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Short Review Paper

Clove (Syzygium Aromaticum) - A Promising Natural Preservative

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Abstract

Presently, people are looking for refuge within nature, mostly from plant, to prevent the food from decaying due to the turmoil in class II preservatives and their impact on both human health and environment. Clove is a natural preservative with an abundance of health benefits, mainly eugenol which is responsible for its strong preservative properties and other components of the plant. The major findings of this review are that cloves and various parts of the plant can be utilized to preserve food. The preservative action is mainly due to degradation of microbial cell membranes, inhibition of enzyme activities, and interference with the metabolic processes of microbes. In addition, clove has notable antioxidant activity, which helps reduce lipid oxidation and preserve quality during storage. Recent formulation techniques, such as nanoemulsion and compact techniques, are considered to enhance the stability, bioavailability, and efficacy of preservatives using clove, while decreasing problems related to unstable and strong scent. Clove is a natural preservative that is a potential candidate for eco-friendly packaging and food preservation, based on the information available. Additional studies are required to improve formulation, assess long-term safety, and broaden the application of clove in eco-friendly and biodegradable preservation technologies.

Keywords: Clove, Syzygium aromaticum, natural preservative, antimicrobial activity, eugenol

Introduction

Food going bad because of germs and oxidation is a big headache for the food industry. When bacteria, fungi, or yeast get into food, they break it down, ruin the taste, and basically make it unsafe to eat. That's not just bad for business—it's risky for people's health too[1]. To slow down this spoilage, companies often rely on chemical preservatives. But those chemicals come with their own problems—toxicity, environmental concerns, and complaints from consumers.

So now, researchers are looking for safer, natural ways to keep food fresh. People have turned to spices and herbs for ages to help keep food fresh, mostly because these plants fight off microbes. Out of all of them, clove really stands out. It comes from the Myrtaceae family and first grew wild in Indonesia's Maluku Islands, but now you'll find clove farms across the tropics—in places like India, Madagascar, Sri Lanka, Tanzania, and, of course, Indonesia.

What's valuable are the clove tree's flower buds. Farmers pick them before they bloom, dry them out, and that's the spice you see in kitchens everywhere. Clove isn't just about flavor, though. People have used it for centuries as a remedy, too. Why is clove so effective? It's packed with phenolic compounds, especially eugenol[2]. That's the stuff that fights bacteria and works as an antioxidant. All of this makes clove a great natural choice for keeping food safe and lasting longer.

Botanical Characteristics of Clove

Clove, or Syzygium aromaticum, is an evergreen tree that usually grows somewhere between 8 and 12 meters tall.
It really likes warm, tropical weather, and you'll mostly find it doing well along the coast, especially at lower altitudes. After about four years, a clove tree starts producing flower buds[3].

Farmers pick these buds while they're still maturing, before the flowers actually open. Once dried, these little buds turn into the spice so many people know—and they're also the main source for clove essential oil. Growing cloves matters a lot for the economies of a few countries. Indonesia leads the world in clove production, with India and Madagascar not too far behind. More and more people want cloves these days, since they show up in so many places—food, medicine, cosmetics, even pharmaceuticals[4,5].

Phytochemical Composition of Clove

The preservative potential of clove is mainly due to its rich phytochemical composition. Clove contains a variety of bioactive compounds including phenolic acids, flavonoids, and essential oils[6].

Major chemical constituents of clove include: Eugenol, Eugenyl acetate, β-caryophyllene, Gallic acid, Caffeic acid, Ferulic acid, Quercetin, Kaempferol. Eugenol stands out as the main compound in clove—it's the one that really drives most of

clove's biological effects. Clove buds pack a punch, holding up to 18% essential oil, and eugenol takes the lead there[7].

But there's more to clove than just its oils. It's loaded with polyphenols and flavonoids, too. They boost clove's antioxidant power, helping mop up free radicals and keeping food from getting damaged by oxidation.

