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Botanicals as Biopreservatives in Foods- A Mini Review

J.M.P. Jayasinghe[1], M.K. Ranasinghe[2] and G. Tharshini[3]

[1,2]Department of Animal Science Uva Wellassa University, Sri Lanka
[3]Chaudhary Charan Singh Haryana Agricultural University, India
E-mail: [1]j.priyanath@gmail.com, [2]madukeshani @gmail.com, [3]tharshg@gmail.com

Abstract—*Bio-preservation is an emerging concept in the world to prolong the shelf life of perishable fresh produce. Biopreservatives are a wide range of natural products that can be used to reduce or eliminate pathogen populations while increasing food quality. Plant essential oils are gaining a huge interest as biopreservatives in food industry for their potential as decontaminating agents, due to they are Generally Recognized as Safe (GRAS). The antimicrobial activity of plant essential oils is due to their chemical structure, in particular to the presence of hydrophilic functional groups, such as hydroxyl groups of phenolic components and/or lipophilicity of some essential oil components. The compounds with phenolic groups as oils of clove, oregano, rosemary, thyme, sage, and vanillin are the most effective. The active components are commonly found in the essential oil fractions that most of them have a wide spectrum of antimicrobial activity, against food-borne pathogens and spoilage bacteria.*

Keywords*: Biopreservation, Essential Oils, Antimicrobial Activity*

1. INTRODUCTION

Many food products are perishable in nature and need to be protected from spoilage during their preparation, storage, and distribution to achieve desired shelf life. The demand for minimally processed, ready-to-serve and ready-to-eat fresh food products has increased rapidly during past few decades due to changes in human life style which pose major challenges for food safety and quality. Microbial growth is a major concern because some microorganisms can potentially cause food-borne illness. The spoilage and pathogenic microorganism outbreaks were reported specially in packaged foods frequently such as, *Listeria monocytogenes, Escherichia coli* O157, *Salmonella, Staphylococcus aureus, Bacillus cereus, Campylobacter, Clostridium perfringens, Aspergillus niger,* and *Saccharomyces cerevisiae* [22]. These microorganisms can cause undesirable quality characteristics to the food that deteriorate flavor, odor, color, sensory, and textural properties. Many studies have been performed to evaluate intervention methods aimed at reducing or eliminating bacterial populations following pre-harvest and postharvest contamination in sprouts [27] and other perishable foods [8]. Recently, the greater consumer awareness and concern regarding synthetic chemical additives, foods preserved with natural additives have been increased.

Bio-preservation is an emerging concept in the world to prolong the shelf life of perishable fresh produce. Biopreservatives are a wide range of natural products that can be used to reduce or eliminate pathogen populations while increasing food quality. Among this type of antimicrobials, essential oils of botanical extracts have long been applied as flavouring agents in foods, and due to their content in antimicrobial compounds, they have potential as natural agents for food preservation [8]. Application of bacteriocins and bacteriocin-producing strains as biopreservatives on the preservation of foods of animal origin has been revealed to greater extent but to a much lesser extent on vegetable foods such as sprouted seeds [7].

Plant essential oils are gaining a huge interest in food industry for their potential as decontaminating agents, due to they are Generally Recognized as Safe (GRAS). The active components are commonly found in the essential oil fractions and most of them have a wide spectrum of antimicrobial activity, against food borne pathogens and spoilage bacteria.

2. BOTANICALS AS BIOPRESERVATIVES

Essential oils, their active components and the phenolic compounds are attractive natural preservatives [6]. Antimicrobial botanicals which have the potential to be used as biopreservatives can be divided in to several useful categories including phenolics, polyphenols, quinines, flavones, flavonoids, flavonols, tannins, coumarins, terpenoids, alkaloids, lectins and polypeptides [12]. The inhibition of spoilage fungi in rye bread using thyme, clove and cinnamon, orange, sage and rosemary oils has been studied [26]. Results showed that thyme, clove and cinnamon oils inhibited spoilage fungi, while orange, sage and rosemary oils had very limited effects. Moreover, it has reported cinnamon, clove and cardamom oil were found to suppress growth of microorganisms in cookies [2]. Cinnamon has shown to reduce levels of *Escherichia coli* O157:H7 in apple

juice [10]. Cinnamon oil at ≤500 ppm can inhibit *Aspergillus flavus*, *A. parasiticus*, *A. ochraceus* and *Fusarium moniliforme* on potato dextrose agar [25]. Mixtures of cinnamon and clove oils showed inhibitory activity against important spoilage microorganism of intermediate moisture foods [17].

Freshly ground garlic when added to mayonnaise at a concentration of 1% reduced *Salmonella enteritidis* counts from log 5 cfu/g to 2 cfu/g after 96 h at 25 °C [16]. Similarly, Garlic has also been shown to reduce levels of *E.coli* O157:H7 in ground meat [10].

Oregano oil at 7-21 µL/g was effective at inhibiting *Escherichia coli* O157:H7 and reducing final populations in eggplant salad compared to the untreated control [24]. Essential oils of clove, cinnamon, bay and thyme were tested against *Listeria monocytogenes* and *S. enteritidis* in soft cheese diluted 1:10 in buffer. Moreover, cinnamaldehyde and thymol are effective against six *Salmonella* serotypes on alfalfa seeds when applied in hot air at 50 °C as fumigation. Increasing the temperature to 70 °C reduced the effectiveness of the treatment [28].

