APPLE POSTHARVEST PRACTICES IN CHILE

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INTRODUCTION

The apple production in Chile (40.0000 ha) is concentrated from Rancagua (34º 5´ Southern Lat.; 70º40´ Western Lat.) to Linares, in 200 km, being almost 50% in the VII Region (34º50´Southern Lat., 71º30´ Western Lat.). Chile produces 1,000,000 tons of apples (13th in the world), and it is placed in 4th position as an exporter country, with 550,000 tons of fresh apples (Table 1). The main varieties grown in Chile are: Red Delicious, Granny Smith, Gala, Fuji and Braeburn, (Figure 1).

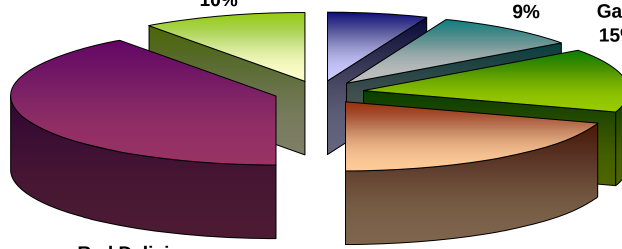

Figure 1. Main Varieties cultivated in Chile (Surface)

Table 1. World Apple Production

Country	Production (ton)	Surface (ha)	Productivity (ton/ha)
China	18.400.000	3.700.000	5.0
USA	4.800.000	170.000	28.2
Turkey	2.100.000	121.000	17.4
Italy	2.000.000	70.000	28.6
Russia	2.000.000	---	---
Polony	1.950.000	---	---
Iran	1.950.000	150.000	13.0
France	1.800.000	70.000	25.7
Ukrania	1.740.000	---	---
Germany	1.400.000	45.000	31.1
Argentina	1.400.000	60.000	23.3
India	1.200.000	210.000	5.7
Chile	**1.000.000** (13)	**40.000** (17)	**25.0**
Japan	936.000	46.600	20.1
Spain	875.000	50.000	17.5
Brasil	670.000	30.000	22.3
South Korea	650.000	40.000	16.3
North Korea	650.000	68.000	9.6
South Africa	650.000	17.000	38.2
Pakistan	600.000	45.000	13.3
New Zealand	581.000	14.000	41.7
Uzbekistan	378.000	83.000	4.6
Australia	369.000	18.700	19.7
Azerbaiyan	244.000	60.000	4.1
Siria	240.000	28.000	8.6
Georgia	140.000	76.000	1.8
Kazajstan	53.000	53.000	1.0
Total	54.000.000	(5.500.000)	

68.000.000 (2005)
(Source: Centro de Pomáceas - Universidad de Talca)

Chile plays an important role in the world apple trade nowadays, regardless of the long distances to the markets and the constantly growing supply. The main limitation of Chilean apple business is related to the production of high quality fruit.

Postharvest practices in Chile began in the 70s, at the University of Chile, and from the 80s research was started at various other Universities and institutes, both private and government. The “Centro de Pomaceas” of the Universidad de Talca, was created in 1995, supported by the University, the government and the industry, as a center devoted to the study of apples and pears, aiming at enhancing the quality of fruits produced in Chile. The research of this entity has contributed to decrease, to some extent, some of the main causes of rejection of Chilean fruit at the exporting markets. Special analysis will be focused on the main achievements in terms of postharvest handling of fruit and the challenges to be faced on this field.

