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Antibacterial and antioxidant activity of green cardamom and rosemary extract in food products: A brief review

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Abstract
Cardamom and rosemary extract are a good source of several bioactive compounds, which possess ant oxidative and antimicrobial properties. In addition, cardamom and rosemary has been used for flavouring and culinary proposes respectively and sometime as a medicine. Furthermore, the uses of cardamom and rosemary along with other spices have received increasing attention as the natural additives for the shelf-life extension of food products, due to the risk in using synthetic preservatives. Meanwhile, the application of the synthetic preservative such as sulphites, benzoates, sorbates etc. for food preservation can cause certain health problems. Furthermore, natural preservatives are easy to obtain since the sources are from plant origin. Since all the spices are coming from plants they have been generally recognized as safe (GRAS). The unique properties of spices and herbs have created a huge demand for cardamom and rosemary around the world making them a niche of research and economical benefits. This review covers up to date literatures on cardamom and rosemary extract including sources, chemical composition, extraction methods, bioactivities, and their applications, particularly with the emphasis on preservation and the shelf life extension of food products.

Keywords: Antioxidant, antimicrobial, spices, colorants, preservatives, properties

Introduction
The retention of food quality is important to ensure the consumption of food with high nutritional values for our health. Thus, the best way to retain food quality and prevent them from deteriorating is by preservation methods. Nowadays, there are various types of preservation methods that can be applied to maintain the condition of food products for a long period of time, either by using the conventional or modern preservation technology methods. Some of these preservation methods use additional food preservatives which can be classified into artificial and natural preservatives. Generally, consumers are aware of the short and long term effects of using artificial preservatives to their health. Food preparations containing synthetic antibacterial and chemical preservatives (*e.g.* sorbic acid and benzoic acid) are restricted in many countries as well as carcinogenic effect of synthetic additives such as BHT, BHA and TBHQ has been demonstrated Madsen, *et al.* 1995 [32]. Moreover, with the large and diverse increase in food consumption, the known biological preservatives approved for use in food preparation remain rather limited and unfit for all foodstuffs. The search for cheap, non-toxic and natural food preservatives which could be used safely and effectively is an important factor for future food industry.

So the application of some spices as preservatives in food has been evaluated in order to determine its efficiency, since spices are natural sources having antioxidant and antimicrobial activity that offer an opportunity to replace synthetic preservatives in food, such as nitrates, which have been claimed to possess negative effect on human health (Anand and Sati, 2013) [4]. Inhibitory activity of spices against "microbes"" has long been reported (EI-Kady *et al.* 1993) [21]. Moreover, little work was done to match their ethno botanical information with analytical research to identify active chemical compounds. Combinations of probiotics with spices may provide further therapeutic properties. In-vitro studies that tested spices on the growth of selected probiotics showed that spices significantly enhanced the growth of probiotics while inhibiting pathogens (Be *et al.* 2009) [10]. Compounds isolated from different spices shows positive antimicrobial activity against some of the most common microorganisms that affect the food quality and decrease the shelf life of food (Tajkarimi. *et al.* 2010) [50].

This review paper focuses on, the scientific literature on cardamom and rosemary used as a food preservative to improve the oxidative stability of foods reports renewed research interest

in natural compounds of vegetable origin as valid alternatives to synthetic preservatives. Cardamom and rosemary are traditionally used as food ingredients, as well as for their antioxidant properties. Natural antioxidants are currently receiving considerable attention in human nutrition and good starting material is provided by secondary metabolites, such as the polyphenolic compounds present in plants that have been reported to have antioxidant properties Liu, *et al.* 1992 [30].

Cardamom and rosemary have the potential to be used as preservatives in many foods namely in processed meat to replace chemical preservatives. Main chemical compounds in spices also confer other properties providing a variety of applications to spices, such as insecticidal, medicines, colorants and natural flavouring. Spices provide beneficial effects, such as antioxidant activity levels that are comparable to the level of regular chemical antioxidants used so they can be used as a natural alternative to synthetic preservatives.

In this review, the main characteristics of cardamom and rosemary are examined as well the chemical compounds in cardamom and rosemary which confer several properties that lead to wide ranging applications of cardamom and rosemary. Finally, a brief discussion is presented about the advantages and disadvantages of use of cardamom and rosemary regarding their potential.

