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POLYPHENOLS AS AN ANTI-AGING AGENT IN FRUITS: A REVIEW

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Abstract – Massive post-harvest losses of fruits and vegetables are a major source of worry in practically all developing nations. However, this is a general truth that also exists in industrialized nations. Because of their high moisture content, horticulture crops are naturally far more likely to degrade, especially in tropical climates. Furthermore, horticultural crops are physiologically active, engaging in ripening, transpiration, respiration, and other biochemical processes that degrade the quality of the product. Fruits with polyphenols applied (in extract or isolated form) have a longer shelf life. Applying artificial polyphenol can significantly alter post-harvest management by increasing fruit and vegetable shelf life and decreasing post-harvest losses. The purpose of this review paper is about to discuss extracted polyphenols and their artificially application on fruits and vegetables.

INTRODUCTION

Horticultural crops utilize approximately 11. 6 million hectares of land and yield over 91 million tonnes annually, representing a substantial portion of the country's overall agricultural output. Fruits and vegetables production is essential for sustaining household nutritional security, producing revenue, and creating jobs. The entire yearly yield of fruits and vegetables in India is projected to surpass many folds in forthcoming years. Nevertheless, the anticipated yield of fruits and vegetables will only meet domestic need, with little chance for export growth because of high loss, which is predicted to rise in the absence of on-farm processing facilities (ASSOCHAM, 2013). Every year, India loses over Rs. Two lakh crore in post-harvest fruits and vegetables are lost due to inadequate modern cold storage facilities and insufficient food processing units. Fruit, vegetables, and root crops experience significant post-harvest losses due to their delicate nature and rapid perishability. Without proper attention to their harvesting, handling, and transportation, they can quickly deteriorate and become unsuitable for human consumption (Singh, 1995; BAU, 2013).

Food losses happen during the production, post-harvest, and processing phases of the food supply chain, whereas food waste happens at the end of the food chain, i.e., retail and end-use consumption, according to the FAO's study on food losses and food waste (Gustavsson *et al.*, 2011; Parfitt *et al.*, 2010). Harvesting and production, handling and storing after harvest, processing, distribution, and consumption are the five steps into which post-harvest losses in horticultural commodities can be divided. A waste of production resources, such as land, water, energy, and inputs, is represented by post-harvest losses.

Physiological, pathological, mechanical, and environmental variables are the primary causes of fruits and vegetables' post-harvest loss (Yahaya, 2005). Careless handling of fruits and vegetables during harvesting, packing, transportation, and storage, among other things, causes mechanical damage. Mechanical damage in fruits and vegetables is also caused by insects and birds (Alao, 2000; Hayatu, 2000; Yahaya, 2005). Apples, for instance, possess a soft outer skin that is particularly vulnerable to mechanical damage. Consequently, damaged fruits are susceptible to pathological attacks, including rotting (Alao, 2000; Yahaya, 2005). Vegetables and fruits can also be attacked by microbes (Elias and Colleagues, 2010). The primary causes of microbiological spoiling are molds, bacteria, yeast, and fungi. When it comes to rots in fruits and vegetables, fungi like *Diplodia, Alternaria, Botrytis, Monilinia, Rhizopus, Penicillium, Fusarium,* and others are the most common culprits. Ervinia, *Pseudomonas*, and other bacteria result in significant damage. Postharvest decay organisms flourish in environments characterized by high temperatures and elevated relative humidity. While fungi typically target more acidic tissue, fruits and vegetables with pH levels exceeding 4. 5 are primarily susceptible to bacterial attack (Opadokun, 1987).

As a result, this review proposes a procedure for managing fruits and vegetables post-harvest to minimize losses and maximize returns, potentially leading to increased availability and reduced commodity costs. Furthermore, recent studies have shown that applying polyphenols, whether in isolated form or as extracts, to fruits can prolong their shelf life. The use of polyphenols led to advantageous outcomes, including color retention, delayed softening, and a significant reduction in the loss of total phenolics, titratable acidity, betacyanin, and soluble solids in fruits (Panhui *et al.*, 2017). However, there are still questions regarding the effectiveness of polyphenols on all fruits due to a lack of research. Initial research indicates that it can be highly promising agent for prorogating the shelf life of fruits. Polyphenols are secondary metabolites naturally occurring in plants that play a role in defense against ultraviolet radiation and pathogen attacks. Fruits such as grapes, apple, pomegranate, pineapple, and custard apple, many vegetables, some cereals and beverages carry polyphenols in large amount (Pandey and Rizvi, 2009 and Carvalho *et al.*, 2024). They contain multiple phenol rings in their structure, which is the origin of their name. Many polyphenols are potent antioxidants that protect our tissues from toxins. Polyphenols may help prevent blood clots and reduce blood sugar levels. Some polyphenols function as antioxidants, assisting in the protection of cells from potentially harmful "free radicals". Others are believed to reduce the risk of serious heart issues. Polyphenols may promote the growth of beneficial gut bacteria, potentially aiding digestion. Certain polyphenols may enhance healthy brain function, thereby aiding concentration, learning, and memory.