New Varieties

Introduction of new varieties in Chile (mid 80s), resulted initially, in higher profitability than the former ones. But, due to the fast increase in volume there was a need for long term storage. So studies of maturity evolution and postharvest behavior were necessary. From all cultivars introduced, the most promising were Royal Gala and Fuji, and to a lesser extent Braeburn. In **Royal Gala** the necessity of ethylene measurement as a physiological maturity index was evaluated, since it exhibits a high metabolism and low storage potential. Compounds that inhibit ethylene production or action (ethylene scrubbers, ionization system, catalytic combustion, 1-MCP, etc) are needed to extend storage life of this cultivar (Figure 2). Main problems of this variety under Chilean conditions are: rapid loss of firmness and acidity, as well as weight loss. In Chile Royal Gala is stored from 4 to 6 months mainly under controlled atmosphere (CA), with levels of O_2 ranging from 1.0 to 2.0% and CO_2 between 1.8 and 2.0%. **Fuji** is a very resistant variety, that stores well (6 to 8 months), both under regular air and CA (1.8 to 2.0% O_2 and 1.3 to 1.5% CO_2). Its main problems are internal browning, sunburn and cracking. Additionally, in some years, Fuji Stain has appeared. **Braeburn,** although it has a good storage potential, under Chilean conditions, has resulted very prone to bitter pit and sunburn. Due to a wrong geographic location, other cultivars, such as Fiesta, Jonagold and Elstar were removed from commercial orchards. In the last growing seasons, **Pink Lady®** brand apples have taken great interest, and although there is no much information on the behaviour of this cultivar in our country, preliminary studies show that fruit is prone to internal browning, bruising, rotting (caused by *Glomerella cingullata),* and also that scald can develop in early harvested fruit (Figure 3).

Bitter Pit

This has been a serious problem of Chilean fruit, since the limit for exporting fruit is less than 2% of damaged fruit. At present, a relevant number of exporting companies use a pre-harvest prediction system, based on Mg infiltration (methodology developed in USA, 1991). Once possible incidence of bitter pit has been defined (which can be determined almost 20 days before harvest), control strategies can be determined. These include: reinforcing with calcium application in orchard or giving a short storage period for highly risky fruit. Additionally, guidelines for integrated management have been developed, which include appropriate fertilization, pruning, thinning and irrigation.

