

Effect of postharvest treatment on new physiological disorders of apple

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Abstract

The present work focus on the promising apple scab resistant cultivar Galant (Lumaga A 913) which shows great interest as an alternative cultivar for organic production but little is known about its postharvest storage. Experiments performed by Fondazione Edmund Mach (FEM) from 2015 to 2017 show a complex of different physiological disorders affecting this apple: superficial scald, flesh browning, browning of the skin and underlying flesh (soft scald & soggy breakdown). Here, we present the results of different postharvest treatments applied in order to avoid fruit injury, including initial low oxygen stress conditions (ILOS) and 1-methylcyclopropene (1-MCP) application. Superficial scald increases on early stages of maturity but the reduction of the respiratory metabolism by using ILOS technology allows to keep it under a certain level (4%) in comparison with Controlled Atmosphere (CA) (35%) after 180 days storage. On the other hand, both ILOS and CA storage do not affect the incidence of internal browning and the incidence rates is always higher than 60% after 14 days shelf-life. Based on flesh browning disorders, the storability of Galant is always limited to 120 days. Regarding 1-MCP treatment, the superficial scald and flesh browning incidence were similar in both 1-MCP treated and untreated apples.

Keywords: Scab resistant variety, physiological disorder, storage, postharvest treatment

INTRODUCTION

Traditional varieties are still in demand, but growers are weeding them out in favor of varieties which they say taste better, have crunchier texture and sell for a higher price. The success of new varieties will depend on its distinctiveness, consistency of quality and the efforts of those growing, packing and marketing it. New varieties offer enhanced quality often coupled with unique attributes but there are still many aspects that need to be investigated.

Generally, apples are stored many months at low temperature under Controlled Atmosphere (CA) in order to reduce the metabolic rate. The storability of several new introduced varieties is, however, limited by physiological disorders occurring naturally during storage which seem to cause the main postharvest fruit losses. The present work focus

on the promising apple scab resistant cultivar Galant (Lumaga A 913) developed in Switzerland as a cross between Resi and Delbar Jubilée. Galant shows great interest as an alternative cultivar for organic production as well as good tree growth habitat, productivity and excellent taste. However, little is known about its storability. Previous research by Neuwald *et al.* (2014) showed Galant softens quickly with the development of internal browning in the period between January and May, therefore, it has a limited postharvest storage life. In this study performed from 2015 to 2017 we aimed to investigate the effects of several postharvest treatment on a complex of different physiological disorders already observed on Galant like superficial scald, flesh browning and browning of the skin and underlying flesh (soft scald & soggy breakdown).

For this purpose CA conditions were compared with Initial Low Oxygen Stress (ILOS). Furthermore, 1-methylcyclopropene (1-MCP), which is known to inhibit ethylene production but may induce stress-like conditions and increase polyphenol oxidase activity responsible for browning reactions, was also tested.

MATERIAL AND METHODS

Harvest time and quality parameters

Apples (*Prunus domestica* 'Galant') were harvested from 2 to 5 years old trees at different maturity stage, fruit size and color from the experimental orchard of the Consorzio Innovazione frutta (CIF) located in Cunevo (elevation approximately 700 m), northern Italy. A total of 360 fruits of three different maturity stage free from physical defects and diseases were harvested. Physico-chemical parameters related to quality in apples were measured: starch content, flesh firmness, soluble solids concentration and titratable acidity were measured. Fruits were harvested and transported to the postharvest laboratory of Fondazione Edmund Mach (FEM) where they were divided into the 3 groups (120 fruits each) with different harvest time. 12 fruits per each group were analyzed by the Pimprenelle automated laboratory (SETOP, France). For each fruit, Pimprenelle measured the weight, the soluble sugars content (SSC, ° Brix), the flesh firmness (FF, kg/cm²) and on the juice expressed by the entire sample the titratable acidity (TA, g/l of malic acid).

8 fruits per each group were used for starch index determination by visual observation of the development of starch level in the flesh. The starch content was expressed using a scale from 1 to 5.

Postharvest storage treatments

Harvested apples were laid in commercial boxes (60 apples per box) and were stored with different technologies for 180 days (Table 1) and then physiological disorders were

assessed. Initial Low Oxygen Stress (ILOS) and treatment with 1-MCP (SmartFresh, Agrofresh, Italy), which are known to improve storage by preventing early ripening and reducing superficial scald and flesh browning (Matte *et al.*, 2003; Zanella, 2003), were compared. The ILOS was kept for a period of 20 days after harvest followed by Ultra Low Oxygen (ULO) technology with O₂ level below 1%. 1-MCP was applied in the cold room 5 to 7 days after harvest during cooling stage and then ILOS + ULO technologies were combined. Controlled atmosphere (CA) technology was used as reference.

Table 1. Storage technologies tested in the experiments on Galant apples

Technology	T (°C)	RH (%)	O₂ (%)	CO₂(%)	days
Controlled Atmosphere (CA)	1,2	>90	1,4	1,2	180
Initial Low Oxygen Stress (ILOS)	1,0	>90	0,5-0,6	0,8-0,9	180
ILOS + 1-MCP	1,0	>90	0,5-0,6	0,8-0,9	180

Evaluation of physiological disorders after storage

Symptoms of flesh browning were assessed with destructive analysis on 12 fruits/treatment whereas superficial scald, browning of the skin and underlying flesh (soft scald & soggy breakdown) were evaluate by estimate the percentage of skin surface covered by the symptoms on the total number of apples (120) after 120 days of storage.

