European cooperation in the field of scientific and technical research

COST 914 COST 915

Joint Workshop

Non Conventional Methods for the Control of Postharvest Disease and Microbiological Spoilage

Belgium
Czech Republic
Denmark
Estonie
Germany
Greece
Spain
France
Croatia
Ireland
Iceland
Italy
Luxembourg
Hungary

Malta
Netherlands
Norway
Austria
Poland
Portugal
Romania
Switzerland
Slovenia
Slovak Republic
Finland
Sweden
Turkey
United Kingdom

European Commission

EUR 18514 EN

DECAY CONTROL OF "FEMMINELLO SANTA TERESA" LEMON FRUITS BY PRESTORAGE HIGH TEMPERATURE CONDITIONING.

S. D'Aquino*, A. Piga*, M. Agabbio**, and M. G. Molinu*

* Istituto per la Fisiologia della Maturazione e della Conservazione del Frutto delle Specie Arboree Mediterranee - CNR - Via dei Mille 48, 07100 Sassari, Italy.
** Dipartimento di Scienze Ambientali Agrarie e di Biotecnologie Agro-alimentari - Università degli Studi - Viale Italia 39- 07100 Sassari, Italy

Summary

Marketing quality and juice chemical parameters of late harvested "Femminello Santa Teresa" lemon fruits (*Citrus limon* Burm), wrapped with a 15 mm heat shrinkable film or left unwrapped, and then either conditioned at 36°C for 72 hours in a 85-90% relative humidity (RH) atmosphere or not conditioned, were determined over 3 months storage at 6°C and 95% RH or after 1 week at 20°C and 75% RH following each month of storage.
Conditioning significantly reduced the incidence of decay caused by *Penicillium digitatum*, but not that due to other pathogens, such as *Botrytis cinerea* and *Alternaria citri*, especially in combination with film wrapping. Positive was the effect of heating in ameliorating the physiological response of lemon fruit to low temperature, although the beneficial effect appeared to be time-dependent, in fact at the end of the storage period severe symptoms of chilling injury were also noticed in conditioned fruit. No differences were instead observed in chilling sensitivity between conditioned and nonconditioned wrapped fruit. Weight loss was higher in conditioned fruit than in non conditioned one. Regarding chemical parameters, either conditioning or film wrapping hastened the rate of degradation of acidity, total soluble solids (SST) and Vitamin C.

Key words: Chilling injury, chemical parameters,*Citrus limon* Burm, decay, high temperature conditioning.

Introduction

Lemons coming from normal blooming ripen from October to May. During the summer period in Sicily is available the "verdelli" production, which is a special crop obtained by the application of the "forzatura", an ancient agronomic practice very common in Sicily [4]. However, "Verdelli" fruit present wors characteristics with respect to the fruit coming from the spring blooming; they are much harder than normal lemons (difficulty to squeeze) and less juicy. So, cold storage of the late ripening lemon fruits coming from normal blooming can be very convenient both for the economical point of view of packaging houses, which can sell the product at a price 4-5 times higher than that of the harvesting time, and for the consumers, who can have for the same price of stone and green fruits as the "verdelli" are, yellow lemons rich in juice and acidity. On the other hand, lemons, as the other citrus fruits, during the refrigeration period can report high losses due to decay, mainly caused by *Penicillium digitatum*, and for the susceptibility to low temperature exposure. However, refrigeration remains the most important way to prolong postharvest life, delay micro-organism development and reduce metabolic activity.

High temperature conditioning at 30-40 °C for up to 72 hours has been effective in reducing the incidence of decay caused by *Penicillin spp.* and mitigating the harmful potential of subsequent storage [5; 6] in different citrus species. Reduction in the incidence of chilling injury in storage has also been achieved by the use of film wrapping [7]. The combination of curing at temperatures ranging from 30-38°C with wrapping the fruit in plastic film has been reported to be effective for different citrus fruit in ameliorating the preservation of the quality of the fruit during storage, including reduction of chilling injury, decay, ageing, weight loss and chemical parameters [1;2;3]

The purpose of this experiment was to verify the feasibility of improving the keeping quality of late ripening "Femminello Santa Teresa" lemon fruit in cold storage by the use of the combination of high temperature conditioning and film wrapping.