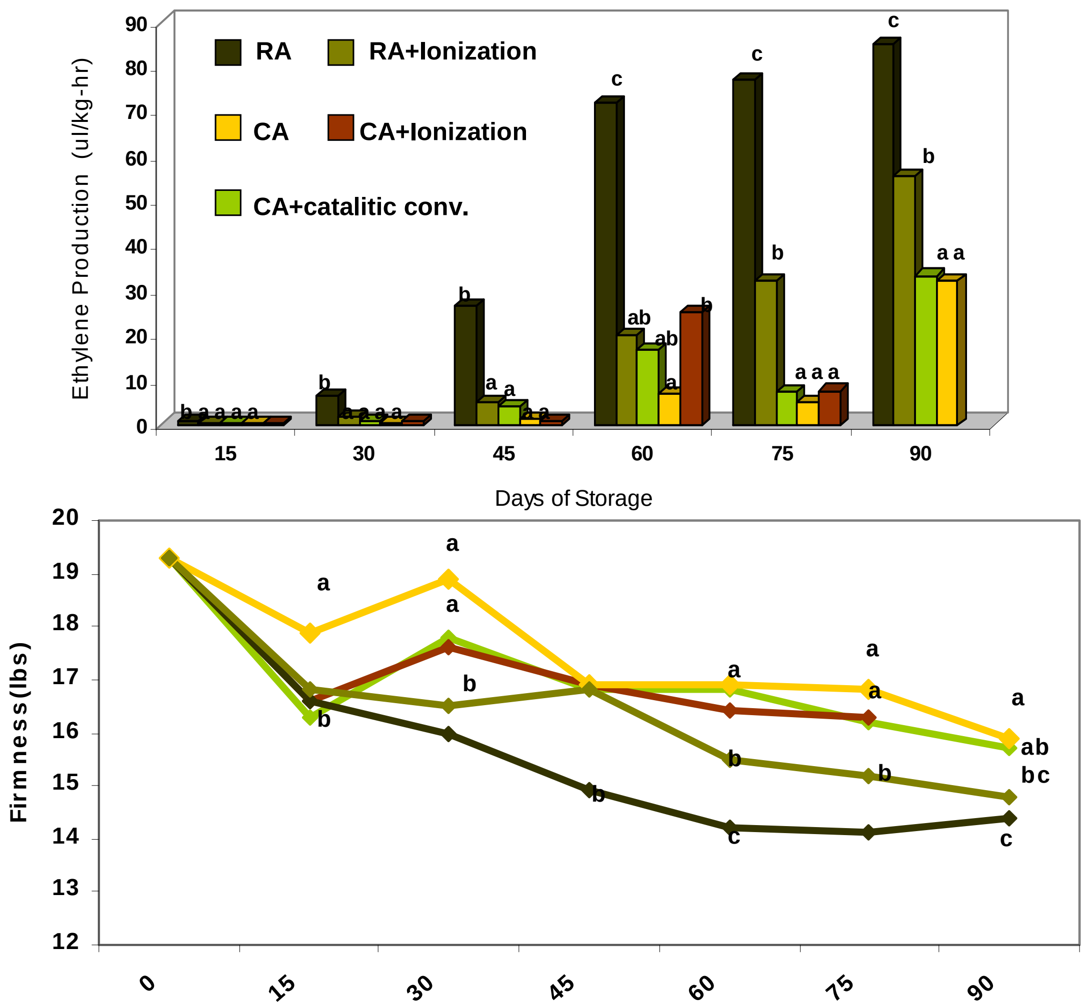

Figure 2. Ethylene production (uL/kg-hr) and firmness loss of Royal Gala Apples stored under Regular Air (RA) and Controlled Atmosphere (CA). Effect of the use of Ionization and Catalyst Combustion.

Figure 3. *Gloesporium* or bitter rot in Pink Lady® brand apples

Bruising

Mechanical damage to the fruit can happen at any stage of development; but it has been demonstrated that it is most probable to occur while in the packing line. At the Centro the Pomáceas, an electronic impact detector, IS100 (Instrumented Sphere, developed by Michigan State University), has been validated and it is used to assess severity of impacts by handling equipment. After 8 years of tests bruise thresholds for different varieties have been established (Table 2). Every year more than 20 exporting companies check their facilities in order to improve the quality of their fruit.

Table 2. Peak acceleration threshold necessary to produce a bruise greater than ≥ 1 cm^2 in different apple varieties.

Variety	g´s
Jonagold	20
Granny Smith	26
Fuji	28
Red King Oregon	39
Braeburn	43

Sunburn

Sunburn damage is the main problem for Chilean apple growers, representing around 40% of economic losses, depending on the region, variety and growing season. Injury appears more severely on susceptible varieties such as Fuji and Braeburn. Trials have been carried out for the last 10 years, based on chemical protectors, sprinkle irrigation, shade cloth and UV filters. Results have shown that under Chilean climatic conditions, chemical protectors do not control sunburn, whereas overhead sprinkle irrigation and shade cloth significantly reduce it, being sprinkle irrigation the most effective. It has been determined that sunburn, in this area is mainly induced by high temperatures on the southwestern side of the fruit (Tables 3 and 4).

Table 3. Effect of sprinkle irrigation and shade cloth on sunburn severity (%) in Gala Apples

Treatment	Healthy	Light	Moderate	Severe
Control	52.0 c	32.8 b	9.8 b	5.4 b
Sprinkle Irrigation	72.0 a	23.6 a	4.3a	0.4 a
Shade Cloth	65.1 b	23.0 a	8.2 b	3.6 b
Significance ($p \leq 0.05$)	*	*	*	*

Table 4. Effect of different chemical protectors on sunburn incidence (%) in Fuji Apples

Treatment	Healthy fruit
Control	67.7
Vapogard™ 0.5%	60.5
Nufilm™ 0.5%	61.6
Vitamin E 0.5%	63.1
Significance ($p \leq 0.05$)	n.s

Superficial Scald

Studies carried out for 6 years have demonstrated that scald is still a problem, which is not likely to be naturally controlled. Due to the high susceptibility of fruit produced in the central valley of Chile (Figure 4), it must be treated with antioxidants before storage. At present, DPA (diphenylamine) and most recently 1-MCP are the only reliable alternatives of control. Additionally, harvesting fruit at the right time on some specific geographic locations can help to reduce the problem. Scald incidence can be partially predicted based on weather conditions before fruit is collected (number of hours below 50 °F, between February 1st and harvest).