Cardamom *(Elettaria cardamomum)* Ela (Cardamom)

The search for unique food ingredients and flavours with enhanced health properties is at present one of the key global market trends (Netzal. *et al.* 2007) [35].

There is now mounting scientific evidence of health benefits of spices including antioxidant, antimicrobial, anti-inflammatory and anti-carcinogenic properties (Srinivasan, 2004, Tapsell *et al.* 2006) [49, 51]. The largest published study to date which reported the antioxidant activity of 1113 food samples found that within the top 50 foods with antioxidant properties, the top five were spices (Halvorsen *et al.* 2006) [25].

Elettaria cardamomum is plant of *Zingiberaceae* family. As a spice, cardamom is used in cuisine for curry, coffee, cakes, bread, and flavouring sweet dishes and drinks. The seed and the essential oil are used as flavouring component in a variety of foods including alcoholic and non-alcoholic beverages, frozen desserts, candies, gravies, meat and meat products. Another use of cardamom is in traditional Chinese and Indian medicine as a digestive aid and for the treatment of intestinal gas (Ravindran *et al*. 2002) [43].

India ranks second in global cardamom production with approximately 21% contribution with 23890 tonnes in the year of 2014-15 (SBI, 2017) [46]. Guatemala ranks first with 45% contribution of the same (Prasad, *et al.* 2017) [39]. Also, India is the world's largest consumer market for cardamom, but behind in imports from Saudi Arabia due to the fact that unlike Saudi Arabia, India produces a substantial amount of cardamom domestically that is consumed at home (USAID, 2011) [52].

Composition and chemistry

The chemical composition of cardamom varies considerably with variety, region and age of the product. The main compound are 1, 8-cineole (representing 50% or more), with smaller amounts of limonene, α-terpenyl acetate, α-terpineol, borneol, camphor and α-pinene. Indian cardamom is low in fat and high in protein, iron and vitamins B and C. Seeds of Cardamom are with their sweet and spicy aroma, used in aromatherapy to stimulate energy.

The content of volatile oil in the seeds is strongly dependent on storage conditions, and may be as high as 8%. The volatile oil contains about 1.5% α-pinene, 0.2% β-pinene, 2.8% sabinene, 1.6% mycrene, 0.2% α-phellandrene, 11.6% limonene, 36.3% 1,8-cineole, 0.7% γ-terpinene, 0.5% terpinolene, 3% linalool, 2.5% linalyl acetate, 0.9% terpinen, 2.6% α-terpineol and 31.3% α-terpinyl-nerolidol (Korikontimath *et al.* 1999) [28].

The basic cardamom aroma is produced by a combination of the major components, 1, 8-cineole and α-terpinyl acetate (Lawrence. *et al.* 1979) [29]. It is knowan as *Queen of spices* and traditionally employed in foods as flavouring component and for its medicinal effect (Ravindran *et al.* 2002) [43]. Limonene, 1, 8-cineole and its esters; α-terpinyl acetates are the most abundant bioactive compounds in cardamom (Agbor *et al.* 2001) [1]. Cardamom has total phenolic content: 0.317-1.66 g/100 g, total flavonoid content: 11.33-14.63 g/100 g and antioxidant activity: 85-90% sufficient for inhibition of lipid peroxidation (Bhatti *et al.* 2010) [11].

Medicinal use and Pharmacological properties

Cardamom has effective against digestive problem and urinary complaints, asthma, bronchitis and several other human aliments.

The plant also stomachic, cardamom oil is a effective as an antioxidant, uterine complaints and liver disease, Externally, it is also applied to tumours of the uterus. Cough use as general tonic, anti-bacterial, Haematological and Lipid Peroxidation activities, Insecticidal Activity, Anti-inflammatory, Analgesic & Antispasmodic Activity. (Gadekar, *et al.* 2017) [24]

Use of cardamom in food products

Cardamom exhibits antifungal, anti-inflammatory, anti-microbial properties (Daswani and Bohra, 2003) [17].

