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Role of Ascorbic Acid in the Preservation of Food

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Abstract

Vitamin C or ascorbic acid is a well-known nutrient that is present in many food products including certain fruits and vegetables. However, its importance is not only limited to health for it is a very crucial component in the preservation of food. This review looks at the ways through which ascorbic acid acts as a preservation agent in foods through its antioxidant activity and its action against enzymatic browning and microbial growth.

Introduction

The issue of food quality and safety is a major consideration in the food industry. It involves the desire to preserve the shelf life, nutritional values, and safety of food for the consumers. Vitamin C also known as ascorbic acid has received a lot of interest due to its multiple uses in food preservation.

Ascorbic acid is widely used in the food industry in various products starting from fresh-cut fruits and vegetables to meat, poultry, and dairy products. By inhibiting polyphenol oxidase (PPO) activity, ascorbic acid helps maintain the color and freshness of fruits and vegetables post-harvest and during processing. This review focuses on the ways by which ascorbic acid works as a preservative; the antioxidant properties, the inhibition of enzymatic browning, and the antimicrobial activities.

Antioxidant Properties

Mechanism of Action

Ascorbic acid acts as an antioxidant by donating an electron to eliminate free radicals and Reactive Oxygen Species (ROS). This antioxidant activity plays a crucial role in the prevention of oxidation of food components, especially lipids and vitamins. Thus, maintaining the nutritional and sensory properties of food products. Davey et al., (2000) note that ascorbic acid can prevent the oxidation of foods that in turn helps preserve the colour, flavour, and quality of the foods. Ascorbic acid inhibits the oxidative chain reactions that are responsible for a decline in the quality of foods through electron donation. Ascorbic acid also helps to stabilize the reactive oxygen species and free radicals hence preventing oxidative deterioration of foods (De Oliveira et al., 2015).

Applications in Food Preservation

Fruits and Vegetables

Vitamin C is commonly used as a food preservative to control oxidative spoilage of fruits and vegetables. Bozkurt and Erkmen (2007) also showed that ascorbic acid was capable of delaying the oxidation browning in apple slices. Likewise, Lee and Kader (2000) observed that ascorbic acid helped in the preservation of fresh-cut kiwifruit by minimizing the effects of oxidative stress.

Meat Products

In meat products, ascorbic acid plays an important role in inhibiting the oxidation of lipids which results in rancidity and off-flavor. Rojas and Brewer (2007) noted that ascorbic acid was able to prevent the oxidation of lipids in beef patties hence enhancing their storage quality. In the recent past, Zhang et al. (2016) also supported the above finding that the incorporation of ascorbic acid in pork sausage formulation helped to minimize oxidative rancidity.

Dairy Products

In dairy products, ascorbic acid has been reported to prevent oxidative processes that are likely to impair quality. For example, Luckow and Delahunty (2004) discovered that adding ascorbic acid to probiotic dairy drinks enhanced the preservation of the product's sensory characteristics during the storage period. Garcia et al. (2009) also showed the same results.

Beverages

Ascorbic acid is also used in the preservation of beverages to avoid oxidation and to retain the flavour and colour of the product. Vermeulen et al., (2006) found that ascorbic acid was capable of preventing the oxidation of flavonoids in fruit juices hence maintaining the colour and taste of the fruit juices.

Combined Use with Other Antioxidants: Ascorbic acid is generally applied in conjunction with other antioxidants in order to increase its efficacy. Liao and Seib (1988) showed that ascorbic acid and tocopherol worked synergistically in preventing lipid oxidation in foods. Brewer (2011) also established the same point.

Prevention of Enzymatic Browning

Mechanism of Action

PPO-catalysed enzymatic browning is one of the major concerns in fruits and vegetables. Ascorbic acid competes with this process by converting the quinones formed back to the phenol, thus preventing the browning reaction (Lozano-de-Gonzalez et al., 1993).

Ascorbic acid can reduce the quinones formed by the action of polyphenol oxidase on phenolic compounds and thus inhibit browning (Sapers et al., 2001). This action assists in keeping the fruits and vegetables visually appealing and nutritious as they are consumed.

Applications in Food Preservation

Fresh-cut Fruits and Vegetables

Sodium benzoate and ascorbic acid are commonly used for the preservation of fresh-cut fruits and vegetables. According to Toivonen and Brummell (2008), ascorbic acid was able to inhibit the process of browning in fresh-cut apples and potatoes. In the same manner, Kim et al. (2013) showed that separate applications of ascorbic acid and calcium chloride reduced browning in fresh-cut lettuce.

Processed Products

Ascorbic acid also has uses in processed products where enzymatic browning can be a problem. For example, Ferrentino and Scampicchio (2015) proved that ascorbic acid contributed to the preservation of the colour of the processed apple puree.