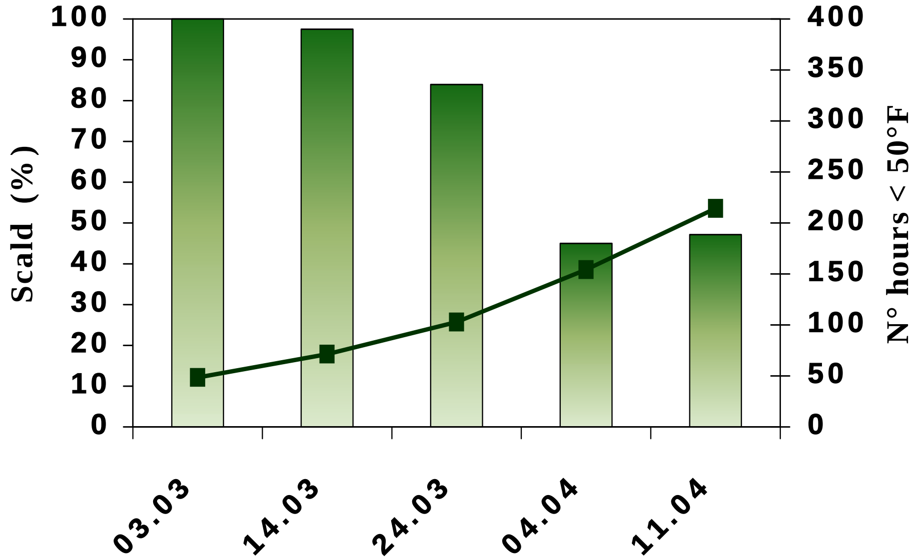

Figure 4. Scald Incidence related to numbers of hours under 50°F (10°C) for an orchard located in Curicó (34.51° Southern Lat)

Use of 1-MCP

This new tool for extending shelf life of fruits is a growth regulator that acts by inhibiting the binding of ethylene to its binding site, thus restraining ethylene action when applied at the parts per billion level. Results in apples and pears in Chile have shown that its effect can stay even when fruit is exposed to higher temperatures (Figure 5); thus it should be a useful tool for cultivars such as Royal Gala. Although it has a very potent action, it is necessary to determine proper doses for each specie and cultivar, based on the expected storage time, so that fruit can be stored for a longer period without affecting its normal ripening process. This is especially important for pears, since they must soften for consumption; our results show that suitable doses in this case should be between 200 and 300 ppb.

Optimizing postharvest chemical applications

The common practice of drenching fruit with DPA and fungicides to prevent scald and rot incidence of apples and pears has a number of disadvantages: diseases can be exacerbated by dipping the fruit in a water solution, specially on apples with open calyx-end; erratic control of scald can be obtained because of variable amount of residues in the fruit (variations in concentrations of tank solution); DPA solution disposals will eventually be questioned by environmental authorities. So, new techniques, as thermofogging, must be used, which has the advantage of using very small amounts of chemicals, which are gasified, so there are no liquid residues released to the environment. This technique can allow application of chemicals (DPA, fungicides) directly in the storage facility, even with cold fruit. At present the effect of a second application of DPA during storage, to enhance scald control is being studied. The best moment for a second DPA application seems to be between 2 and 3 months of storage (Table 5).

