Peach chilling injury for different conservation conditions
A review

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Introduction

- The scientific name Prunus persica emerged from a European belief, originating from Persia, however this fruit arose and was first cultivated in China.

- It was introduced in Europe at the beginning of the Roman era and emerged in the United States of America (USA) during the 19th century (Campbell, 2004).

World Production

Country	Production		Area	
	Tonne (T)	%	Hectare (ha)	%
China	12 452 377	54.6	728 354	48.7
Spain	1 573 640	6.9	86 118	5.8
Italy	1 376 428	6.1	74 478	5.0
Greece	962 580	4.2	50 270	3.4
USA	959 983	4.2	50 602	3.4
Portugal	**41 053**	**0.2**	**3 610**	**0.2**
World	22 795 854	100	1 494 837	100

- Portugal (2016) produced:
  - 32000 tons
  - in 3800 hectares (INE, 2016).

Edafoclimatic conditions

- Portuguese region of Beira Interior is:
  - crossed by the river Zêzere
  - located between mountains Serra da Gardunha and Serra da Estrela
- Has cold, mild spring and protection against the atlantic winds.
- The ideal conditions for the peach production (DGADR, 2018).

Dystrophic Cambisols (63.1%)
(Simões, 2016)

- Moderate erosion aused by the small proportion of clay and organic matter;
- High permeability;
- Coarse texture.

Dystrophic Fluvisols (27.7%)
(Simões, 2016)

- Higher clay content;
- Higher fertility;
- Poor drainage.

Organoleptic characteristics

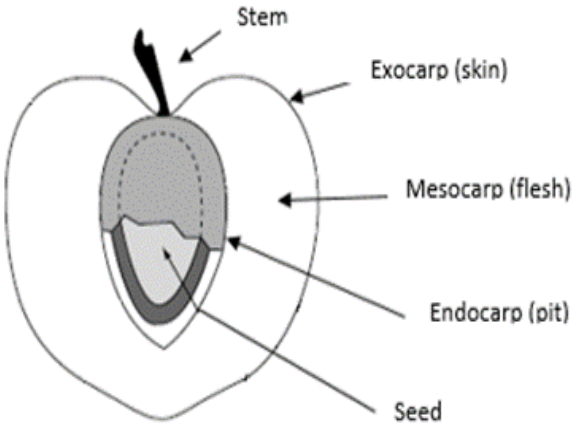
Peach:

- Coating of the epicarp is by indument;
- Color and coloration homogeneity of the epicarp can present a great diversity (yellows, whites or reds shades)
- Majority of the peaches contain a yellow pulp (Lurie & Crisosto, 2005; Aubert & Milhet , 2007, Simões, 2016).

Thin exocarp - skin

Juicy mesocarp - flesh

Hard endocarp - pit



Evaluation parameters

- **Color**
- **Size**
- **Hardness**
- **Total Soluble Solids (TSS)**
- **Acidity**

- Important at the normalization level and of technical decisions, as well as the simplicity of the required devices. (Zhang *et al.,* 2011; Simões, 2016)

Color

- Parameter used by producers as 1st indicator of maturation status.
- Determined by naked eye on the pigments of the epicarp (shades yellow, red or even rayed).
- Determined technically using of a reflectance colorimeter. (Cáceres et al., 2016; Simões, 2016)

The coloration is strongly influenced by climatic conditions

Size

- Evaluated, in a simply form, through weight (expressed in grams - g).
- Evaluated accurately through caliber (measuring the equatorial diameter in mm of the fruit) (Simões, 2016)

Designation Calibers	Equatorial range (mm)	Weight (g) Range of values / Average	
AAA	≥ 90	>332	
AAA	81 the 90	245 – 332	290
AA	74 the 80	165 – 245	220
A	68 the 73	155 – 165	170
B	62 the 67	120 – 155	135
C	57 the 61	94 – 120	106
D	51 the 56	< 94	

Hardness

- Determines the harvesting date
- Is an indicator of the state of maturity of the fruits.