Influence of Concentration and Application Methods

The concentration of ascorbic acid and methods of application can affect its ability to inhibit enzymatic browning. Aguayo et al. (2010) found out that kiwifruit with higher ascorbic acid concentrations offered better protection against browning in fresh-cut kiwifruit. In the same way, Soliva-Fortuny et al. (2002) have also established that coating the fruits in ascorbic acid solutions before packaging reduced the browning.

Combined Use with Other Anti-browning Agents

Rojas-Graü et al., (2009) showed that ascorbic acid together with citric acid had a synergistic effect on preventing browning in fresh-cut apples. In similar studies by Gorny et al. (2002), it was found that ascorbic acid and calcium ascorbate blend were effective in preventing browning in fresh-cut pears.

Microbial Inhibition

Mechanism of Action

Ascorbic acid has a bacteriostatic effect, which means that it may suppress the growth of some microorganisms and thus help in increasing the microbial safety of foods. It does this by making the environment hostile to the microorganisms, for instance, by lowering the pH level and increasing oxidative stress (Kallio, et al., 1986). The antimicrobial effects of ascorbic acid reduced the pH of the food matrix thereby inhibiting the growth of microorganisms. Also, ascorbic acid can produce oxidative stress in microorganisms through the production of reactive oxygen species that inactivate them (Munoz et al., 2009).

Applications in Food Preservation

Dairy Products

In dairy products, ascorbic acid has been reported to have the ability to check the growth of spoilage microorganisms. Luckow and Delahunty (2004) established that ascorbic acid reduced microbial activity in probiotic dairy drinks hence increasing their shelf life. Likewise, Garcia et al. (2009) concluded that ascorbic acid in cheese formulation lowered microbial growth.

Meat and Poultry

Koutchma et al. (2005) have reported that the ascorbic acid treatments have a bacteriostatic effect on the spoilage bacteria in chickens. Suman et al. (2010) also found that ascorbic acid in combination with other preservatives reduced microbial growth in ground beef. The findings of Mancini et al. (2010) revealed that ascorbic acid treatments were effective in lowering microbial counts in fresh pork.

Fruits and Vegetables

In fruit and vegetable preservation, ascorbic acid assists in preventing the growth of microorganisms that cause spoilage and hence increases shelf life. Sivakumar and Bautista-Baños (2014) have established that ascorbic acid treatments helped in minimizing microbial loads in fresh-cut fruits. Other studies by Martínez-Hernández et al. (2013) also showed similar results.

Influence of Concentration and Application Methods: The antimicrobial potential of ascorbic acid depends on the amount of the compound and its application techniques. According to the study conducted by Dong et al. (2013), it was ascertained that enhanced levels of ascorbic acid offered enhanced antimicrobial barriers in fresh-cut tomatoes. In the same manner, Garcia-Gimeno et al. (1996) established that the form of application including dipping or spraying influenced the antimicrobial effectiveness of ascorbic acid.

Combined Use with Other Antimicrobial Agents

Ascorbic acid is always used together with other antimicrobial agents to increase its efficiency. Varoquaux and Wiley (1994) showed synergistic antimicrobial effects of ascorbic acid and calcium lactate in fresh-cut apples. In the same regard, Rojas-Graü et al. (2009) showed that a combination of ascorbic acid and citric acid could efficiently control microbial growth in fresh-cut pears.

Conclusion: It is well known that ascorbic acid is very crucial in food conservation since it fights oxidation stress, hence playing a role in food conservation. As a reducing agent, ascorbic acid neutralizes ROS and prevents the oxidation of lipids which is beneficial in maintaining the nutritional and sensory quality of foods. This antioxidative capability is very useful in the retention of color, flavor, and general quality of fruits, vegetables, meat, and dairy products.

The action of ascorbic acid not only helps to retain the appearance of the produce but also the quality. Also, ascorbic acid competes with the oxidizing agents for the binding of metal ions required for PPO activity, and therefore, amplifies its action in inhibiting browning. Another function of ascorbic acid in food preservation is microbial inhibition. In the fruit and vegetable sector, ascorbic acid is used to prevent the formation of browning and microbial growth as it helps to extend the shelf life of the fruits and vegetables. In meat products, it is applied to hinder oxidation and microbial deterioration which in turn enhances shelf life and safety. In the same way, in dairy products, ascorbic acid aids in preserving quality and increasing shelf life since it prevents microbial activity and oxidative deterioration. Also, it has been discovered that the application of ascorbic acid is more effective when used in conjunction with other antimicrobial substances. Thus, ascorbic acid has a significant function in preventing food spoilage and preserving the quality, safety, and shelf life of foods.

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