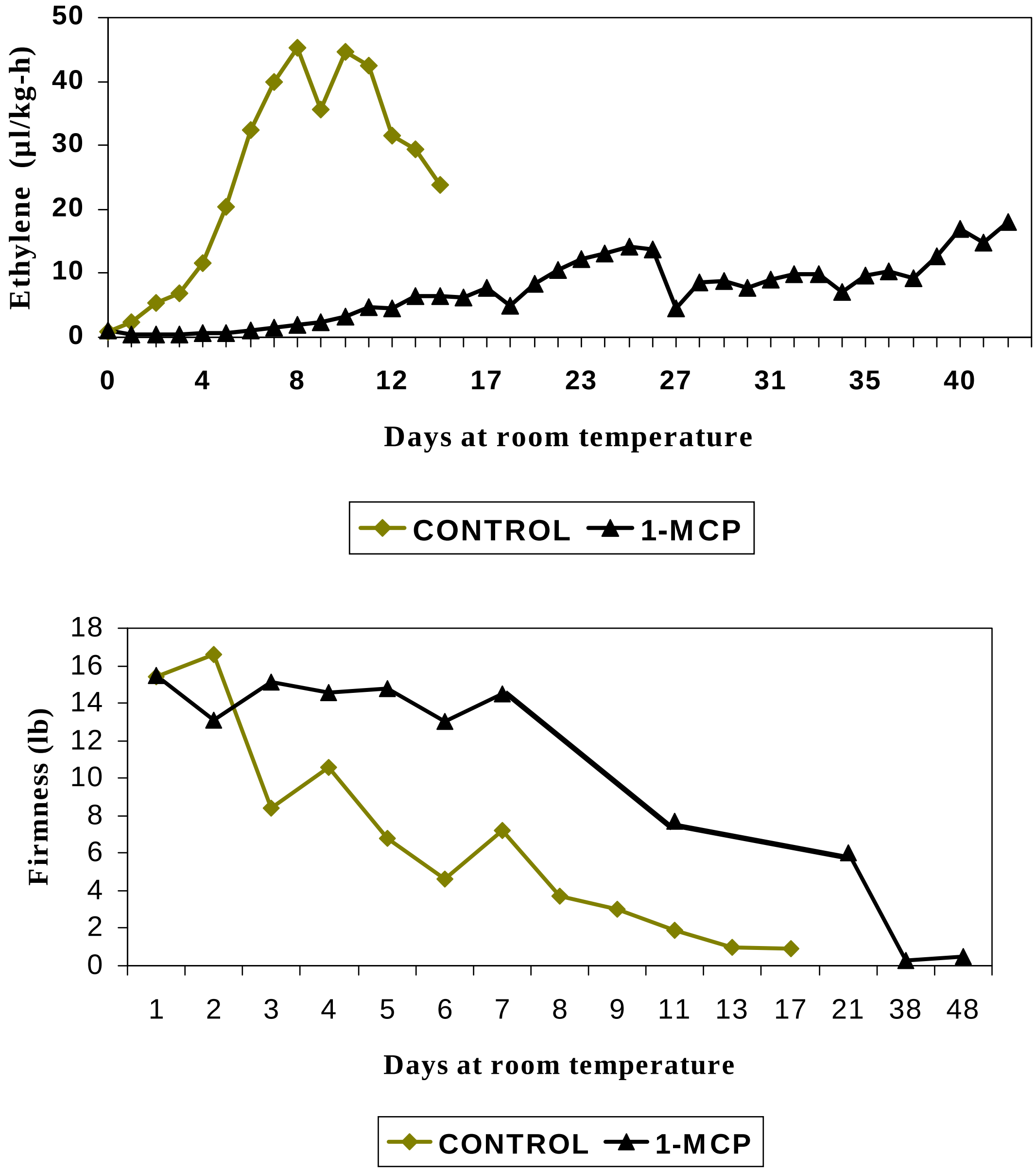

Figure 5. Effect of 1-MCP on ethylene production and firmness loss of Packham´s Triumph pears after 2 months of storage and 48 days at room temperature

Table 5. Effect of DPA application, and re-application after 2, 4 and 6 months, on control of Superficial Scald (%) in Granny Smith apples, Fruits were held under Regular Air (RA) or Controlled Atmosphere (CA) for 8 months plus 10 days at room temperature.

Harvest date	Treatment	8m + 10 d.
March 13	RA	100.0 c
	RA+DPAh	92.5 c
	CA	100.0 c
	CA+DPAh	35.0 b
	CA+DPAh+DPA 2m	1.3 a
	CA+DPAh+DPA 4m	8.8 a
	CA+DPAh+DPA 6m	36.3 b
	Significance	**
March 27	RA	88.8 c
	RA+DPAh	29.1 b
	CA	100.0 d
	CA+DPAh	10.0 b
	CA+DPAh+DPA 2m	0.0 a
	CA+DPAh+DPA 4m	10.9 ab
	CA+DPAh+DPA 6m	22.5 b
	Significance	**

New Disorders

During the last growing seasons skin disorders have become a problem in some regions and orchards. Among the many factors involved, harvest date seems to be one of the most relevant, especially when fruit has to stay longer in the tree in order to enhance color. The main problems we face are: **Lenticel breakdown** (Gala is more prone than Fuji), **Blotch Pit**, which does not involve damage to lenticels, and symptoms under the skin are similar to bitter pit; **Cracking** that affects both Gala and Fuji and **Splitting** which is seen more in Gala (Figure 6). In general, all symptoms become more visible with storage and process of the fruit along the packing line. Studies are now focused on determining causes, in order to find out how to avoid them.

New cultivars and new production areas in Chile

This project initiated in 2001, is aimed at determining the most appropriate rootstock/scion combination for different productive regions of Chile. The objective is to optimize the location of new cultivars and study differences in postharvest behavior based on geographical and climatic condition, in order to obtain better quality fruit for exporting markets. This initiative was born from the definition of priorities by the industry in the Chilean Apples Congress held in 1998 and it has been supported by both the industry and the government.

