gram positive and gram negative bacteria. Highest zone of inhibition (28 ± 1.2 mm) was observed against *E. coli* for petroleum ether extract. They concluded that peels of *R. sativus*, generally wasted, have important medicinal constituents. Ward *et al.* (1998) used the volatile horseradish distillates/oil in beef hamburger and cooked roast beef and assessed its bactericidal activity against most dangerous strain of *Escherichia coli* O157:H7, *Listeria monocytogens* and *Staphylococcus aureus* which are major food borne pathogens.

### 4.6. Seabuckthorn

Recently seabuckthorn extracts was evaluated against the foodborne pathogens and extends the shelf life. Dhanze *et al.* (2013) reported that aqueous extract of seabuckthorn leaves significantly lowered the (*P < 0.05*) standard plate count (SPC), psychrophilic count (PC), coliform count (CC), and yeast and mold count (YMC) on chicken leg as compared with the control. While the 3% seabuckthorn leaf extract treatment
resulted in significant ($P < 0.05$) lowering of SPC, PC, CC and YMC through 7 days. Negi et al. (2005) tested the extract of Seabuckthorn (Hippophae rhamnoides L.) seeds for their antibacterial activity and found the MIC values of methanolic extract for Bacillus cereus, Bacillus coagulans, Bacillus subtilis, Listeria monocytogenes, Yersinia enterocolitica, to be 200, 300, 300, 300, and 350 ppm, respectively. Chauhan et al. (2007) reported that Seabuckthorn (Hippophae rhamnoides) seeds aqueous extract possessed antibacterial activities against Listeria monocytogenes and Yersinia enterocolitica and implicated that the extract had potential for natural preservation. Upadhyay et al. (2010) conducted a study on the antibacterial effects aqueous and hydroalcoholic extracts of Hippophae rhamnoides L. (Seabuckthorn) (SBT) and showed that leaf extracts of Seabuckthorn had growth inhibiting effect against Bacillus cereus, Pseudomonas aeruginosa, Staphylococcus aureus and Enterococcus faecalis. Michel et al. (2011) reported that crude ethanolic extract from Hippophaë rhamnoides L. (Elaeagnaceae) leaf, stem, root and seed, were active against Gram positive and negative bacteria. Arora et al. (2012) assessed antibacterial properties of crude extracts of seabuckthorn (Hippophae rhamnoidesL.) pomace, seeds and leaves against seventeen foodborne pathogens. The methanolic extract of leaves exhibited a low minimum inhibitory concentration (MIC) value of 125 μg/ml against Listeria monocytogenes.

5. Conclusion

Based on the different studies, it is finally concluded that few extracts have antimicrobial activity against various foodborne pathogens as well as these extracts have antimicrobial activity against range of spoilage microorganisms and extends the shelf life. These extracts can be effectively used as alone in combinations with other extracts or other preservation methods to protect the consumer from foodborne pathogens and early spoilage of the foods.

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