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Edible film coating to extend the shelf-life of fresh-cut kiwi

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Edible film coating to extend the shelf-life of fresh-cut kiwi

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Abstract. In this work, a novel coating strategy able to prolonge the shelf-life of fresh-cut kiwi is proposed and the effectiveness of the procedure was evaluated over a period of 15 days in order to propose innovative minimally processed fruits as ready-to-eat. Chitosan and carboxymethyl cellulose were compared as coating material while a number of pretreatments were tested in order to assess the most performing strategy leading to the most stable product. The complete characterization of the Volatile Organic Compounds (VOCs) was achieved by Solide Phase Micro Extraction associated to gaschromatography and mass spectrometry (SPME-GC/MS) and correlated to the weight losses occurring with the increase of aging. The obtained results suggested that the involvement of carboxymethyl cellulose and ascorbic acid on pretreated fresh-cut kiwi, permitted to extend the shelf- life of the fruit until 15 days during storage at 4°C.

1. Introduction

The demand of minimally processed fruits as ready-to-eat food is growing more and more in the last decades and innovative coating technologies are required to extend the shelf life of fresh-cut fruits [1-9]. The Kiwifruit (Actinidia deliciosa) is one of the most appreciated fruits with excellent nutraceutical properties mainly due to the high vitamin C content. In particular, fresh-cut kiwi is usually used in different salads as peeled and sliced fruits [10-16]. As a consequence, these procedures may cause the physical damage of the fruit and an increase in the ethylene production with aging. In addition, the cutting of fruits may cause the increase in the microbial content, leading to a less stable product [15, 17-24]. The application of edible film coatings is largely used to avoid contact between fruits and air and a number of procedures were tested including thermal treatments [25-32], coating [33-42] and modified atmosphere [43-46].

This study introduces a novel strategy to improve the shelf-life of fresh-cut kiwi and to ensure the appealing as well as the suitable quality of the fruits until 15 days using biodegradable cases for storage at 4°C [47-50].

2. Experimental

Materials and methods

Fresh fruits were provided by different markets in Rome and were peeled and cut into small pieces. A number of pretreatments were tested including sodium chloride (NaCl) and sodium hypochlorite (NaClO) in order to eliminate pathogenic microorganisms prior to coating.

The edible coating materials (carboxymethyl cellulose and chitosan) were purchased from Sigma-Aldrich (Milan, Italy) as powders to be dissolved in acetic acid at different ratio and the obtained solution was stirred overnight at 40°C. The coating of the fruits was performed by dipping twice the peeled fruits after pretreatment and drying with an inert gas in order to avoid oxygen inclusion during the process.

Coated and uncoated fruits were compared in order to evaluate the weight losses, expressed as percentage %ww and the chemical composition of the VOCs. To assess significances among measurements the analysis of variance (ANOVA) followed by the Tukey test was performed to compare results [50-52].

GC-MS analysis of VOCs

Head-Space Solid Phase Micro Extraction (HS-SPME) was used for the sampling of the Volatile Organic Compounds (VOCs) by a polydimethylsiloxan fiber (DVB/CAR/PDMS, 50/30 μm).

Extraction was achieved from 1 g of kiwi heated in closed vials in water bath at 50 °C for 15 minutes. The fiber was exposed for 30 minutes and then injected into the GC-MS (PerkinElmer, Waltham, MA). The chromatographic separation was obtained using an HP-5MS (30 m Å x 0.25 Å x 0.25 mm) capillary column and the carrier gas was helium at a constant flow rate of 1 mL/min. The initial temperature was set at 40°C for 1 minute, increased to 180°C at 5 °C/min and then ramped to 250°C at 10 °C/min for 5 minutes. Electron impact (EI) ionization was employed at a voltage of 70 eV and the inlet temperature was 250 °C. The temperatures of the interface, the ion source and the quadrupole were 280 °C, 230 °C and 150 °C, respectively. Mass spectra were collected in full scan mode from m/z 35 to 450 and the injection was performed in split mode with a split ratio of 60:1 [53, 54].

3. Results

In order to study the effect of two different edible coating material, fresh-cut kiwi were coated by chitosan and CMC and the weight losses as a function of the time since cutting, were calculated to evaluate the material able to maximize the respiration rate.

Chitosan and CMC were dissolved in water containing the acetic acid and stirred at 500 rpm for 24h at a constant temperature of 100 °C. Kiwifruits were peeled with an iced knife washed in NaClO and cut into pieces. A further step of washing with NaCl salt solution (0.1% w/v) and 0.1% NaClO solution or lime, was also included in order to eliminate interferences due to the microbial growth. Fruits were then dipped twice into the solution and dried under a flow of nitrogen to avoid oxygen inclusion [55-61]. Results of the weight losses are reported in Figure 1, where each coated sample with chitosan (A) or CMC (B) is compared to the corresponding reference in order to estimate the improvement due to the coating procedure.

