Compounds Exhibiting Antioxidant and Anti-Browning Properties

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The browning process is a natural phenomenon occurring in fruit and vegetable, which has become a challenge in the food industry sector. The undesired condition caused by browning processes has a significant impact on food quality as it causes deterioration in nutritional and sensory properties, as well as safety. Enzymatic browning is an oxidation reaction. This reaction can be prevented by the removal of oxygen from the cut surface of fruit and vegetables. Nonetheless, the browning can be recovered when oxygen is re-established. Therefore, the utilization of antioxidant and browning inhibitors to inactivate the enzymes responsible for browning is widely employed in the food industry, especially the fresh-cut industry. Seeking the natural compounds as food preservatives derived from natural extracts is highly recommended.

Keywords: enzymatic browning ; anti-browning ; antioxidant

1. Polyphenols

Polyphenols are considered the largest group of chemical substances in fruits, vegetables, and herbs. They present in various forms and serve as great anti-browning and antioxidant agents due to their multiple hydroxyl groups and phenol ring structures [1]. Polyphenols can be divided into three mains classes such as phenolic acids (gallic acid), flavonoids (flavone), and other phenolics (tannins). Phenolic-based compounds and their derivatives obtained from plant extract depict strong anti-browning and antioxidant properties and therefore present potential as natural inhibitors [2][3]. The natural inhibitors sourced from plants (phenolic-rich extract) are free from harmful side effects and offer performance comparable to synthetic agents [4]. The benefits provided by plant extracts as natural preservatives, among others, such as low toxicity, low cost, biodegradability, renewability, etc. [5]. Many studies have reported on the utility of plant extracts from different plant parts (leaves, flowers, fruits, and seeds) as anti-browning and antioxidant additives for foods [5][6]. Various studies have also reported a strong positive correlation between the total phenolic content and antioxidant activity of plant extracts, which could prevent brown pigment formation in fruit and vegetable [7]. The antioxidant activity of phenolic compounds could be due to their redox properties, which allow the phenolic substances to act as reducing agents, singlet oxygen quenchers, and hydrogen donators [8]. Malaysia has a diverse range of plant species which could possess both potent anti-browning properties and antioxidant benefits for foods. The exploitation of natural plant extracts for the industrial production of natural preservatives is a fast-growing sector. These natural preservatives are expected to become very competitive in the market due to their higher biological value, and their potency as inhibitors of brown pigment formation. Importantly, these natural substances are not associated with cytotoxicity effects in human cells when compared to synthetic products [4].

2. Carotenoids

Carotenoids are plant pigments naturally present in many fruits and vegetables. Depending on the presence of oxygen in the carotenoid structure, they can be classified into two main carotenoids groups, namely oxygenated xanthophylls (zeaxanthin and lutein) and unoxygenated carotenes (lycopene, α-carotene, and β-carotene) [9]. Tomato and its by-products (skin) have been noted as an excellent source of carotenoids that may contribute to anti-browning activities [10] [11]. Tomato varieties with a predominance of carotenoid contents have exhibited lower PPO activity [12]. For instance, lycopene and its derivatives act as an antioxidant agent that reconstructs the polyphenols oxidized by the PPO activity, resulting in reduced colour changes in tomatoes [11][12]. Martínez-Hernández et al. [11] prepared the lycopene microspheres obtained from tomato skin for reducing the apple browning. Thus, the application of carotenoids as an anti-browning agent in fresh-cut products is promising. Besides their anti-browning properties, carotenoids have been used as natural antioxidants for food product development in order to extend their shelf-life [10]. Carotenoids also play significant roles in the photosynthesis process by absorbing the light and protecting the organism from excessive light exposure, resulting in oxidative stress formation [13]. Hence, the application of carotenoids as an anti-browning agent in fresh-cut

food products is highly recommended thanks to their ability to scavenge the free radicals associated with the development of browning.

3. Terpenoids

Terpenoids, also known as terpenes or isoprenoids, are secondary metabolites derived from natural sources. Terpenoids are ubiquitous, and can be found in nearly all living organisms. They are essential for plant growth and development and contribute the flavor, scents and colour [14]. Studies have reported that terpenoids found in citronella exhibit anti-browning activities [15], while Nakatsu et al. [16] reported that the terpenoids in the plant's essential oil showed strong inhibitory effects on PPO activity in mushrooms. The results obtained will be beneficial and can provide fundamental understanding for researchers in carrying out an extensive study in the future, and at the same time can encourage them to diversify the research by investigating the isolation and determination of the enzyme-inhibition activity of terpenoids extracted from different natural sources.

4. Organic Acids

Organic acids are a type of organic compound that possess weak acid properties which can be found naturally in plant and animal sources. Most of the organic acids are known as carboxyl acids, exhibiting anti-browning properties attributed to their metal-chelating activities or pH lowering effects [2]. They are great enzyme inhibitors as they able to deactivate the PPO enzyme and POD enzyme by lowing the pH in the medium. A recent study highlighted that organic acid such as ascorbic acid, citric acid, and malic acid found in unripe grape was responsible for lowering the enzyme activity to prevent browning development [17]. These organics are safe, with no restriction on their ingestion. Therefore, future studies are encouraged to search for organic acids derived from natural sources in order to replace the chemical anti-browning agents that are available in the market.

5. Bioactive Peptides

Bioactive peptides are protein fragments that possess potential health benefits. Typically, it exists as a peptide residue with 2–20 amino acids and is inactive within the parent protein but can become active when it is released through fermentation, enzymatic or chemical digestion. Bioactive peptides are known to have various properties such as anticancer, antimicrobial, antihypertension, antidiabetic and antioxidative. Recently, bioactive peptides studies on preventing enzymatic browning have become a new trend. This is due to the fact that the antioxidants in bioactive peptides are capable of scavenging free radicals, donating electrons and chelating metals. One of the major factors that play a vital role in regulating their antioxidant activity is the amino acid composition. Previous studies have shown that bioactive peptides composed of hydrophobic amino acids (Methionine, Tryptophan, Phenylalanine and Proline) are crucial for the interaction with lipids, to facilitate superior radical scavenging activity, and one or more residues of Cysteine, Tyrosine and Histidine in their sequences [18][19][20][21]. Because of these, many food scientists have found that the protein hydrolysate (peptides) can be used to replace the sulfite agents for PPO inhibition [22]. From this perspective, bioactive peptides that improve food products' shelf-life would be of utmost importance. Several recent studies showed that bioactive peptides from natural sources are able to suppress PPO activity, such as egg white [23], cod fish protein [24] and buffalo whey protein [25]. These bioactive peptides generated from natural sources serve as potential anti-browning agents due to their excellent antioxidant functions.

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