Antimicrobial Activity of Clove

People have looked at clove's antimicrobial power for a while now, especially when it comes to fighting off all sorts of food borne bugs. Study after study shows that clove extracts can stop both Gram-positive and Gram-negative bacteria in their tracks[8,9].

For example, when researchers tested different spice extracts, they found that just a 3% water-based clove extract wiped out big-name pathogens like E. coli, Staph aureus, and Bacillus cereus. Even when they dropped the concentration down to 1%, clove still put up a strong fight. In another experiment, clove essential oil managed to take on 25 different bacterial strains—covering both Gram-positive and Gram-negative types—and held its ground[1,10].

Clove oil has also demonstrated antifungal activity against several fungal species such as: *Mucor sp*, *Aspergillus sp.*, *Fusarium oxysporum*, *Trichophyton rubrum.* The antifungal mechanism is mainly associated with eugenol-induced disruption of fungal cell membranes, leading to cell lysis and inhibition of spore formation[11].

Antioxidant Properties

Oxidation really takes a toll on food. When fats oxidize, you get rancid flavors, weird smells, and food just loses its nutritional value[12,13]. That's why natural antioxidants matter so much for keeping food fresh. Clove stands out here. Among all the spices, it's one of the strongest natural antioxidants you can find. Its power mostly comes from its phenolic compounds—especially eugenol and gallic acid.

Researchers have looked at all sorts of plant extracts, and clove consistently shows much higher antioxidant activity than most fruits, vegetables, or other spices. It's in a league of its own. The antioxidant mechanism of clove includes: Free radical scavenging, Inhibition of lipid peroxidation, Metal ion chelation, Stabilization of oxidative reactions. These properties help protect food products from oxidative degradation during storage[14-16].

Applications of Clove in Food Preservation

Clove has been successfully applied in various food preservation systems due to its antimicrobial and antioxidant activities.

Meat Preservation: People have turned to clove extracts to keep meat and poultry fresh for longer. When researchers treated meat with clove extract, they found fewer bacteria during refrigerated storage than in untreated samples. At 4°C, meat with clove held onto its color, smell, and texture a lot better, which means it lasted longer and stayed more appealing[17].

Food Packaging: Lately, food packaging has taken a new turn. Now, natural preservatives—like clove essential oil—get mixed right into biodegradable packaging films. This move doesn't just help the environment; it also keeps microbes off food surfaces, so the food stays safer for longer.

Natural Food Additives: Clove extracts are also used as natural additives in beverages, sauces, and processed foods. Their antimicrobial properties help reduce microbial growth while enhancing flavor.

Mechanism of Preservative Action

Clove owes its preservative power mostly to eugenol and other phenolic compounds. They go after microbes in a few ways—breaking down cell membranes, causing important stuff inside the cells to leak out, blocking enzymes, messing with how microbes process nutrients, and even triggering oxidative stress inside the cells[18]. All together, these actions stop the growth and spread of the microbes that spoil food.

Challenges and Future Perspectives

Despite the promising applications of clove as a natural preservative, several challenges remain[2,5]. Some limitations include: Strong aroma that may affect food flavour, Stability issues during food processing, limited solubility of essential oils, Regulatory approval for large-scale applications. To overcome these challenges, researchers are exploring advanced technologies such as: Nano-encapsulation of clove oil, Controlled release packaging systems, Combination with other natural preservatives, Development of biodegradable antimicrobial films. These innovations may enhance the stability and effectiveness of clove-based preservatives in food systems[19,20].

Conclusion

Clove (Syzygium aromaticum) packs a punch when it comes to preserving food. Thanks to its high levels of phenolic compounds—especially eugenol—it fights off microbes and keeps oxidation in check. Plenty of research backs this up: clove extracts stop food borne germs and slow down spoilage. Lately, newer methods like nano-encapsulation and active packaging are opening more doors for clove in the food world. With ongoing research, clove stands out as a real, sustainable alternative to synthetic preservatives. Safe, natural, and effective—it's got a lot going for it.

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