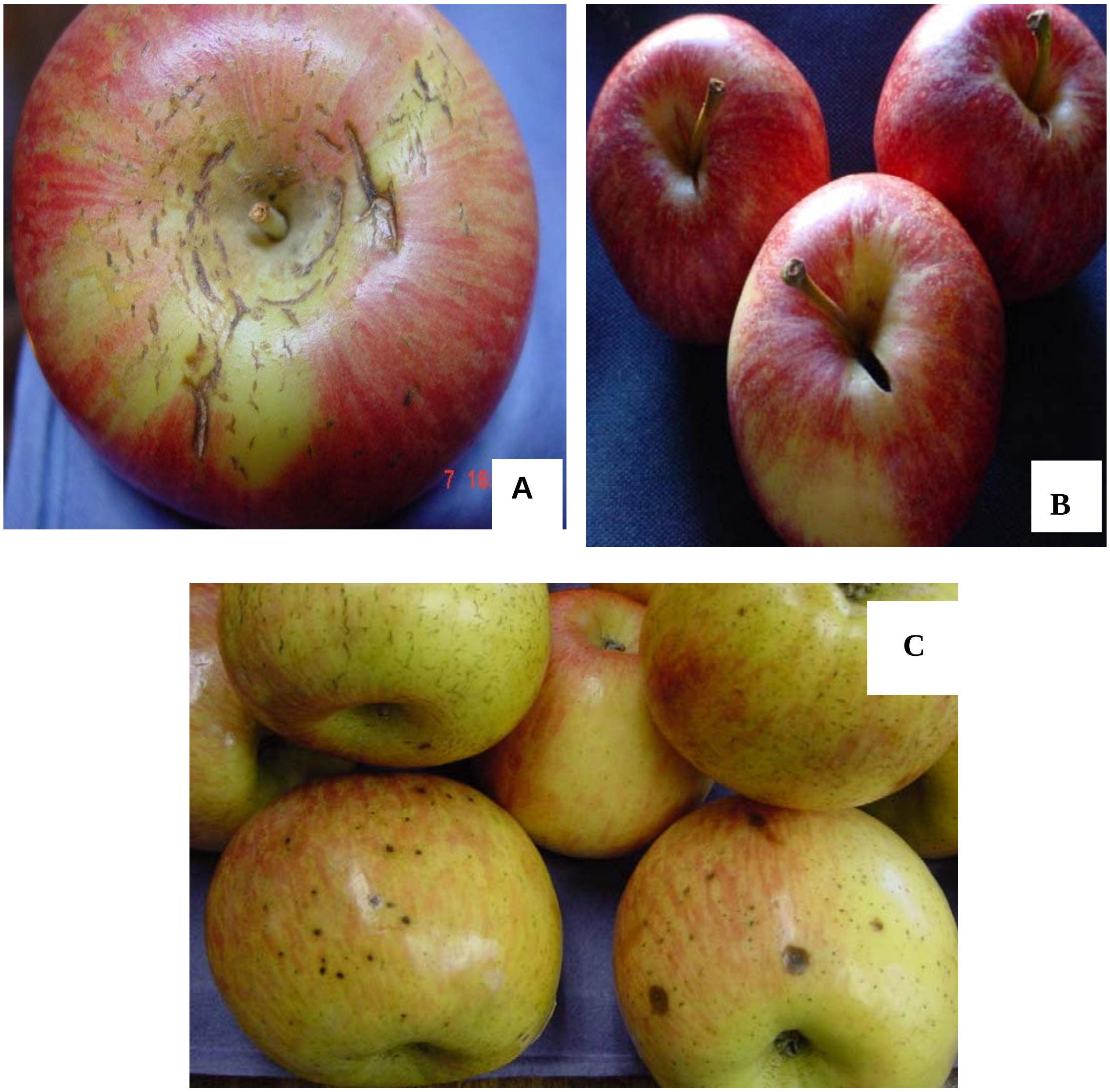

Figure 6. Skin disorders: Cracking in Fuji (A); Splitting in Gala (B); Lenticel breakdown in Fuji (C)

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