Polyphenols are prevalent in plant-derived foods that humans frequently consume, including fruits, vegetables, cereals, wine and tea (Manach *et al.*, 2004). They are responsible for the major organoleptic properties of plant-derived foods and beverages, including color and flavor (Cheynier *et al.*, 2005). Plant polyphenols comprise a range of chemicals that pose classification challenges, except for a few well-known compounds whose mechanism of action, structural composition are not know. Polyphenol structures (containing multiple hydroxyl groups in an aromatic ring) found in plants are categorized according to the number of phenol rings they contain in relation to each other. They are categorized into four groups: phenolic acids, flavonoids (flavones, anthocyanidins), stilbenes, and lignans (cinnamic acid). Each of these phenolic compounds can be further categorized based on the type of heterocycle they contain. The chemical composition of phenolic compounds can vary from simple to polymerized structures, and they may exist in complex forms alongside carbohydrates, proteins, or plant components, resulting in significant insolubility (Naczk *et al.*, 2004). Furthermore, a single polyphenol may consist of multiple polyphenols, each varying in quantity (from a few milligram to a few grams per kg or liter), stability, and activity. There are approximately 8,000 known phenolic compounds, and around 4,000 flavonoids have been identified (Tsao, 2010).

How polyphenols act as anti-aging agent in fruits

Recent studies have shown that polyphenols elicit the ability of shelf life extension of fruits. In fresh-cut red pitaya fruit, apple polyphenol (APP) treatment provided advantageous effects, including improved color retention, delayed softening, and decreased loss of soluble solid content, titratable acidity, betacyanin, and total phenolics (Panhui *et al.*, 2017). Treatment with APP also resulted in increased antioxidant activity, potentially linked to betacyanin and total phenolic levels influenced by APP (Panhui *et al.*, 2017). In a different study, harvested litchi fruit was treated with APP by immersion at 5 g a.i. l"1, which substantially decreased enzymatic browning, increased antioxidant property, shelf life extension and preserving quality (Zhang *et al.*, 2015).

A separate study found that an antimicrobial nanocoating spray based on polyphenols significantly enhances the shelf life of vegetables and fruits. Prof. Choi and colleagues developed a sprayable nanocoating technology utilizing plant polyphenols (tannic acid) in 2017. These polyphenols were combined with iron ions present in the body to form an adhesive compound. This polyphenol-iron combination was prepared using spray techniques by the research team. Sprays can minimize cross-contamination and expedite the coating of specific areas. Twenty-seven percent of the uncoated mandarin oranges (10 out of 37) after 28 days of storage at 25 °C

displayed rot and mold, whereas the coated mandarin oranges remained consumable, according to the findings of a field test. Additional experiments on 25 °C stored strawberries and with humidity levels of 32-45 percent relative humidity indicated that unsprayed strawberries developed white mold and rotted after 58 hours of storage, whereas sprayed strawberries remained intact (Park *et al.*, 2017).

Further evidence was provided by Pan *et al.* (2024), who emphasized the use of phenolic compounds in biodegradable packaging materials based on polysaccharides, particularly for food preservation. These active packaging systems not only reduce oxidative damage and microbial contamination but also help maintain the quality of fruits and vegetables during storage. The review highlighted various techniques used to incorporate phenolic compounds into packaging films and discussed improvements in their physical and functional properties. These films can serve as intelligent packaging solutions, and future research may explore their preservation mechanisms and integration with supply chain technologies (Pan *et al.* 2024).

