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Review

Green tea and grape seed extracts — Potential applications in food safety and quality

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ABSTRACT

Using "natural green" plant extracts or their derived products in various food and beverage applications is an increasing trend in the food industry. Selection of these plant extracts and their application depends on their functional properties, availability, cost effectiveness, consumer awareness and their effect on the sensory attributes of the final product. Green tea extract (GTE) and grape seed extract (GSE) are two popular plant extracts that have been widely used in various food and beverage applications. Green tea is a widely consumed beverage that has attracted more attention in the recent years due to its health benefits like antioxidant, antimicrobial, anticarcinogenic and anti-inflammatory properties. Grape seed extract is derived from the grape seeds that is extracted, dried and purified to produce polyphenolic compounds-rich extract that also has well documented antioxidant, antimicrobial and anti-inflammatory properties. These two plant extracts (polyphenolic and proanthocyanidin rich compounds) have potential antioxidant properties by inhibiting the lipid oxidation and warmed over flavors and antimicrobial activities against major food borne pathogens like *Listeria monocytogenes*, *Salmonella* Typhimurium, *Escherichia coli* O157:H7, and *Campylobacter jejuni* in preventing pathogen contamination. Furthermore, they have demonstrated synergism in antimicrobial activity when used in combination with organic acids (malic, tartaric acid, benzoic acids etc.), bacteriocins like nisin or chelating agents like EDTA in various model systems including fresh produce (fruits and vegetables), raw and ready-to-eat meat and poultry products. Apart from beneficial effects of grape seed extract in food safety and quality, concerns regarding the side effects of GSE are also addressed. Nevertheless, persistent recalls of the food products involving foodborne pathogens despite various control measures calls for efficient bacteriostatic and bactericidal agents and technologies to deliver the active components for an effective inhibition of pathogens. Therefore, further research involving electrostatic spray and nanoscale delivery of the active components present in these natural, green, plant extracts and using them as a component in multiple hurdle approach would enhance the food safety and quality in addition to providing alternative "green" solutions to the food processors.

Contents

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1. Introduction

Utilization of plant extracts as an alternative to chemical or synthetic antimicrobials and antioxidants to combat the foodborne pathogens, inhibiting lipid oxidation and thus extending the shelf life is an increasing trend in the food industry. Major groups of chemicals present in plant extracts include polyphenols, quinones, flavanols/flavanoids, alkaloids, and lectins (Cowan, 1999). Phenolic extracts prepared from sage, rosemary, thyme, hops, coriander, green tea, grape seed, cloves, and basil are known to have antimicrobial effects against foodborne pathogens (Bisha, Weinsetel, Brehm-Stecher, & Mendonca, 2010; Davidson & Naidu, 2000; Elgayyar, Draughon, Golden, & Mount, 2001; Hong, Lim, & Song, 2009; Juven, Kanner, Schved, & Weisslowicz, 1994a,b; Larson et al., 1996; Shelef, 1984). Natural plant extracts used along with other hurdles like low storage temperature, low pH, anaerobic temperatures, organic acids, bacteriocins and irradiation showed synergistic antimicrobial action in various food systems (Beuchat, Brackette, & Doyle, 1994; Gadang, Hettiarachchy, Johnson, & Owens, 2008; Over, Hettiarachchy, Johnson, & Davis, 2009). Lipid oxidation is one of the major deteriorative chemical changes that would decrease the shelf life of the food product and thus decrease its overall acceptability (Cortinas et al., 2005). Oxidation of labile double bonds in polyunsaturated fatty acids (PUFA) produces secondary oxidative compounds such as hexanal, pentanal, heptanal and octanal that is responsible for quality deterioration, warmed over flavors (WOF) and present health risks (Grun, Ahn, Clarke, & Lorenzen, 2006).