As shown in Figure 1A, the coated kiwi fruits exhibited the lowest weight losses with respect to the reference until the ninth day, leading to a comparable total weight loss over 15 days. On the contrary, the coating of CMC ensured the highest values of weight retained from the kiwi (about 80%) and showed a significant improvement in the shelf-life of the fruit when CMC with ascorbic acid was involved after a washing step in NaCl/NaClO.

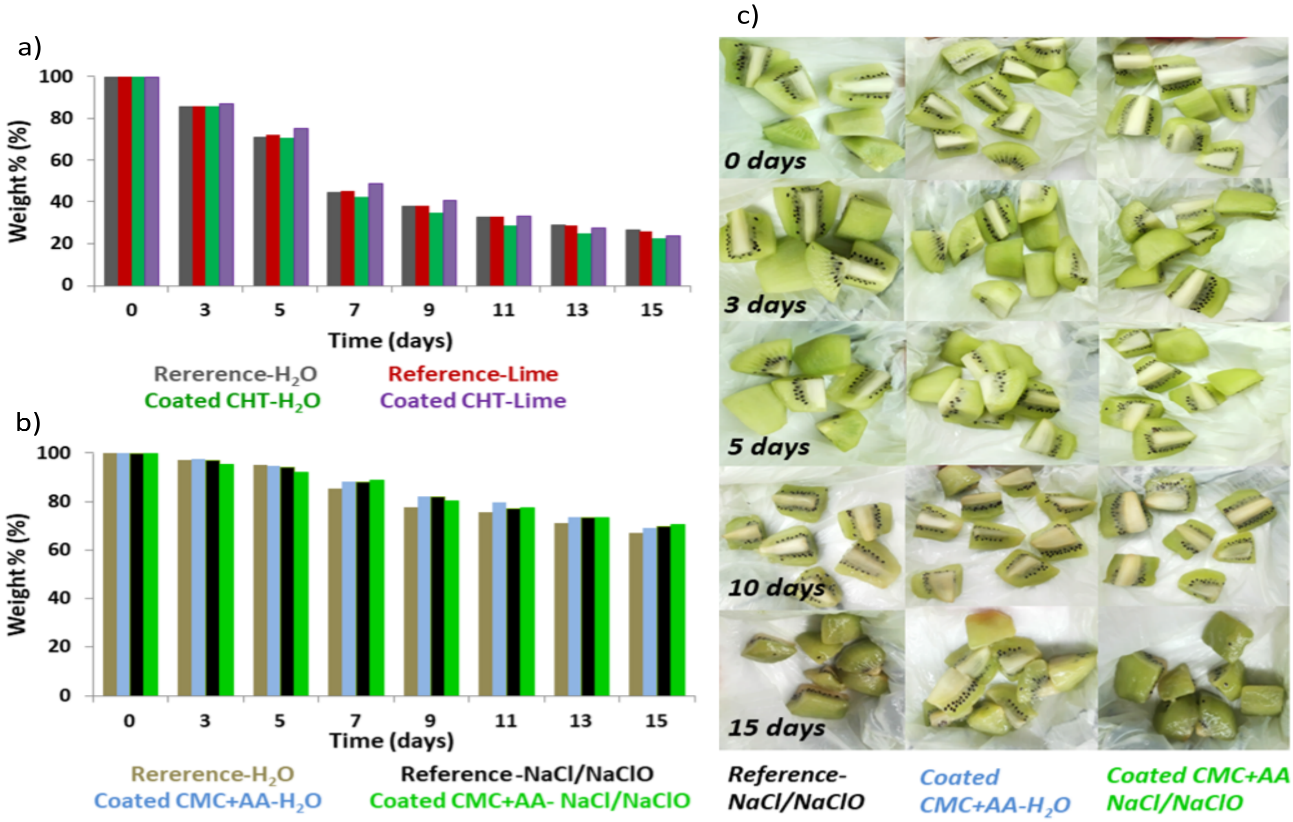

Figure. 1 a) Calculated weight losses (%) of: coated (green) and uncoated (grey) kiwi with chitosan and washed with water; coated (purple) and uncoated (red) kiwi with chitosan and washed with lime. b) Calculated weight losses (%) of: coated (blue) and uncoated (beige) kiwi with CMC and ascorbic acid and washed with water; coated (light green) and uncoated (black) kiwi with CMC and ascorbic acid and washed with NaCl/NaClO; c) visual examination of fresh-cut kiwi.

