TREATMENTS WITH GRAS COMPOUNDS TO KEEP FIG FRUIT (*FICUS CARICA* L.) QUALITY DURING COLD STORAGE

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ABSTRACT

The trade of fresh fig fruit is restricted by its high perishability and numerous attempts have been done to extend the postharvest life. The main difficulties can be found in the fast ripening and the easiness of pathogen spread. Although the ripening can be slowed by low storage temperatures (close to 0 °C) the control of pathogens remains still unsolved since no pesticide treatments are allowed. Generally Recognized As Save Compounds (G.R.A.S.) are possible candidates to fulfil this void. Sodium carbonate (SC) solutions (0.5, 1, 2 and 3%) and acetic acid (AAC) vapours (25, 50 and 100 *ppm*) have been used as postharvest treatments to control *Botrytis cinerea* on black (Craxiou de Porcu) and white (Rampelina) fig varieties. Fruit was subsequently stored at 2 or 8°C and 90% relative humidity for two weeks. At the end of the experiment decay, weight loss, pH, acidity, total soluble solids and visual assessment were performed. SC treatment at 1% reduced significantly the decay while, lower and higher concentrations did not. Between the two studied varieties the lowest decay percentage (9.8%) was found for the Craxiou de Porcu. Using AAC a good efficacy was achieved only with 100 *ppm*, this treatment decrease to 2.4% the incidence of decay irrespective to storage temperature. Lower concentrations were lesser effective and the efficacy was strictly dependent on the storage temperature, being higher at 2°C. No treatment damages were observed following SC or AAC applications. Regarding fruit weight loss all treatments did not affect this parameter that was 10.1% and 16.9% at 2 and 8°C, respectively. Chemical analyses performed at the end of the storage period did not evidenced differences among the treatments and slight ones if compared to initial values. Visual score of the fruit at the end of storage evidenced a better keeping quality for Craxiou de Porcu especially when stored at 2°C. Both G.R.A.S. compounds are promising, but in the reported experiments AAC was the most effective.

INTRODUCTION

The Italian annual fig production has drastically decreased, over the last fifty years, moving from 380.000 tons to 32.000 tons, namely from the 42% of the total European production to the 14%. Currently, fig is mostly cultivated in restricted marginal areas in the central and southern farms of Italy, where

its production continues to play an important role from an economic point of view (Grassi *et al.*, 1998).
In fact fig tree is a very interesting specie for a sustainable agriculture, due to the low input requirements and to the possibility to grow in a wide range of soils and climates, particularly under arid conditions and hilly areas.
Fig fruit has high standard quality properties, many components are useful for human health such as sugars (glucose and fructose), vitamins A, B, and C, mineral salts (potassium, iron and calcium) and they are a good source of both, soluble and insoluble fibers (pectins, cellulose, hemicellulose, lignin and polysaccharides). These components are useful to reduce cholesterol levels in the blood and in the prevention and treatment of cancerous tumors (Vinson, 1999). Additionally high amounts of polyphenols with antioxidant properties against ROS (reactive oxygen species) have been identified in fresh fruit evidencing a potential role in preventing hearth diseases and cancerous tumors (Vinson *et al.*, 1998). Fig latex also contains a potent cytotoxic agent, which has shown some positive results in the treatment in vitro of cancerous cells (Rubnov *et al.*, 2001).
The trade of fresh fig fruit is restricted by its high perishability, in fact, if not promptly and adequately cold stored, shrivels, softens and is easily invaded by microorganisms at an elevated rate (Turk, 1989).
Numerous attempts have been done to extend the postharvest life (Colelli *et al.*, 1991; D'Aquino *et al.*, 2003; D'Aquino *et al.*, 1998; Piga *et al.*, 1998) and every technological development in postharvest processes has produced a significant increase in the demand for table figs (Ozer *et al.*, 2003). The main difficulties can be found in the fast ripening and the easiness of pathogen spread. The ripening can be slowed by low storage temperatures (close to 0 °C), but unfortunately, even under these conditions, quality losses, intended as nutritional values and mould incidence, are still very high especially during transportation and marketing. Furthermore, the control of pathogens still remains an unsolved problem since no chemicals are registered for postharvest use on figs.
The aim of this work is to study new ecologically friendly technologies, to keep quality of fig fruit during storage, among them G.R.A.S. compounds (Generally Recognized As Safe) are promising. These compounds are common food additives employed with no restriction as preservatives in Europe and North America (Barkai-Golan, 2001).
Sodium Carbonate (SC) solutions and Acetic Acid (AAC) vapours, are possible candidates to fulfil this void, particularly as postharvest treatments to control *Botrytis cinerea* on black (Craxiou de Porcu) and white (Rampelina) (local) fig varieties.