Cardamom incorporated yoghurt had the highest anti-oxidant activity as measured by DPPH assay (Vijaylakhshmi *et al.* 2014) [53]. Deepa *et al.* (2013) [18] reported that among cardamom, coriander and bay leaves, although bay leaves showed greater amount of phenols and high antioxidant activity, cardamom and coriander were also good sources of flavonoid and scavengers of free radicals. They recommended that extracts of these spices are promising alternative to synthetic substances as food ingredients with antioxidant activity.

Badei *et al*. (2002) [7] reported that the threshold level (in cookies) of the volatile oils of cardamom and cinnamon was 0.05%, while that for clove volatile oil was 0.075%. The authors noticed that cookies mixed with cardamom, cinnamon and clove powders or their volatile oils were acceptable for human consumption at concentrations ranged from 1.5 to 2 times of their threshold levels. During the oxidative stability test of cookie lipids with added volatile oils, it was found that oxidative stability increased with increasing concentration of volatile oils in cookies. Palit and Pal (2005) [36] observed that vacuum packaging and addition of cardamom and potassium sorbate, each at the rate of 0.1% of *khoa* (w/w) increased the shelf life of *burfi* upto 60 days at 30±1 ˚C. Prasad *et al.* (2017) [39] reported that the flavour score of cardamom added *burfi* was not significantly (p<0.05) different from that of control *burfi*. Anandaraj and Sudharshan (2011) [5] reported that major chemical constituents for imparting flavour in cardamom extract were α-terpinyl acetate and α-terpineol.

Rosemary (*Rosmarinus officinalis)*

Rosemary grows as a small evergreen shrub with thick aromatic leaves. The plant has small, pale-blue flowers that bloom in late winter and early spring. Although rosemary is native to the Mediterranean, it now is cultivated worldwide. Other types of rosemary include bog rosemary (*Andromeda* species) and wild or marsh rosemary (*Ledum palustre*).

Rosemary (*Rosmarinus officinalis* Linn.), a household plant, is commonly found throughout the world. The extract of this plant has historically been used to inhibit oxidative deterioration in foods, fats and oils. A number of components have been identified to be responsible for the antioxidative properties of rosemary. The main antioxidative effect is attributed to three phenolic diterpenes: carnosic acid, carnosol, and rosmarinic acid

Composition and chemistry

Rosemary contains a-pinene (18.25%), followed by camphor (6.02%), 1.8-cineole (5.25%), camphene (5.02%), b-pinene (4.58%), bornyl acetate (4.35%), limonene (3.56%), borneol (3.10%), a-terpineol (2.89%), and cymene (2.02%) Derwich, *et al.* 2011.

Extract of rosemary (*Rosmarinus officinalis*), whose antioxidant activity is well known (Bousbia *et al.* 2009) [12], is the most abundantly tested active natural agent in both food-simulating systems and in real food matrices (Akhtar, *et al.*1998) [2]. The antioxidative properties of rosemary are mainly related to their content of phenolics compounds, suggesting that their antioxidant actions are similar to those of synthetic phenolics antioxidants (Cuvelier, *et al.* 1996) [16]. The antioxidant capacity of rosemary is attributed to three phenolic diterpenoids (carnosic acid, carnosol, rosemaric acid) but many other components (rosmanol, epirosmanol, isorosmanol, rosmaridiphenol, rosmadial, rosmariquinone, carvacrol, carvone, cymene, cineole, fenchone, limonene, terpinene and thymol) are expected to contribute to its antioxidative and antimicrobial properties Fu, *et al.* 2007 [23].

Traditional/Ethnobotanical uses

Rosemary is a widely used culinary spice. Tradition holds that rosemary will grow only in gardens of households where the "mistress" is truly the "master." The plant has been used in traditional medicine for its astringent, tonic, carminative, antispasmodic, and diaphoretic properties. Rosemary is one of the oldest known medicinal herbs, used centuries ago to enhance mental function and memory.

Rosmarinic acid, carnosic acid, and carnosol are the major bioactive constituents in rosemary leaves responsible for the antioxidant, anti-inflammatory, and anticarcinogenic effects (Masuda *et al.* 2001) [33]. Carnosic acid (CA) is a phenolic diterpene compound found in rosemary and sage leaves. It is the most powerful antioxidant among diterpenes and is a free radical scavenger. Antioxidative activity of CA is as high or higher as synthetic antioxidants (Cuppett *et al.* 1997) [15]. Carnosic acid has a wide spectrum of actions, including antimicrobial, anticancer, and antimutagenic effects, and also has inhibitory effects on HIV-1 protease (Paris *et al.* 1993) [37].