A study on antimicrobial activity of six ethanolic extracts from plants of ginger (*Zingiber officinale*), cinnamon (*Cinnamomum verum*), black cumin (*Nigella sativa*), clove (*Syzygium aromaticum*), black pepper (*Piper nigrum*) and chamomile (*Anthemis nobilis*) showed that clove strongly inhibited the growth of *Bacillus subtilis, Pseudomonas aeruginosa and Candida albicans*, whereas cinnamon was strongly inhibited the growth of *B. subtilis and C. albicans* only. The other plants have no inhibition activity or have stimulation activity on test organisms. *Staphylococus aureus* and *Escherichia coli* were resistant to all the plants extracts. *Ps. aeruginosa* was resistant to almost all of the plants extracts except clove. Both clove and cinnamon extracts showed remarkable effect on *B. subtilis* and *C. albicans* at very low concentration (3.125-6.25 µg/ml and 12.5-25, respectively). In addition, clove extract have marked inhibitory effect on *Ps. aeruginosa* at low concentration (25 µg/ml) [1].

Cabbage (*Brassica oleracea*) seeds treated with essential oils of thyme, oregano, cinnamon and clove, plant extract of biosept, and organic acids like ascorbic and propionic acid in concentrations of 0, 0.1, 0.3, 1.0 and 3.3% were assessed for the microbial population of seeds. In the investigation, all treatments except biosept at 0.33% concentration and oregano oil at 0.1% and 0.33% concentrations showed reduction in bacterial counts significantly compared to untreated seeds and water control [27].

The bactericidal effect of garlic extract was apparent within an hour of incubation and 93% killing of *Staphylococcus epidermidis* and *Salmonella typhi* was achieved within 3 hours and yeasts were totally killed in an hour by garlic extract but in 5 hours with clove [4]. Further, another study reported that garlic oil when incorporated at 100 mL/g concentration in chitosan film effectively controlled the growth of test microorganisms *Escherichia coli*, *Staphylococcus aureus*, *Salmonella typhimorium*, *Listeria monocytogenes* and *Bacillus cereus* [21].

The application of complexes containing essential oil (trans-cinnamaldehyde, eugenol, cinnamon bark, and clove bud extracts) were having antimicrobial properties against the pathogens *Salmonella enterica serovar, Typhimurium LT2* and *Listeria innocua*. All antimicrobials effectively inhibited bacterial growth except free eugenol [13]. Chicken meat patties treated with essential oil of cinnamon and garlic at 1:250 and 1:500 concentrations (2%) and oil of clove at 1:250 concentration (2%) recorded significantly lowered counts of *Staphylococcus aureus* during storage [5].

An investigation on antibacterial activity of ginger, eucalyptus and sweet orange peel essential oil on fish borne bacteria showed that among three essential oils, ginger oil had best antibacterial activity against all bacteria tested [15]. Moreover, another study conducted on the antimicrobial activity of dried ginger (ginger peel, peeled and unpeeled ginger) extracts prepared in acetone to control the growth of pathogenic microorganisms such as *Escherichia coli*, *Staphylococcus aureus, Salmonella typhimurium, Aspergillus niger* and *Bacillus subtilis* at different concentrations of 0.5, 1.0 and 1.5 ml, respectively. The results showed that the extracts were effective against *B. subtilis* and *A. niger* at the different concentrations and ineffective against *E. coli, S. aureus*, and *S. typhimurium* [20]. Analysis of bioactive components and antioxidant effect of ginger ethanolic extract and aqueous extract carried out and results showed that ethanolic extract more effective than aqueous extracts in Trolox equivalent antioxidant capacity and Ferric reducing ability of plasma. Contrarily, ginger aqueous extracts were more effective in free radical scavenging activities and chelating abilities [30].

3. REGULATIONS ASPECTS

Natural products or extracts from plant origin are being widely used in food processing industry as biopreservatives. Even though, these extracts have characteristic benefits in the industry including enhance the organoleptic properties, antimicrobial, antioxidant activity and by that extend the shelf life of the overall products, regulations to use as food additives are important. Most of the botanical extracts have been a safe part of the diet of human from many years back. But it is important to define the safety level for the botanical bio preservatives in term of Acceptable Daily Intake (ADI) or No Effect Level (NOEL), Tolerable Upper Intake Level (UL) to avoid the potential toxicological damage to the organs and their functions. The Food Act No. 26 of 1980 and an amendment titled Food (Amendment) Act No. 20 of 1991 came into operation and under Part I, food additives and their application are well explained with related laws and regulations. These regulations have been formulated based on the behavior of the functional groups of the particular extract including its adverse drug interactions with other compounds,

strong aromatic compounds. Permitted bio preservatives are prescribed with their maximum limits under the Food Additives Regulations in Sri Lanka and they are based on the Codex Limits. Labeling of such preserved product is governed by the Food (Labeling & Advertising) Regulation– 2005.

4. FUTURE PERSPECTIVE

Value of the functional foods has increased dramatically over the past few decades and it is expected to share significant value in the future with the demanding consumers in its niche market. Use of botanicals in the context of biopreservatives overweighs among other naturally occurring ingredients, bacteriocins, enzymes, protein isolates. Though food processing industry uses botanicals as biopreservatives, little number has been identified and the expansion of the field is needed to be little motivated. Moreover, innovative preservatives should be subjected to careful investigation and later careful clinical analysis with animal or human studies to diagnose the ADI level and sensitive populations and precaution in over dose ingestion should also be addressed and well documented. Finally use of the active component after well investigation should be disseminated through the food industry.

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