FONDAZIONE EDMUND MACH

ISTITUTO AGRARIO
DI SAN MICHELE ALL'ADIGE

NEW DEVELOPMENT OF DYNAMIC CONTROLLED ATMOSPHERE STORAGE OF APPLES APPLYING REPEATED AND CONTROLLED LOW OXYGEN STRESS TREATMENTS

L. Fadanelli[(1)], F. Zeni[(1)], L.Turrini[(1)], P. Barchetti[(1)], P. Matte'[(2)], L. Buglia[(2)]

(1) Centro di trasferimento Tecnologico FEM-IASMA S.Michele all'Adige (Trento) ITALY, Via E. Mach 1-38010 San Michele all'Adige-Italy (2) Fruit Control Equipments, Via R. Luxemburg 55-20085 Locate di Triulzi– Italy

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INTRODUCTION

The experience was acquired on large scale application of I.L.O.S. techniques on commercial rooms of apples since the beginning of the year 2000 (Mattè P. -Fadanelli L. et al ILOS + ULO AS A PRATICAL TECHNOLOGY FOR APPLES SCALD PREVENTION, 2004). During the years 2007-2009, the technique has developed into the realization of repetition of the low oxygen stress phases in a dynamic way (Swinglos[TM]), several times during the entire storage period.

This technique was again applied on commercial rooms using equipment by Fruit Control Equipments (FCE), Italy and has allowed storage to be carried out in different situations corresponding to various apple production areas on the cultivars Red Delicious, Granny Smith and Pink Lady for up to 8 months + 10 days shelf life, without evidence of scald and/or pulp browning, with optimal quality requirements (Rizzolo.A., Vanoli. M., Visai.C., Fadanelli.L. 1997), & (Visai.C., Vanoli.M., Fadanelli.L. 1997).

To determine the start and the end of the gaseous stress periods a method of measurement of ethyl alcohol accumulated in the fruit pulp has been developed, on a representative sample of 20 apples periodically taken out of the same storage rooms.

The gaseous stress conditions (O2=0,5 – 0,7% and CO2 = < 1%) have been reached thanks to technical solutions (***Fig 1***) consisting of special N2 Generators, adsorbers with high CO2 adsorption capacity and excellent gas tightness requirements ***(Table 1)*** of the rooms (from 30 or 25mm down to 26 or 22 mm of water column in 30') The applicative experiences have allowed to identify the accumulation levels of alcohol until the point of interruption of the stress conditions , bringing the apples back to the condition of metabolic respiratory level that allows them to metabolize the alcohol accumulated ***(Tables 2, 3,4,5)***.

The repetition of this technique in a dynamic way for 2-3 periods (8÷15 days and more, each time) during the storage period, has demonstrated that a complete control over superficial scald even on sensitive cultivars such as Granny Smith ***(Table 6)*** and Red Delicious ***(Table 7)*** can be obtained.

This application has also shown interesting results with regards to the control of internal breakdown on the Cripps Pink cultivar ***(Table 8)***.

MATERIALS AND METHODS

Applicative testing of the new repeated gaseous stress technique were carried out at cooperatives with medium-large sized rooms (350-400 t). In order to allow an experimental test of the trials, 4 lots of apples of 1000 units for each cultivar, were divided into 2 parts and stored in Dynamic L.O.S.(Low Oxygen Stress) rooms as well as in U.L.O.CA rooms (Red Delicious and Granny Smith cultivar : O2 = 1-1,3%, CO2= 1,0-1,3%), and in conventional C.A rooms (for Cripps Pink cultivar).

For application of the dynamic L.O.S. technique, the necessary requirements of the rooms were:

- Apples with uniform maturity ***(Fig 2, 3)***, of the same variety (avoid mixing spur clones and standard), delivered within the first 7 days of the harvest period indicated by the consultancy service (website www.iasma.it),
- Room loading at 25% per day with loading coefficient of 250-260 kg/m3, with uniform cooling and final desired fruit pulp temperature reached within 5-6 days from the first loading day,
- Preparation of representative samples of all lots of apples of the rooms (4-5 apples per lot until obtaining a mix of 4-5 boxes of apples), to be placed in front of the inspection port-hole.