Materials and Methods

Fruits of "Femminello Santa Teresa" lemon were harvest at the end of May from the experimental station of the CNR in Oristano (Sardinia). The fruits were prepared for treatments first by eliminating all those presenting any defect, and then dividing the chosen ones into 4 lots. Two lots were sealed in packages of 6 fruits using a 15 μm heat shrinkable film (Cryovac® - MR), while the remaining 2 were left unwrapped. Therefore, 1 lot of wrapped fruits and one of unwrapped ones were stored at 6°C and 95% relative humidity (RH). The other 2 lots prior of being cold stored, were conditioned at 36°C and 85-90 % RH for 72 hours. The storage period was of 3 months, with inspection time intervals of 1 months, which were followed by an additional week at 20°C and 75% RH of simulated shelf life conditions.

At each inspection time fruits were weighed to determine the weight losses and checked for decay and visual symptoms of chilling injury (CI), as pitting of the peel. According to the severity of CI, the fruits were classified into one of 4 categories, were 0 = nil, 1 = slight; 2 moderate, and 3 = 0 severe.

In addition, the chemical analysis of the juice, including pH, TSS (°Brix), titratable acidity (% citric acid) were carried out as previously reported by D'Aquino *et al.* [5]

Results and Discussion

The amount of rotten fruit increased during storage time (Fig.1), reaching an average close to 30% at the end of the trial. The influence of high temperature conditioning was significant in reducing decay incidence either in non-wrapped fruit or in wrapped one, but the positive influence decreased by the time in storage, and after 3 months at 6°C and the following week of simulated shelf-life conditions at 20°C no significant difference was observed between heated and non-heated fruit. Most of decay in non-heated fruit was caused by *P. digitatum*, while in heated fruit together with *P. digitatum* other kinds of pathogens occurred, such as *Botrytis cinerea* and *Alternaria ssp.*, especially by the 2nd inspection time. Ben-Yehoshua et al. [1] and D'Aquino et al. [5] respectively in lemon and satsuma mandarin fruits reported a similar shift in pathogen distribution.

However, even until the 2nd inspection time, when the differences between heated and non heated fruit were significant, the contribution in reducing decay of heated fruit was of little practical importance from the commercial point of view.

Chilling injury appeared in the form of brown pitting of the rind. However, fruit seemed to be quite resistant to chilling injury and it was only after 3 months of storage that several fruits showed signs of pitting on the rind varying from slight to severe. High temperature

conditioning gave a positive contribution in delaying pitting development, at least until the 2nd inspection time, after that no significant difference was observed between cured and non-cured fruit. So the influence of heating seemed to be time dependent, the beneficial effect ceasing after 2 months of storage in our experimental conditions. Much more consistent and efficacious than curing in delaying and reducing the severity of chilling injury was the action of plastic film. At all the inspection times heated fruits reported higher weight losses than non-heated ones, but those differences were not statistically different.
Very positive was, on the other hand, the effect of film wrapping in reducing transpiration; sealed fruit reported less than 2% of weight loss after 3 months of storage and the additional week of shelf-life at 20°C; while the losses for non wrapped fruit, in the same time, were about 10%.Either heating or film wrapping had a negative influence on chemical parameters, whereas the control fruits (table 1) reported no substantial changes throughout the storage period. In addition, even if there was no statistical interaction between heating and wrapping (data not shown) at least there was some additive effect; in fact wrapped-heated fruit reported the highest losses of vitamin C, titratable acidity and TSS.

Conclusion

The results obtained, confirm only in part the beneficial effect of the combination of high temperature conditioning and wrapping with plastic film reported by other authors either with lemon fruit or other citrus cultivars. High temperature conditioning was effective in reducing decay only in non-wrapped conditioned fruit, and only for the first months of storage. In any case, the incidence of decay was too high to make the use of high temperature conditioning on commercial scale convenient. Probably the response of the fruit to the treatments was negatively affected by the advanced stage of maturity, in fact the harvest was carried out at the end of May.