These studies indicate that the application of polyphenols may serve as an anti-aging agent in fruits and vegetables. Polyphenols applied to fruits and vegetables can enhance antioxidant capacity, improve color retention, delay softening, and minimize enzymatic browning in these products.

Methods for the application of polyphenols on fruits

There have been numerous studies on the separation and isolation of phenolic chemicals over the past 20 years. Modern procedures for the preparation, separation, identification, and detection of samples are gradually replacing the conventional methods (Knez, 2016). The suitable extraction process must be addressed in the initial phase. The chemical composition of the material, sample particle size, and the presence of interfering chemicals all have an impact on the extraction method chosen. The temperature, solvent-to-feed ratio, number of sample extractions, extraction time, and extraction solvents utilized, all affect the extraction yield. Extraction time and temperature both have an impact on solubility. A greater temperature enhances solubility and mass transfer velocities while lowering surface tension and solvent viscosity, leading to a quicker extraction rate (Brunner, 1994; Brunner, 2005). Additional procedures may be added to get rid of undesirable substances such waxes, lipids, terpenes, and chlorophylls (Diaz-Reinoso *et al.*, 2006; Martinez, 2007; King and Srinivas, 2009). Plant samples that are dried, frozen, or fresh can all be used to extract phenolics. Prior to extraction, the material is prepared via milling, grinding, drying, and homogenization. The chosen drying technique has an impact on the total phenolic content. Compared to air-dried plant samples, freeze-dried plant samples retain a higher amount of phenolic content (Abascal *et al.*, 2005). Strongly anthocyanin-containing phenolic extracts can also be made using an acidified organic solvent, like ethanol or methanol. Due to their ease of use, shortened extraction durations and less use of organic solvents, a number of straightforward and contemporary extraction techniques, including ultrasound-assisted extraction, ultrasound-microwave-assisted extraction, microwave-assisted extraction, supercritical fluid extraction, and subcritical water extraction, have recently garnered a lot of attention (Solanaa *et al.*, 2015). After extraction, polyphenols can be applied on harvested fruits through spraying or coating on its surface area. Another method of applying polyphenols can be by dipping the fruits in polyphenol solution (Panhui *et al.*, 2017; Zhang *et al.*, 2015; Park *et al.*, 2017).

Benefits of using polyphenols as an anti-ageing agent

The use of polyphenols on fruits to extend their shelf life can be quite useful. Polyphenols are naturally occurring substances found in plants that can provide farmers with a new source of revenue by selling their plants to companies who extract polyphenols from them. There are various chemical preservatives applied on fruits to extend their shelf life, such as Silver Nitrate ($AgNO_3$), Ascorbic acid, Citric acid, and others, however regular use of these preservatives may cause health problems in people, such as breathing problems, skin problems, cancer, and others (John, 2003; Kinderlerer and Hatton, 1990), but polyphenols are natural substances with no adverse effects on human health. This strategy is potentially cost-effective. Fruits that have been treated with polyphenols can be assured of being of the highest quality on the market. Farmers may now wait until the fruits are fully mature before plucking them from the vines, allowing the fruits to exude their maximum quality. Consumers will see a return on their investment. Farmers now have more market prospects because their produce can be carried for longer periods of time, and some of it doesn't even need to be refrigerated. Postharvest losses are reduced. Delayed In comparison to typical fruits, ripening fruits do not go mushy as easily and are thus more resistant to injury during handling and transportation. This ensures that a considerable portion of the harvested fruits make it to the market. Fruits have a longer shelf life because they stay fresher and more nutritious for longer. These fruits aren't going to go "over the hill" easy.

CONCLUSION

Losses throughout post-harvest operations because of unsuitable storage and handling are substantial and might be up to 35%. Polyphenols are natural, abundantly occur in fruits and vegetables, and have been reported to possess strong antioxidant and antimicrobial properties that may act in inhibiting the growth of spoilage microorganisms, which is a major factor in the degradation of fruits. Studies have provided experimental evidence that the application of polyphenols resulted in beneficial effects such as betacyanin, total phenolics, titratable acidity, colour retention, and delayed softening and loss of soluble solid content in fruits. Polyphenols can help in extending the shelf life of fruits and may maintain their freshness by reducing enzymatic browning, which makes polyphenols a promising natural alternative to synthetic preservatives in the food industry; however, further studies are still needed to formulate the doses and types of polyphenols as per their effectiveness.

Conflict of Interest – None

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