The first oxygen pull down (initial stress) was made within 5-7 days from closing the room with O2 at 0,4-0,5%, maintaining the level of CO2 < 1% according to the varieties: Red Delicious 0,8-0,9 %, Granny Smith 0,7-0,8 %, Cripps Pink 0,5-0,7 %.

After 7 days from the start of gaseous stress the first sample checks were made on 20 apple samples for measurement of the accumulation of ethyl alcohol, repeating them on other samples every 7-10 days until the end of the stress period.

The level of ethyl alcohol detected each time determined the continuation or interruption of the anaerobic gaseous stress treatments.

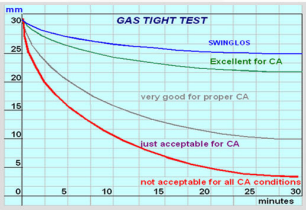
In ***Table 9*** is shown Indicatively the relation between maximum ethanol thresholds verified in our works and considered tolerable for the different apple cultivars and the reversibility of alcohol accumulation without altering taste and flavour of the apples.

The stress periods were regulated in duration according to the level of ethyl alcohol measured in the 20 apple samples tested each time for each room, allowing a dynamic course of the controlled atmosphere with low levels of 02 and CO2.

At the end of each stress period the controlled atmosphere conditions in the rooms were brought back to typical U.L.O. values (O2 = 0,9-1-%, CO2= 0,8-1,0-1,3%) according to the different cultivars.

RESULTS

Table 1



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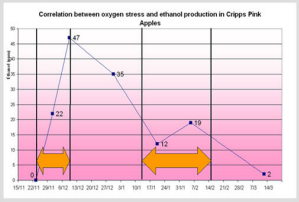

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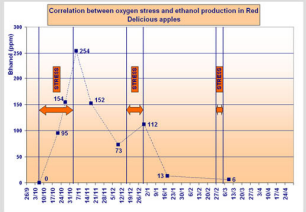

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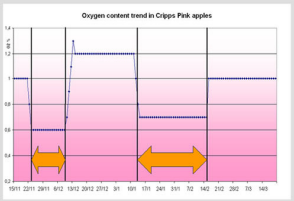

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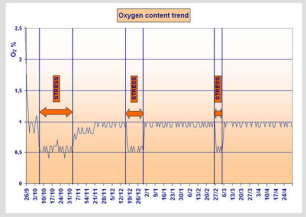

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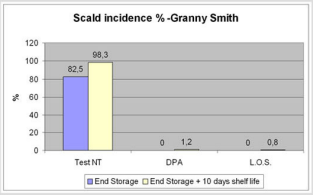

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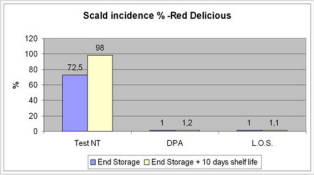


FIG. 2

FIG. 3

FIG. 4

Table 8

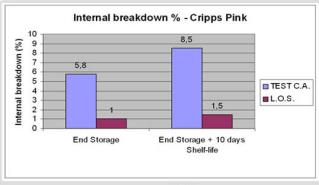
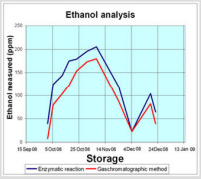


FIG. 1

Table 9

CULTIVAR	MAX. ETHANOL LIMIT in ppm
Fuji	80-100
Gala	40-70
Golden	30-40
Granny Smith	60-70
Morgenduft	30-50
Pink Lady	40-50
Red Delicious	300-400

Table 10



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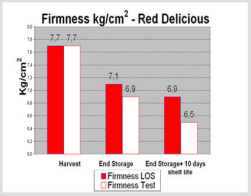

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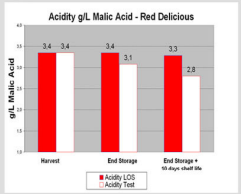

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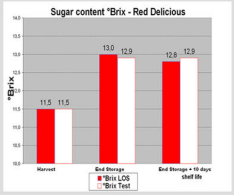

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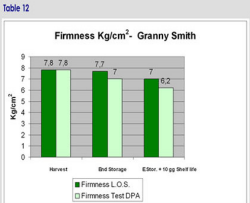