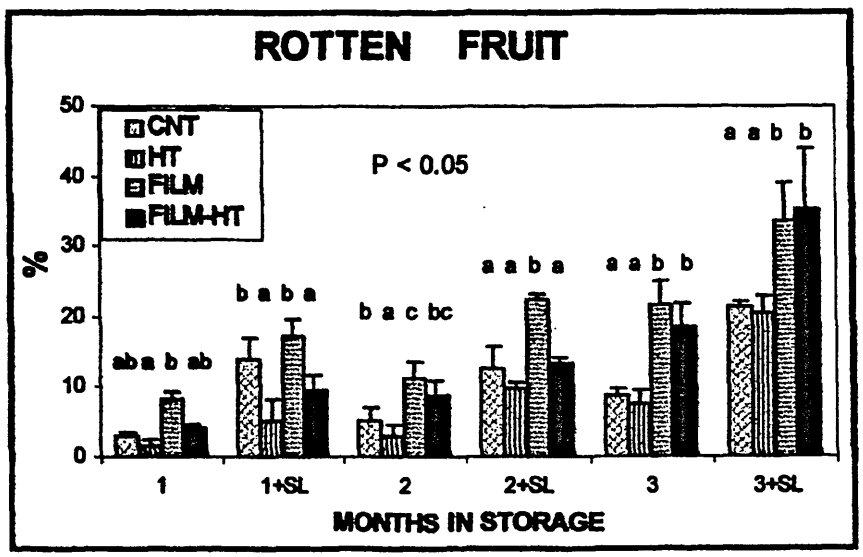

Fig. 1 Effect of treatments on decay incidence over the storage period in fruit stored at 6°C and 95% RH and at 20°C and 75% RH in simulated marketing conditions. Vertical bars represent SE (n=100)

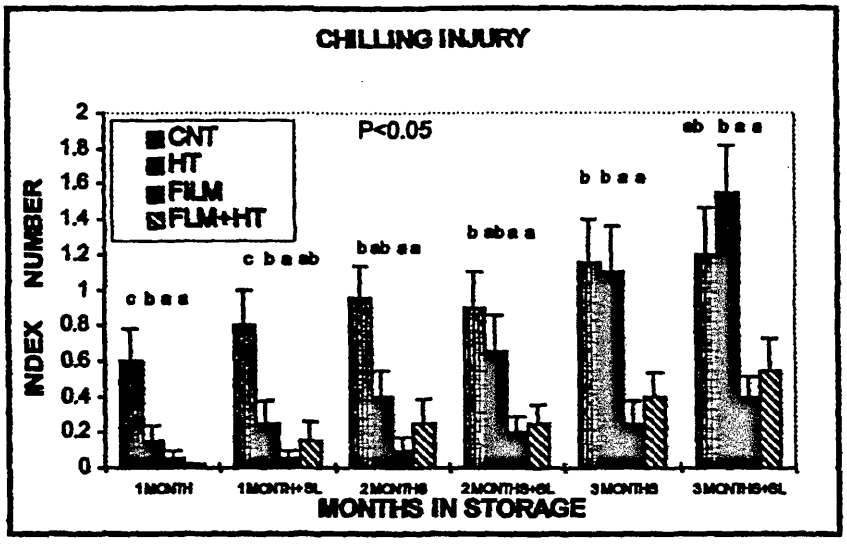

Fig. 2 - Effect of the treatments on chilling injury after 1, 2, or 3 months of storage at 6°C and 95% RH followed by an additional week of shelf-life conditions at 20°C and 75% RH to simulate marketing conditions. Vertical bars represent SE (50< n < 100).

On the other hand the fruit seemed to be quite resistant to low temperature than fruit of the same cultivar stored at 6°C but harvested in February-March (data not published). A different behaviour of citrus fruit to high temperature conditioning might verify in relation to the harvesting time, so we believe that more investigations aimed to verify the response of citrus fruit over the whole harvesting season would give more important information on the effectiveness of heating treatments on postharvest physiology of citrus fruit.

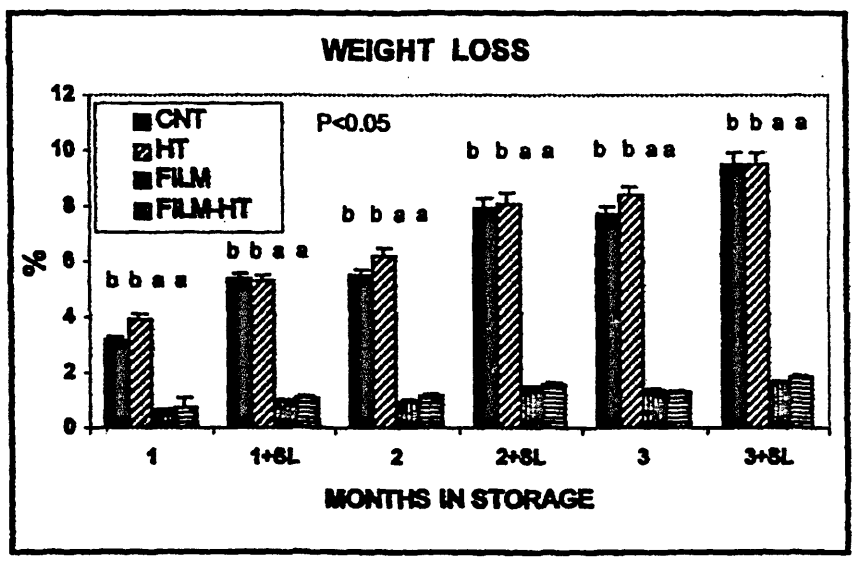

Fig. 3- Effect of treatments on weight losses during the storage period. Vertical bars indicate SE (n=40)