In Figure 1c, all the collected pictures of fruits over a period of 15 days are collected and compared to evaluate the effect of the coating procedure on the visual aspect of the product. The visual examination of the fruits is a critical issue for consumers that select the most agreeable and appealing product, unless its quality or declared freshness. The most performing results were obtained when fruits were washed with NaCl/NaClO and then dipped into a CMC solution with ascorbic acid.

VOCs characterization

The chemical composition of the Volatile Organic Compounds (VOCs) of fresh-cut kiwi was estimated by Headspace Micro-Extraction (HS-SPME) and the effect of the coating procedure was evaluated by comparing coated and uncoated fruits. All the recovered molecules are summarized in Figure 2a, while the behavior of each molecule was monitored over time and calculated as normalized area (Figure 2b).

a)

	Molecule	RT (min)	m/z
Alcohol	1-Penten-3-ol	2.41	57, 41
	1-Pentanol	3.98	42, 55, 70
	(E)-2-Hexen-1-ol	7.82	57, 41, 82
	1-Hexanol	8.04	56, 43, 69
	2,2-Dimethyl-1-hexanol	14.03	57, 41, 99
	2-Ethyl-1-Hexanol	16.57	57, 41, 70
	2-Nonen-1-ol	20.33	57, 41, 69
Esters	Ethyl acetate	1.81	43, 61,70
	Ethyl propanoate	2.76	57, 45, 75
	Methyl butanoate	2.92	43, 74, 87
	Ethyl isobutanoate	3.66	43, 71, 88
	Ethyl 2-methylbutanoate	6.89	57, 102, 41
	Ethyl benzoate	23.54	105, 77, 122
Aldehydes	Pentanal	2.57	44, 58
	2-methyl-4-pentenal	4.8	41, 56, 69
	(E)-2-Hexenal	7.01	41, 55, 69
	Heptanal	9.9	70, 41, 55
	Octanal	15.07	43, 56, 84
	Nonanal	17.68	57, 41, 98
	Decanal	20.03	43, 57,70
Terpenoids	α-Pinene	10.93	93, 77, 41
	β-Pinene	13.26	93, 41, 69
	Limonene	16.16	68, 93, 79

b)

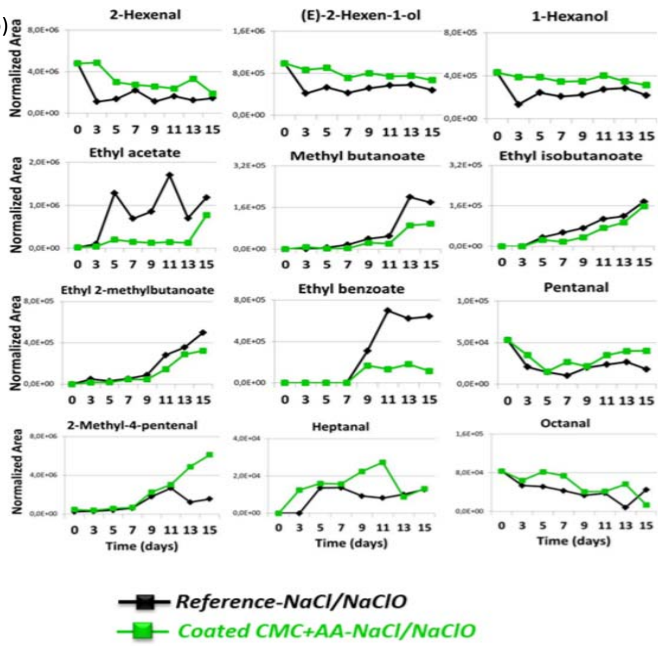

Figure. 2 a) Volatile Organic Compounds (VOCs) recovered in fresh-cut kiwi and the monitoring of each molecule over time for the reference uncoated kiwi (black) and the coated with CMC and ascorbic acid after washing in NaCl/NaClO.

As reported in Figure 2b, the aroma flavour of kiwi is strongly affected by the ripening and the aging of fruits after cutting. Significantly higher values of esters (ripening index) may be recovered in the reference samples compared to the coated fruits, suggesting positive effect of the coating material in preserving the aroma and thus the quality of the kiwi.
On the contrary, aldehydic compounds were found to be higher in the coated samples with respect to the reference ones. This behavior confirms that the flavour was most preserved in the coated fruits due to the coating process.

Conclusions

This study introduces a novel way to perform coating processes by edible film materials to extend the shelf-life of fresh-cut kiwi. The assessment of the coating conditions was performed by calculating the weight losses of fruits, the relative abundance of the molecules recovered in the fresh-cut kiwi and by examining the visual aspect of the fruits over a period of 15 days at 4°C. The comparison of the coated and uncoated fruits demonstrated that the involvement of CMC and ascorbic acid on pretreated fresh-cut kiwi, can improve the quality of the fruit.

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