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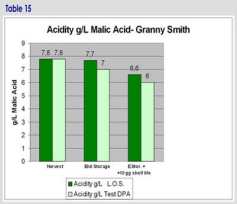

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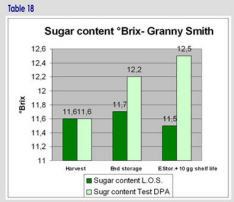

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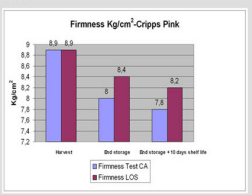

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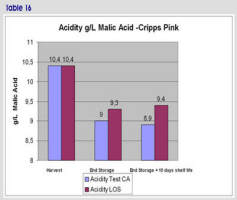

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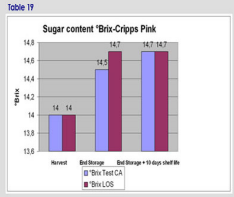

RESULTS AND CONCLUSIONS

The results obtained in the last two years refer to the application of dynamic L.O.S. regimes on 10 commercial apple storage rooms, for a total amount of stored apples of approximately 3.500 tons per year. The storage was extended in some cases for up to 8 months from harvesting, on average up to 7 months, as evidenced in the enclosed graphs. On the basis of previous experience, these parameters were realized mainly with the purpose to prevent scald disorder on Red Delicious and Granny Smith and to contain internal breakdown on Pink Lady. These results were confirmed as reported in the graphs with control of superficial scald equal to 98-99% with respect to the Test NT and in accordance with the efficiency of DPA 31% treatment (1800ppm) and U.L.O. storage.

The incidence of internal breakdown on Cripps Pink cultivar was contained after 6 months of storage + 10 days shelf life at 1,0% compared to 8,3% of the thesis in conventional C.A.(T°1,5-2 , RH 90-93% , O2 1,5-2,0%, CO2 1-1,3 %) **(Table 8)**.

Out of the positive results obtained in controlling important physio-pathological disorders , it was also evident how the internal quality of the repeated low oxygen stressed fruits is much better compared to the Test fruits :

- Firmness : +0,4 , +0,8 and +0,4 Kg/cm2 at the end of storage + 10 days shelf life respectively for Red Delicious, Granny Smith and Cripps Pink **(Table 11, 12, 13)**
- Acidity : + 0,5 +0,6, 0,5 gr/l of ;Malic acid at the end of storage + 10 days shelf life respectively for Red Delicious, Granny Smith and Cripps Pink **(Table 14, 15, 16).**
- Sugar content °Brix : the evolution of the sugars during storage appears lower for the Granny Smith **(Table 17)**, while there are no interactions for Red Delicious **(Table 18)**, and Cripps Pink **(Table 19)**.

In conclusion the quality parameters at the end of storage + 10 days shelf life are better in the repeated L.O.S. thesis than with respect to the Test ones.

The evolution of the I.L.O.S. technique applied since the 1990's (A.B. Truter , J.C. Combrink and S.A. Burger 1994) with the best results obtained particularly in combination with ultra low oxygen (U.L.O.) conditions (C.R. Little et al 1982 and Wang and Dilley 2000) has undergone various evolutions and studies in particular with regards to the effects of ethanol on superficial scald either when applied alone (Chervin C., Raynal J.,Andrè N., Bonneau A., and Westercamp P., 2001 :Combining Controlled atmosphere storage and ethanol vapour to control superficial scald on apple. Hort Science 36) or combined with oxygen stress (Gharhamani F., Scott K.J., and Holmes R., 2000, Effects of alcohol vapours and oxygen stress on superficial scald and red colour of stored Delicious apples Hort Science 35).

The concept of dynamic gas stress treatments carried out keeping under control the ethanol concentration in the fruit pulp has found practical application on a wide scale, thanks to technology (storage room construction, equipment, software) which enable the realization and control of the CA rooms with very low gas concentrations especially O2 and CO2 and thanks to a simple and rapid method for checking the dosage of ethanol in the fruits.

Correct sampling methods and uniformity of the apples placed in L.O.S. storage rooms, allow for optimal results to be obtained in the control of superficial scald and brown core physiological disorders , as well as in maintaining high standards of organoleptical and commercial qualities for the Consumers.

Acknowledgements

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