Rosemary is a known antimicrobial agent. The powdered leaves of rosemary are used as an effective natural flea and tick repellent. Rosemary oil possesses marked antibacterial, antifungal, and antiviral properties. Rosemary oil was found to be most active against "meat-spoiling" bacteria (*Listeria monocytogenes*). A report on the use of rosemary to treat head lice found it to be ineffective.

There are numerous research reports available on rosemary's anticancer effects. The rosemary extract induces an anticarcinogenic enzyme. Other anticancer mechanisms include polyphenol constituents that inhibit metabolic activation of procarcinogens. Rosemary has been reported to decrease capillary permeability and fragility. The plant may have spasmolytic actions and immune effects. Rosemary also may reduce headaches as well as stress, and helps in asthma and bronchitis treatment. Rosemary also is used in aromatherapy for chronic pain treatment. Several reports exist concerning rosemary's antioxidative actions. Rosemary antioxidants have less scavenging potential than green tea polyphenols, but have more potential than vitamin E.

Use of rosemary in food products

Rosemary as antioxidants:

One of the most important sources of natural antioxidants is rosemary. Loliger (1983) [31] reported that rosemary was one of the few spices used in the food industry primarily for its antioxidant property, whereas other spices are used for their flavouring properties. Many studies have been conducted to examine the antioxidative activities of crude rosemary and different rosemary extracts (Riznar *et al*. 2006) [45].

Studied the antioxidant and antibacterial effect of rosemary, orange and lemon extracts was investigated in cooked Swedish-style meatballs. Activity in a lard system was well established for all the extracts and further determination of the development of rancidity as thiobarbituric acid reactive

substances consistently showed that about 50% of the rancidity can be controlled by the citrus preparations. Two of the rosemary extracts (water soluble and oil soluble) were more effective with practically complete elimination of rancidity (TBA values) after a period of 12 days. Rosemary extract activity against lactic acid bacteria and Listeria but not Brochothrix thermosphacta was demonstrated in an agar diffusion test, but in the product only lactic acid bacteria counts were slightly reduced. Sensory analysis results, particularly aroma and acceptability scores, indicated the significant advantages in using rosemary and citrus extracts in rancidity-susceptible meat products.

While studied lipid oxidation was minimized in meat with added extracts, as indicated by lower (P<0.05) thiobarbituric acid-reactive substances, peroxide value and free fatty acid. Addition of natural antioxidant extracts (Carnosic acid (CA) and rosmarinic acid (RA)) at 10mg equivalent total phenols per 100 g in raw and cooked meat did not affect the sensory scores relative to non-treated controls.

The effects of three concentrations (0.2%, 1% and 3%) of rosemary oil (RO) on the freshness indicators, oxidative stability, fatty acid and biogenic amine (BA) contents of minced rainbow trout muscle (MTM) were investigated after different periods of storage (three and nine days) at 4±1 °C. Moreover, the terpene and sesquiterpene contents in the treated MTM were also measured. RO treatment improves the pH, oxidative stability of the lipids and the FA profile, which resulted in a significant extension of MTM shelf-life (Pier. *et al.* 2012). Essential oil of rosemary has been used not only for its flavouring compounds but also for its antimicrobial and antioxidant activity in meat products.

The antioxidant potential of RME was assessed in many fat rich food products such as palmolein (Jaswir *et al.* 2000) [26], soybean oil (Ramalho and Jorge, 2008) [41], margarine (Azizkhani and Zandi, 2009) [9], cheese spread (Dinnies. *et al.* 2012) [20], turkey meatballs (Tymoszczyk, 2014) [27] and sunflower oil (Simona. *et al.* 2014) [48]. It was observed that RME had a positive effect on the oxidative and thermal stabilities of such products, and it was recommended as an alternative antioxidant. Autoxidation of corn and soybean oils was prevented in the presence of 0.1 g/kg rosemary (*Rosmarinus officinalis* L.) extract and butylated hydroxy toluene (BHT) Basaga *et al.* 1997 [8].