Hardness: high value	• Low state of maturation; • High resistance to manipulation; • Low organoleptic characteristics. (Simões, 2016)
Hardness: low value	• Advanced state of maturation ; • Lower resistance to manipulation; • Intense organoleptic characteristics. (Simões, 2016)

- The range of hardness more favorable to harvest: 5 and 6 kg/0.5 cm^2. (Simões, 2008)

Total Soluble Solids (TSS)

- Related to the sugar content.
- It increases during fruit maturation.

TSS influenced:

- by soil;
- by climatic conditions;
- by cultural techniques;
- by factors intrinsic to the plants.

- TSS is expressed in percentage (%) or ºBrix. (Bonora, 2013; Simões, 2016)

Acidity

- Determined based on a titulation.

Cultivars of high acidity	Cultivars of low acidity
7 to 9 g acid malic/L	3 to 5 g acid malic/L

- Expressed in meq malic acid/L juice or g malic acid/L juice.

Chilling Injury

- A physiological disturbance, induced by low temperatures. (Meng *et al*., 2009)
- Affect fruit quality. (Meng *et al*., 2009)
- Harms lifetime at storage. (Lurie & Crisosto, 2005)

- Chilling injury is generically influenced by the combination of storage temperature and the period of storage time. (Lurie & Crisosto, 2005; Pan *et al.,* 2016)

Chilling Injury Symptoms

- Brown color the peach mesocarp (pulp)
- Floury pulp
- Dry texture
- Lack of flavor
- Separation of the pulp (in more advanced cases)

Biological Factors

Respiration

- Higher the rate, greater the degradation of the products.
- Peach has a moderate respiratory rate. (Pinto & Morais, 2000)

Transpiration

- Influenced by external factors (temperature, relative humidity, air circulation during storage).
- Influeced by product characteristics (morphological, surface/volume ratio, epidermis damage and maturation status). (Pinto & Morais, 2000)

Action of ethylene

- Climacteric fruit sensible to ethylene.
- Regulates growth, development and tissue senescence of the fruit. (Pinto & Morais, 2000)

Chilling injury

- Methods and treatments that retard/prevent Chilling Injury:
  - Improve the preservation the organoleptic characteristics of the peach (such as flavor, texture, aroma, succulence and hardness) (Shinya et al., 2014)
  - Increase in useful life (Lurie & Crisosto, 2005)

Chilinh injury

- Methods and treatments that retard/prevent Chilling Injury:
  - Modified atmosphere - Pre-cooling Methods:
    - Forced air cooling
    - Water cooling
    - Ice cooling
    - Vacuum cooling
  - Controlled Atmosphere - CO2/O2 Concentration
  - Intermittent Warming
  - Ethylene and Ethylene Inhibitors
  - Glycine Betaine

Experimental Analysis

Experimental Equipment	• Refrigeration chambers (farmers)
Fruit quality assessment devices	• Colorimeter • Scale • Penetrometer • Digital Refractometer • Acid-base reaction
Monitoring Devices	• Data Logger – EL-USB-2-LCD

Methods

Color:

Minolta colorimeter

4 readings per fruit in the equatorial section

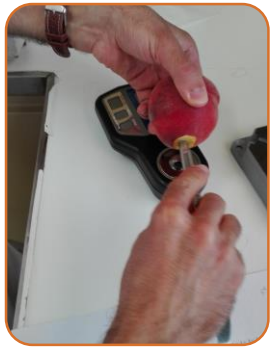
4 measuring points along the perimeter

Weight:

Hardness:

PENEFEL equipment

2 measures per fruit



TSS:

Digital refractometer

1 measure for each fruit

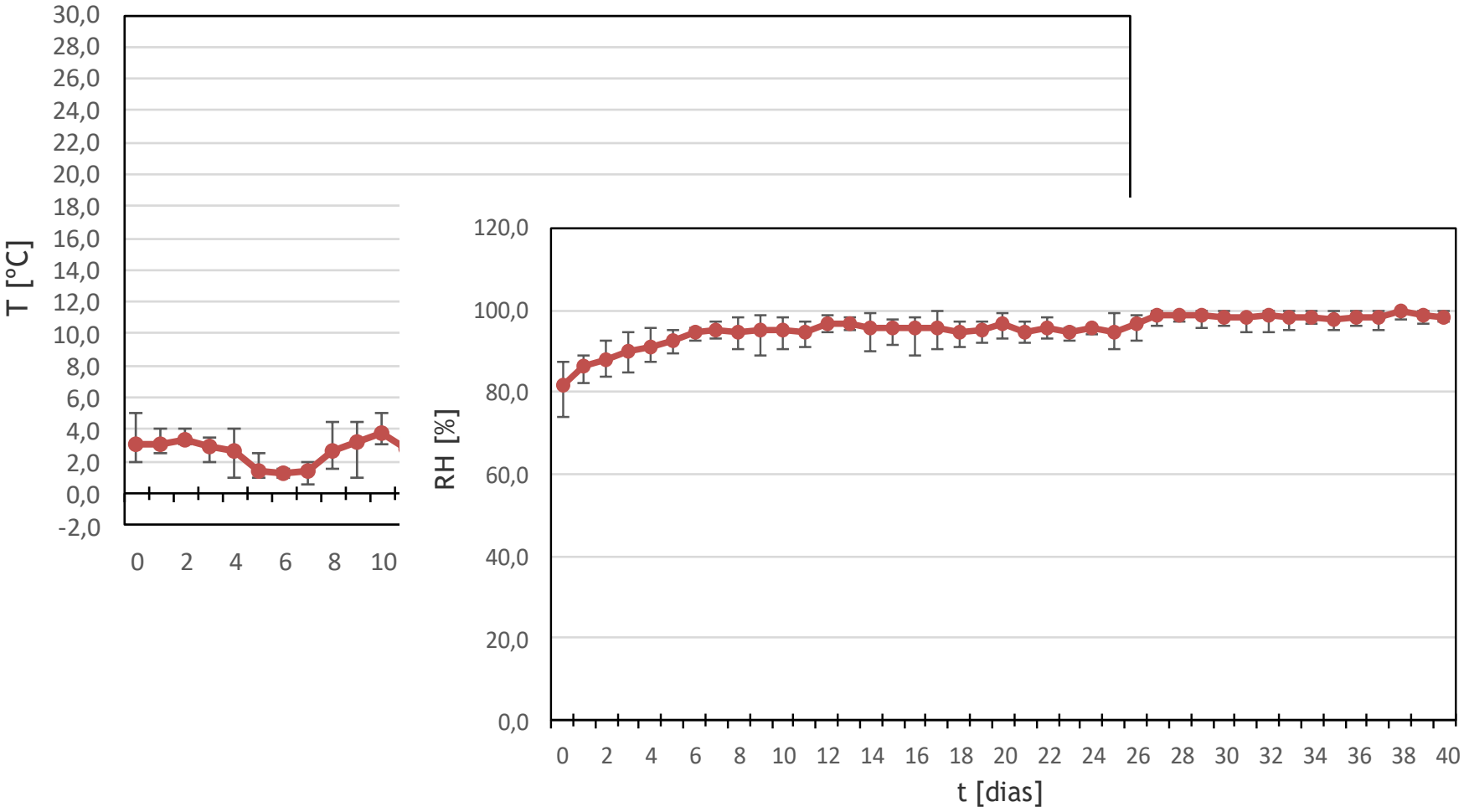
Acidity:

subsamples of 6 fruits

Chilling injury (CI)

visual analysis of the pulp after the cut of the pulp

Results


T [°C]
30,0
28,0
26,0
24,0
22,0
20,0
18,0
16,0
14,0
12,0
10,0
8,0
6,0
4,0
2,0
0,0
-2,0
0 2 4 6 8 10
RH [%]
120,0
100,0
80,0
60,0
40,0
20,0
0,0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40
t [dias]