Treatment design and statistical analyses

A total of 120 fruits per treatment were employed in the present study. There were 2 boxes per treatment in the storage cold room. 8 fruits/treatment were used for determination of starch content, 12 fruits/treatment were used for destructive analysis Pimprenelle and 12 fruits/treatment used for flesh browning assessment after 180 days of cold storage. Others physiological disorders were assessed by observing the apple skin on the 120 fruits/treatment. The boxes were arranged in a completely randomized design into the cold room. Analysis of variance (ANOVA) of data was conducted using STATISTICA 13.0 (Statsoft, Oklahoma, USA) and treatment means were compared by the LSD test ($P \leq 0.05$).

RESULTS AND DISCUSSION

Harvest time and quality parameters

Preliminary trials performed between 2015 and 2016 on 4 to 5 years old trees demonstrated the high susceptibility of Galant apple to superficial scald and flesh browning under CA conditions. Apples picked up at different ripening stage showed different level of superficial scald but always do not significant differed on internal browning (Table 2). At starch index of 1.9 (2015) and 2.2 (2016) there was an increasing of superficial scald but not

in flesh browning in respect to 2.7 and 3.1. No symptoms of soft scald and soggy breakdown were detected in the three stages.

Table 2. Quality parameters and physiological disorders of Galant harvested during 2015 and 2016 in three different maturity stages. Data were collected after 180 days of storage under CA. Different letters indicate significant difference between groups ($P < 0.05$).

Year	Starch Index	SSC °Brix	FF Kg/cm ₂	TA g/l malic acid	Superficial scald %	Flesh browning %
2015	1.9	14.5	6.2	4.6	16.8 (a)	23 (a)
	2.3	14.5	6.3	4.6	9.5 (b)	20 (a)
	2.5	14.3	5.3	4.2	3.8 (c)	18 (a)
2016	2.2	14.2	5.9	3.4	27.4 (a)	33 (a)
	2.7	14.5	5.7	3.2	15.6 (bc)	30 (a)
	3.1	14.6	5.1	2.9	11.8 (c)	36 (a)

Evaluation of physiological disorders after storage

Following trial performed in 2017 confirmed the high sensitivity of Galant to both superficial scald and flesh browning under CA storage but ILOS and ULO technologies allows to reduce symptoms of superficial scald and maintain them under an acceptable value (3.5-4.2%) in comparison with CA (34.8%) after 180 days storage (Figure 1). On the other hand, no significant differences in the incidence of internal browning were observed between ILOS and CA storage and the incidence rates was always higher than 60% after 14 days of shelf-life. Finally, 1-MCP treatment did not affect both the superficial scald and flesh browning which were similar in both 1-MCP treated and untreated apples.

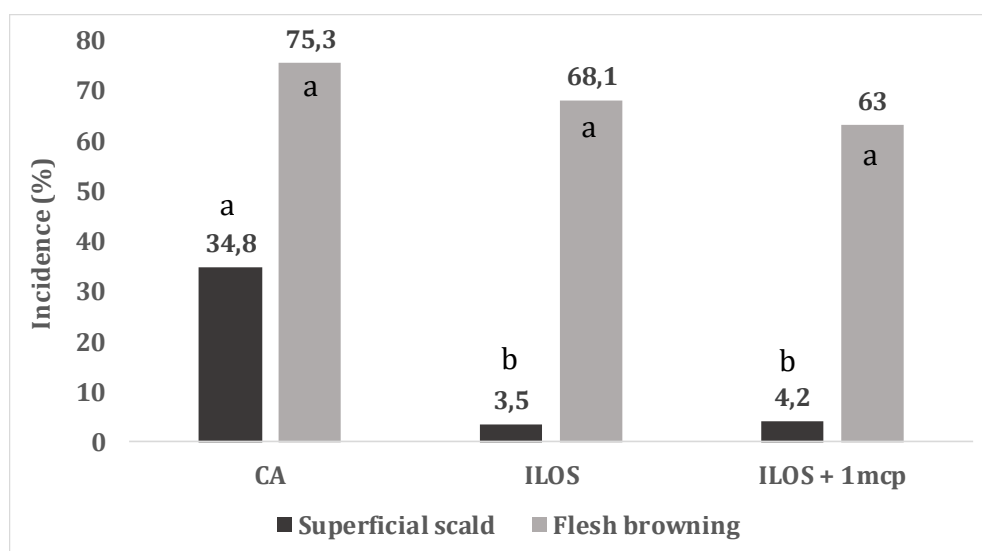


Figure 1. Superficial scald and flesh browning disorder of Galant harvested in 2017 after 180 days of storage under CA, ILOS and ILOS + 1-mcp. Data were expressed as disease incidence (%). Means of 120 fruits were represent. Different letters above the columns indicate significant difference between groups ($P < 0.05$).

CONCLUSIONS

Based on these studies, the reduction of the respiratory metabolism by using ILOS technology allows to effectively control superficial scald on Galant but cannot sufficiently control flesh browning after 180 days of storage. Based on flesh browning disorders, the storability of Galant is limited to maximum 150 days.

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