Rahila *et al.* (2017) [40] reported that addition of rosemary extract (RME), a source of natural antioxidants, at the rate 0.1%, increased the antioxidant potential of *ghee* in terms of radical scavenging activity (DPPH assay) without affecting sensory and physicochemical properties.

Comparison with synthetic preservatives

Rosemary (*Rosmarinus officinalis*) has been shown to strong preservative properties for their use in foods since it's antioxidant activity has been tested in pork products, such as patties (Chen. *et al.* 1999) [14]. The antioxidant properties of rosemary have been attributed to the variety of phenolic compounds in this spice, such as carnosol, carnosic acid, rosmarinic acid, rosmanol and tosemaridiphenol. Carnosic acid is the main compound found in rosemary followed by other phenolic compounds, such as carnosol, the rosemary chemical compounds are classified into three groups, the phenolics diterpenes related to abietic acid structure, the flavonoids and the phenolic acids (Almela *et al.* 2006) [3]. The main preservative properties are due to carnosic acid in rosemary, which have a high antioxidant. The antioxidant activity of this carnosic acid has been compared to the antioxidant activity of substances, such as butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA) and tertiary butyl hydroquinone (TBHQ) and the results showed that this acid has antioxidant activity higher than BHT and BHA (Richheimer, *et al.* 1996) [44]. Carnosic acid, one of the main active compounds of rosemary, has originated from isopentenyl diphosphate via methylerythritol phosphate and is located in chloroplasts and intracellular membranes as carnosol (Almela *et al.* 2006) [3]. The rosemary has been compared with other chemical preservatives and antioxidant compounds proving efficiency that is comparable to the currently used preservatives so that rosemary can be used as a natural green alternative to some chemical antioxidants with comparable results. Rosemary can be used as natural antioxidant in many foods as it does not have a strong flavor akin to the majority of spices, namely cloves, cumin and cinnamon among others. Hence, the use of rosemary as antioxidant will not damage the organoleptic properties of foods.

Uses and Benefits

Spices	Uses	Benefits
Cardamom (Elaichi)	It is used in most of the Indian sweet dishes to give a good flavour. It is also used widely in pharmaceutical sector.	Helps to control bad breath and digestive disorder. A whole cardamom chewed is good for coping with diabetes. (Rathore, *et al.* 2013) [42]
Rosemary	It is used in most of the dishes as a culinary spice It is also used widely in pharmaceutical sector as phenolics s anti-oxidant rosmarinic acid, As well as volatile essential oils such as *cineol, camphene, borneol, bornyl acetate, a-pinene*	Acts as rubefacient to soothe painful ailments in gout, rheumatism and neuralgic conditions. Stimulate the hair-bulbs and help prevent premature baldness. Natural remedy for nervous headache, colds, and depression (Chaitali, *et al.*, 2017) [13]

Conclusion

The review of literature presented above suggests that a significant amount of research work had been carried to preserve and shelf life enhancement of meat, dairy and other food products using cardamom and rosemary extract. Finally, the antimicrobial and antioxidant properties of cardamom and rosemary extract among others leads to a research field in order to use them as preservatives in food. Rosemary extract used in foods, such as meats have a high possibility of success and potential antimicrobial activity that is comparable with the effect of nowadays used preservatives based on nitrites, which have been claimed to own negative health effects, making possible to research a way to substitute chemical based preservatives with natural based ones for food preservation and also Food preparations containing synthetic antibacterial and chemical preservatives (*e.g*. sorbic acid and benzoic acid) are restricted in many countries. However rosemary has been proved to have microbial growth inhibition potential to some of the most common bacteria in food, such as *L. monocytogenes*, *E. coli* and *Salmonella*. Thus, it is possible to use as preservatives but is necessary to prove its antimicrobial effect on different foods, especially on dairy

products, vegetables and fruit to guarantee a preservative effect comparable to the conventional synthetic preservative effect for each food prior to settle the use of spices as preservatives for industrial or commercial proposes. Apart from all each of the spices possesses more than one health beneficial property and there is also a possibility of synergy among them in their action, using spice in diet can make life not only more spicy but also more healthy.

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