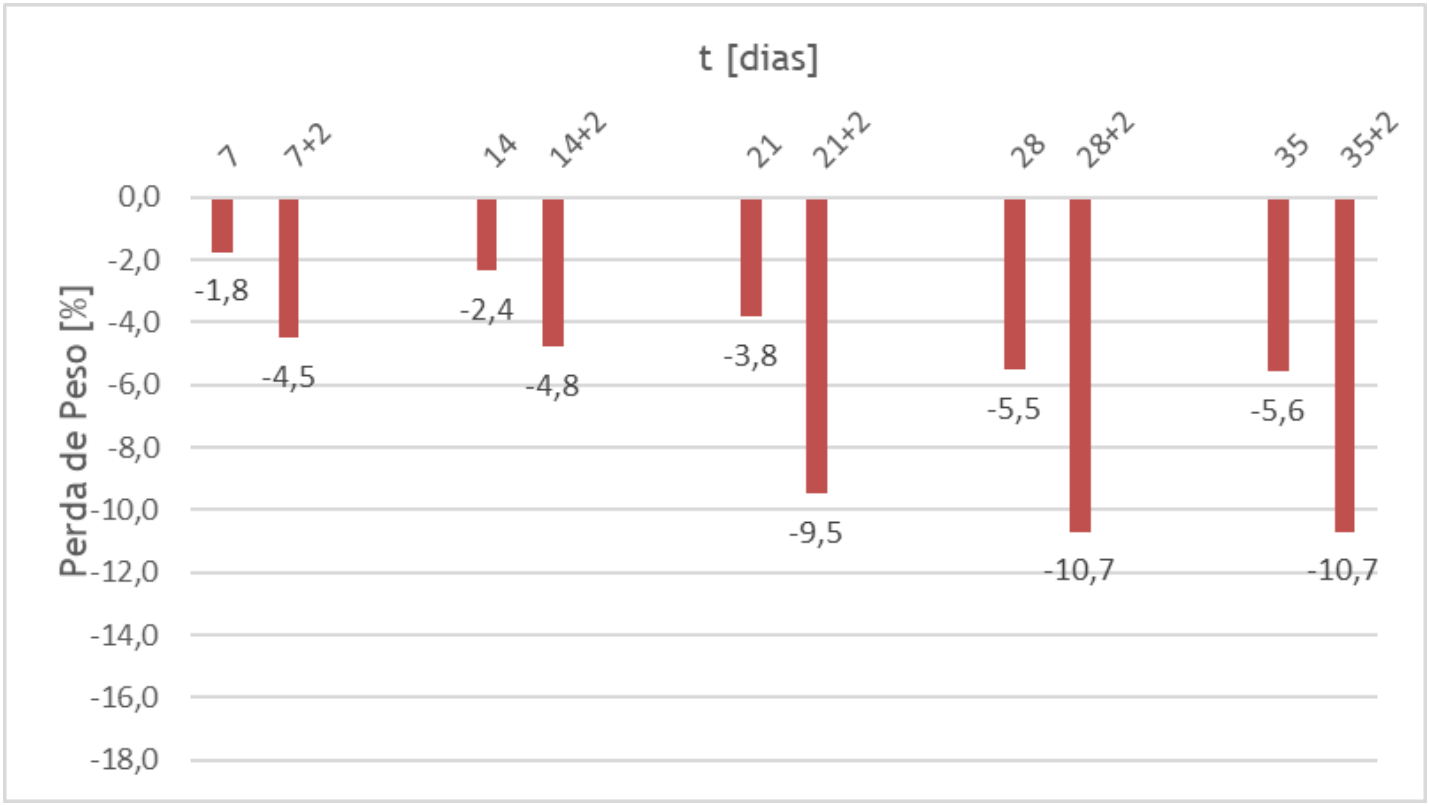
Results

Days of storage	Deteriorated Fruit		Days of storage + Days at room temperature	Deteriorated Fruit	
	Not	Yes		Not	Yes
7	x				
			7+2	x	
14	x				
			14+2	x	
21	x				
			21+2	x	
28	x				
			28+2	x	
35	x				
			35+2		**8,3%**
42	x				
			42+2		**16,6%**

