

# Practical Methods to Improve the Quality and Safety of Fresh-Cut Fruits: A Review

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## Mini Review

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## Abstract

The ready-to-eat fruit and vegetable market has rapidly grown in recent years due to the health benefits associated with these foods and to the increased health consciousness of consumers with busy lifestyles and increased purchase power. Nevertheless, ready-to-use commodities are more perishable than the original materials. The main factors affecting the loss of consumer acceptability are discoloration, enzymatic browning, dryness and texture loss. These parameters determine the visual appearance of the fruits. For this reason, the fruit processing industry requires the development of techniques capable of keeping safe shelf-life, preserving the original visual and organoleptic fresh-like characteristics of fresh-cut products. Another problem associated with the ready-to-eat products, is the microbiological growth. The metabolism of molds and yeasts is responsible for the qualitative decay of minimally processed fruits, so the products decontamination became essential. Natural antimicrobials, ozone, chlorine dioxide, UV and cold gas plasma are some of the different treatments proposed. In combination with these treatments, some actions are carried out to limit the oxidative browning and the firmness loss. Ascorbic acid is the compound most extensively used to avoid the oxidative browning of the fruits, however nowadays there are many alternatives, like chemical or physical treatments. The edible coatings could be effective systems to preserve fresh cut fruits quality, their actions are due to the barrier forming against external agents; in addition, they could carry functional ingredients (antioxidant, antimicrobial, calcium salts). In conclusion, the treatments aimed to preserve minimally processed fruits quality could be chemical or physical, innovative or more established, cheap or expensive or they could require complex equipment. This review describes the most significant contributions regarding preservation of fresh-cut fruits in order to evaluate their effectiveness in preserving quality traits.

**Keywords:** Color; Browning; Antioxidant; Firmness; Fresh Cut; Minimally Processed; MAP

## Introduction

The growth in the ready-to-eat fruit and vegetables consumption has been due to the increasing demand for fresh, healthy and convenient foods. The beneficial health effects of fruit and vegetables have been attributed to the presence of antioxidants that act as receptors of free radicals like ascorbic acid and  $\beta$ -carotene.

Ready-to-eat fruit and vegetables typically involve peeling, slicing, dicing or shredding prior to packaging and storage. It is known that processing stimulates a faster physiological deterioration, biochemical changes and microbial degradation of the fruits, which result in degradation of the color, texture and flavor [1,2].

## Anti-Microbial Treatments

The natural microflora of fresh-cut fruit and vegetables includes bacteria, yeast and molds. Microbial proliferation is one of the causes of reduced shelf-life of minimally processed fruit, with the production of off flavors, discoloration and firmness loss. In general, the high sugar content of fruits induces microbial mold and yeast proliferation [3]. Therefore, the reduction of the initial inoculum can determine a significant increase in shelf-life, in association to low storage temperatures (below 5°C) and modified atmosphere packaging. A control system consists in the washing of the raw material with chlorinated water. The temperature of the water is usually between 0 and 1°C and chlorine is added in the form of NaOCl. The chlorine concentration in the water both before and after cutting operations ranges from 50 to 200 ppm [4-6]. Another possibility to reduce microbial growth is the use of ozone. It is known that the action of ozone is expressed through its high oxidizing power which determines cell damage. Ozone is used in water purification in concentrations between 0.15 and 5.0 ppm that are effective in the control of the bacteria proliferation [7]. Selma, et al. [8] has observed that high levels of ozone (10.000 ppm for 30 minutes) reduce the presence of Salmonella on melons. In conclusion, experimental data suggest that all the systems used to sanitize fresh-cut fruit not guarantee the microbiological quality without change the sensory characteristics of the product [9].

## Anti-Browning Treatments

One of the problems of fresh-cut production is the surface browning which occurs as a consequence of fruits cutting and peeling. The most important enzyme with regard to minimally processed fruit and vegetables is polyphenol oxidase, which causes browning enzyme. Anti-

browning treatments have been studied in different fruits, with different concentrations and treatment modalities (Table 1).

Fruit	Treatment	Reference
apple	7% CaA	[10]
	0,01% HR + 0,5 AA	[11]
	1-3% CA	[12]
	4% CaP	[13]
	1% NAC + 1% GSH + 1% LCa	[14]
	0,75% AA + 0,75% CaCl <sub>2</sub>	[15]
	1% AA + 0,5% CaCl <sub>2</sub>	[16]
	0,5% AA + 1% CaCl + 0,1% PA	[17]
banana	0,5 M CA + 0,05 m NAC	[18]
kiwifruit	1% CaCl <sub>2</sub>	[19]
peach	2% AA + 1% CaL	[20]
pear	2% AA + 0,01% HR + 1% CaCl <sub>2</sub>	[21]
	0,01% HR + 0,5% AA + 1% CaL	[22]
	2% AA + 1% CaL + 0,5% cys	[23]
	0,75% NAC + 0,75 GSH	[24]
	4% NaE + 0,2% CaCl <sub>2</sub> + 100 ppm HR	[25]
	1% AA + 0,5 CaCl <sub>2</sub>	[26]
mango	0,001% M HR + 0,5% M AA	[27]
melon	2,5% CaL	[28]
	1% AA + 0,5% CaCl <sub>2</sub>	[29]

Table 1: Treatments to maintain color and firmness of fresh-cut fruit [29].

CaL: Calcium Lactate; HR: Hesi-resorcinol; CaP: Calcium Propionate; Cys: Cysteine; CaA: Calcium Ascorbate; AA: Ascorbic Acid; CA: Citric Acid; NAC: N Acetyl Cysteine; GSH: Glutathione; PA: Propionic Acid; NaE: Sodium Heditorbate; IAA: Isoascorbic acid.

Among the treatments used, the most recommended is ascorbic acid (AA) with its derivatives. Its effectiveness has been confirmed by numerous studies, on different fresh-cut fruits and at different concentrations Agar, et al. [19], Chiabrando & Giacalone [30], Dorantes-Alvarez, et al. [31], Soliva-Fortuny, et al. [16] showed that AA at 1% + 0.5% of CaCl<sub>2</sub> reduced tissue browning from 31 to 62% in apples stored for 3 months.

Among the treatments, sulfur-amino acids, cysteine, N-acetylcysteine and glutathione are also used for their recognized antioxidant activity. Their action consists in preventing the formation of dark pigments. They have been successfully employed to prevent browning in apples and fresh juices [24,32].

## Edible-Coatings

Another possible method for extending the postharvest storage life of fresh-cut fruits is the use of edible coatings, that is, thin layers of material that can be eaten by the consumer as part of the whole food product. This treatment should reduce moisture loss, restrict the entrance of oxygen, reduce respiration, retard ethylene production, seal in flavour volatiles and carry additives that retard discoloration and microbial growth. Among the substances, is largely used the chitosan, which forms a polysaccharide nature film. The antimicrobial action of chitosan was detected on mango [33], apples [34] and strawberries [35].

Raybaudi-Massilia, et al. [10] observed that the adding of essential oils of cinnamon and lemongrass to the coating based on sodium alginate, reduced the presence of *Escherichia coli* on fresh-cut apples and prolonged the shelf-life up to 30 days.

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