1.1. Why green tea and grape seed extracts?

Finding potent plant extracts; food grade additives that can effectively inhibit foodborne pathogens and/or having antioxidant properties is a continuing challenge and opportunity. Green tea and grapes are traditional, popular beverages that have diverse health benefits including antioxidant, antimicrobial, anti-inflammatory, and anticarcinogenic properties (Xia et al., 2010). Multiple lethality hurdles to the growth of pathogens including *Listeria monocytogenes*, *Escherichia coli* O157:H7 and *Salmonella* Typhimurium can be provided by using lesser amount of chemical antimicrobials in combination with natural antimicrobials from green tea and grape seed extracts (Gadang et al., 2008). Reducing conventional chemical antimicrobials and incorporating natural "green" plant extracts will provide the processing industry with a consumer attractive and preferred alternative of using natural sources of antimicrobials that are effective and inexpensive. Furthermore, the health image and the non-toxic nature of antimicrobials in plant extracts as well as consumer perception and acceptability of products containing grape seed and tea extracts have been well demonstrated (Ahn, Grun, & Mustapha, 2004; Bisha et al., 2010).

This review paper will summarize current knowledge and literature on chemistry, mechanism of action of green tea and grape seed extracts (antioxidant and antimicrobial properties), their synergistic role, and potential applications in various food systems in enhancing the safety and quality through multiple hurdle approaches. Finally, this review paper will also discuss emerging trends and technologies such as electrostatic spraying, nano-particle delivery, and also the health concerns and fate of absorbed nanoparticles that would deliver the active components effectively into food system.

2. Green tea extract (GTE)

Tea (black, green, white and oolong) is a widely consumed beverage next to water that has attracted much attention in recent years due to its numerous health benefits such as antioxidant, antimicrobial, anti-carcinogenic and anti-arteriosclerotic properties (Cooper, Morre, & Morre, 2005; Matthews, 2010). Green tea extract is a derivative of cultivated evergreen tea plant (*Camellia sinensis* L.) of the family Theaceae, processed by spray drying the strong infusions after they have been concentrated to solids (40–50%) (Wang, Provan, & Helliwell, 2000). Fermentation and heating process yields polymerization of catechins (mono polyphenols) and conformational changes, which ultimately contribute to various properties of tea. Based on the degree of fermentation during manufacturing process, tea can be classified in to three major types: non-fermented-green tea (~20%), fermented-black tea (~78%), and the semi fermented-oolong tea (~2%) (Cheng & Chen, 1994; Wei et al., 2009).

2.1. Green tea extract — chemical constituents

The chemical composition of tea is complex, consisting of polyphenols (catechins and flavanoids), alkaloids (caffeine, threobromine, theophylline, etc.), volatile oils, polysaccharides, amino acids, lipids, vitamin C, minerals and other uncharacterized compounds (Karori, Wachira, Wanyoko, & Ngure, 2007). Among these, the largest component present in green tea leaves is carbohydrates (including cellulosic fiber) and the simplest compounds are catechins, a group of flavanoids called flavan-3-ols (Yilmaz, 2006). These catechins are synthesized in tea leaves through malonic acid and shikimic acid metabolic pathways with gallic acid as an intermediate derivative (Naidu, 2000). Catechins are colorless water-soluble compounds which impart bitterness and astringency to green tea infusions (Wang et al., 2000). Total catechin content in green tea is 420 mg/L (Auger et al., 2004). Catechins constitute 15–30% of dry weight of green tea leaves as opposed to 8–20% of oolong and 3–10% of black tea (Amidor, 2009). Green tea extract contains six primary catechins namely (−)-epicatechin (EC), (−)-epicatechin gallate (ECG), (−)-epigallocatechin (EGC), and (−)-epigallocatechin gallate (EGCG) (Kajiya et al., 2004). EGCG is the most important and well studied tea catechin due to its high content (as high as 50%) in tea and has the most potent physiological properties while (+) –GC and (+) –C are usually present in trace components (Stewart, Mullen, & Crozier, 2004; Taylor, Hamilton-Miller, & Stapleton, 2005). Ester type catechins, (−)-ECG and (−)-EGCG are stronger in bitterness and more astringent than (−)-EC and (−)-EGC and these flavanoids have synergistic action than individual tea components (Fujiki, 1999; Han & Chen, 1995). It is estimated that a