MATERIALS AND METHODS

Local figs varieties "Craxiou de Porcu" and "Rampelina" (black and white respectively), were harvested at the end of September from an experimental field, named "Azienda Platamona – Russeglia", belonging to "Consorzio Provinciale per la Frutticoltura-Sassari", located in the north part of Sardinia and immediately transported to the laboratory. Fruits were individually weighed, and divided into two groups, one for the Na_2CO_3 (SC) experiment and the other for the acetic acid (AAC) one. The first group of fruits were treated with 0, 0.5, 1, 2 or 3% of SC solutions, the second ones were treated with 0, 25, 50 and 100 ppm of AAC vapours in closed containers for 15 minutes.

After treatment fruits were placed in trays, the first group, (treated with SC solutions), was stored at 8 °C while the second group (treated with acetic acid vapours), was divided into two subgroups, stored at 2 or 8°C. Relative humidity (RH) for all groups was kept at 90% and fruit was stored for 14 days. Each combination consisted of fifteen fruits and fruits were analysed in three replicates. At the end of the storage period, fruit overall appearance was assessed by scoring according to a one to five scale where one was poor and five excellent. At the same time also decay percentage and weight loss were monitored. Furthermore, chemical analyses were performed for the following parameters: pH, acidity, and total soluble solids.

Chemicals

Sodium Carbonate anhydrous (99.5% purity) and Acetic Acid glacial (99.5% purity) were obtained from Carlo Erba (Carlo Erba Reagenti SpA, Rodano, MI-Italy).

Data analysis

Analysis of variance (ANOVA) of all data was performed using the MSTAT-C software (Michigan State University, East Lansing, 1995) and when appropriate mean separations was performed according to the Duncan test at $P \leq 0.05$ or 0.01. Angular transformation of decay percentage values was performed prior statistical analysis.

RESULTS

Acetic Acid treatment

Regarding fruit weight loss, following acetic acid treatments and storage no differences were found according to AAC treatments whereas, the storage temperature influenced significantly the weight loss being lower by a 10% at 2°C. (Table 1).

The highest percentage of rots was found in non-treated fruits stored at 8°C reaching 39.3%, whereas a good efficacy was achieved only with 100 *ppm*, this treatment decreased the decay incidence to 2.4% irrespective to storage temperature. Lower concentrations were lesser effective and the efficacy was mainly dependent on the storage temperature, being higher at 2°C. Regarding the visual assessment the best scores were obtained when stored at 2°C and when stored at 8°C by using 100 ppm of AAC (Table 1).

Sodium Carbonate treatment

Data relative to fruit treated with SC show how also this treatment did not affected the weight losses, that was similar to fruit treated with acetic acid when stored at 8 °C (Table 2). Sodium carbonate treatment was more effective in reducing decay at 1% compared to 2 and 3% (Table 2).

Table 1. Weight loss, rots and visual assessment of fig fruit treated with 0, 25, 50 or 100 *ppm* of acetic acid for 15 min and then stored at 8 or 2°C for 14 days.

Storage temperature	Temp. (°C)							
	8°C				2°C			
A.A. conc. (ppm)	0	25	50	100	0	25	50	100
Weight loss (%)	24.5	20.0	23.1	23.1	13.1	12.7	12.5	13.9
Rots (%)	39.3	26.2	60.0	2.4	0.0	20.0	2.4	2.4
Visual assessment	2	3	2	4	5	3	4	5

Table 2. Weight loss, rots and visual assessment of fig fruit treated with 0, 0.5, 1 or 2% of sodium carbonate (SC) and stored at 8°C for 14 days.

Varieties	Rampelina					Craxiou de Porcu				
SC conc. (%)	0	0.5	1	2	3	0	0.5	1	2	3
Weight loss (%)	23.1	21.9	24.1	24.8	23.1	21.4	21.4	20.5	23.2	25.0
Rots (%)	39.4	26.2	20.0	39.4	26.2	39.4	26.2	2.4	18.9	18.9
Visual assessment	3	4	4	2	1	2	3	4	2	2

The decay on Rampelina fruit was high and ranged between 20 and 39.4% for fruit treated with 1 or 0% respectively. With 1% SC the decay on Craxiou de Porcu fruit was significantly reduced resulting only 2.4%. The visual assessment as a role was similar to fruit treated with acetic acid when stored at 8°C.

No damage was observed in fruit treated with AAC, whilst only the highest concentrations of SC imparted some damage to the fruit in white variety (Rampelina).

Chemical analyses performed at the end of the storage period did not evidenced notable differences according to the treatments and slight ones if compared to the values at harvest.

DISCUSSION

Treatments with a 100 ppm of AAC or 1% of SC resulted effective, decreasing the incidence of decay, after 14 days of storage at 8 or 2°C to acceptable levels.

Both alternative treatments at all concentrations did not affect the weight loss, whereas this parameter was significantly affected by storage temperatures. In accordance with earlier reports the lower temperature was more effective in preserving fruit quality.

According to all observations performed fruit of the Craxiou de Porcu fig variety seems to perform better with respect to keeping quality and no damage appeared following the G.R.A.S. treatments.

Both G.R.A.S. compounds are promising and represent an alternative method in keeping quality of fig fruits during storage. These treatments must be performed in combination with storage at low temperatures.

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