Tab. 1 -Influence of film wrapping and high temperature conditioning at 36°C and 85-90% RH for 72 hours on chemical parameters of "Femminello Santa Teresa" lemon fruits over a storage period of 3 months at 6°C and 95% RH plus an additional week in simulated shelf-life condition at 20°C and 75% RH.

Treatment	Storage Period	pH	Titratable Acidity (% Citric acid)	TSS (°Brix)	Vitamin C (mg/100ml)
Harvest		2.55	5.81	6.22	43.6
Control	1 Month	2.57a*	5.77b	6.10a	45.4c
HT		2.60b	5.54a	6.10a	42.0b
Film		2.58a	5.70b	6.15a	43.4b
Film-HT		2.60b	5.53a	6.10a	40.9a
Control	1 Month+SL	2.57a	5.76b	6.13b	45.4c
HT		2.60b	5.54ab	5.75a	41.7b
Film		2.58a	5.58ab	6.18b	42.5b
Film-HT		2.61b	5.44a	5.93ab	39.0a
Control	2 Months	2.60a	5.76c	6.04b	43.2b
HT		2.66b	5.45b	5.83a	39.2a
Film		2.66b	5.51b	5.88a	38.2a
Film-HT		2.69b	5.25a	5.88a	38.0a
Control	2 Months+SL	2.69a	5.68c	5.94c	42.6b
HT		2.74b	5.43b	5.72ab	37.8a
Film		2.65a	5.48b	5.85b	38.1a
Film-HT		2.75b	5.10a	5.50a	36.9a
Control	3 Months	2.73a	5.64c	5.91c	41.8c
HT		2.80b	5.20b	5.64b	36.5ab
Film		2.81b	5.18b	5.70b	37.2b
Film-HT		2.85c	4.96a	5.38a	34.1a
Control	3 Months+SL	2.75a	5.62	5.93c	42.2
HT		2.83b	5.22	5.62b	37.2
Film		2.82b	5.28	5.61b	36.8
Film-HT		2.86c	4.92	5.21a	33.4

** Means in columns within each storage period by the LSD test at the 5% level.*

Acknowledgements

Research supported by the National Research Council of Italy- CNR/Prog. Spec. "Agroindustria" - Ist. Naz. Coordin.. - The authors contributed equally to this study.

References

(1) BEN-YEHOSHUA S., BARAK E., and SHAPIRO B., 1987. Postharvest curing at high temperatures reduces decay of individually sealed lemons, pommelos and other citrus cultivars. J. Amer. Soc. Hort. Sci. 112:658-663.

(2) BEN-YEHOSHUA S., SHAPIRO B., and MORAN R., 1987. Individual seal-packaging enables the use of curing at high temperature to reduce decay and heal injury of citrus fruits. HortScience 22:777-783.

(3) BEN-YEHOSHUA S., SHEM-TOV N., SHAPIRO B., MORAN R., and SHARONI J., 1988. Optimising conditions for curing pummelo fruit in order to reduce decay and extend its keeping qualities. Proc. Int. Soc. Citriculture. Vol. 3:1539-1544.
(4) CALABRESE F., and DI MARCO L., 1981. Researches on the "forzatura" of lemon trees. Proc. Int. Soc. Citriculture. Vol. 2:520-521.
(5) D'AQUINO S., PIGA A., AGABBIO M., and TRIBULATO E., 1996. Improving the keeping quality of "Miho" satsuma fruits by heat, Semprefresh and film wrapping. Adv. Hort. Sci. 10:1519.
(6) GRIERSON W., 1974. Chilling injury in tropical and subtropical fruit:V. Effect of harvest date, degreening, delayed storage and peel colour on chilling injury of grapefruit. Proc. Trop. Reg. Amer. Soc. Hort. Sci. 18:66-73.
(7) PURVIS A. C., 1985. Relationship between chilling injury of grapefruit and moisture loss during storage: amelioration by polyethylene shrink film. J. Amer. Soc. Hort. Sci. 110(3)385-388.