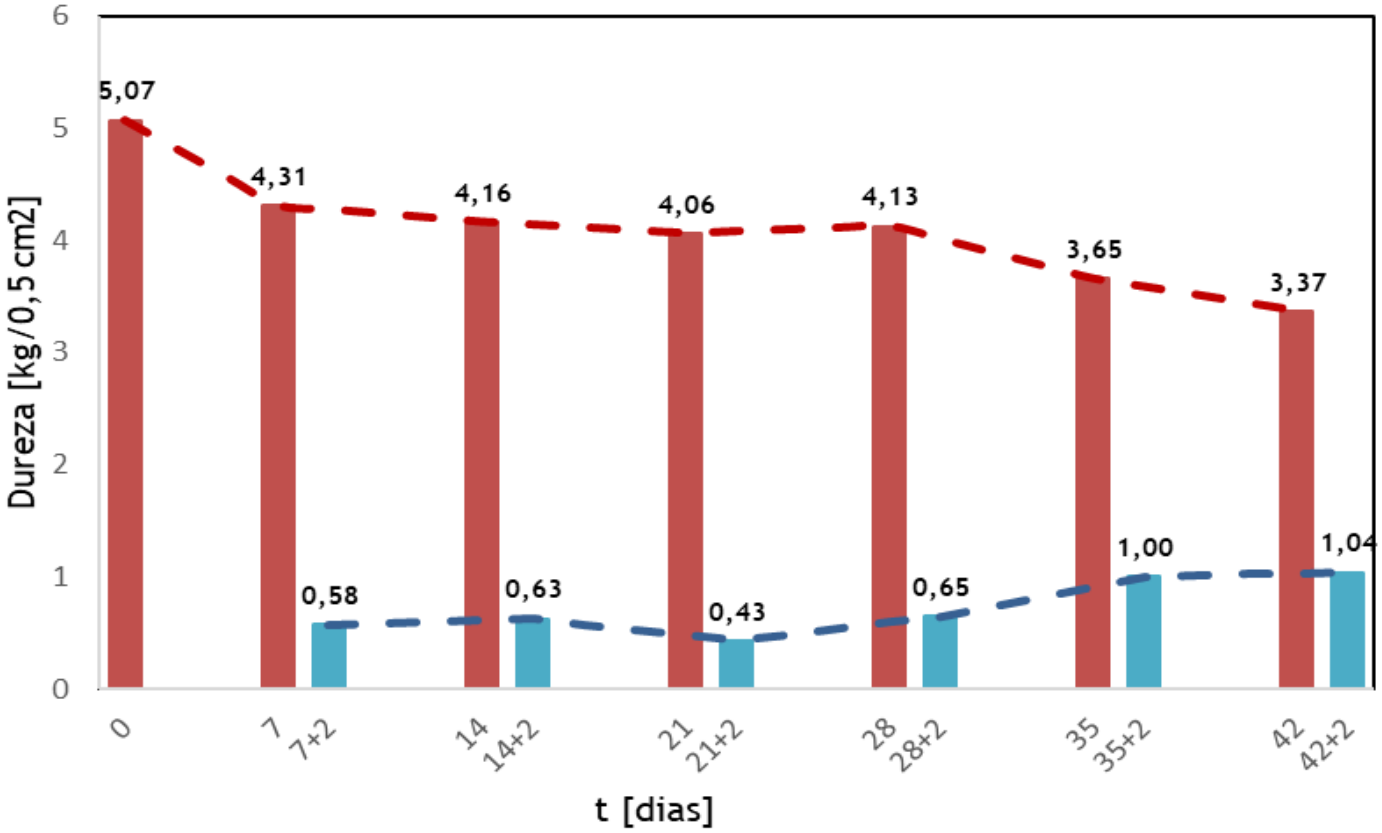
Results

Days of storage	Chilling Injury	Intensity of Chilling Injury	Days of storage + Days at room temperature	Chilling Injury	Intensity of Chilling Injury
7		0			
			7+2		0
14		0			
			14+2		0
21		0			
			21+2	**25%**	**1**
28		0			
			28+2	**66,6%**	**1**
35		0			
			35+2	**81,8%**	**2**
42	**8,3%**	**1**			
			42+2	**100%**	**1**

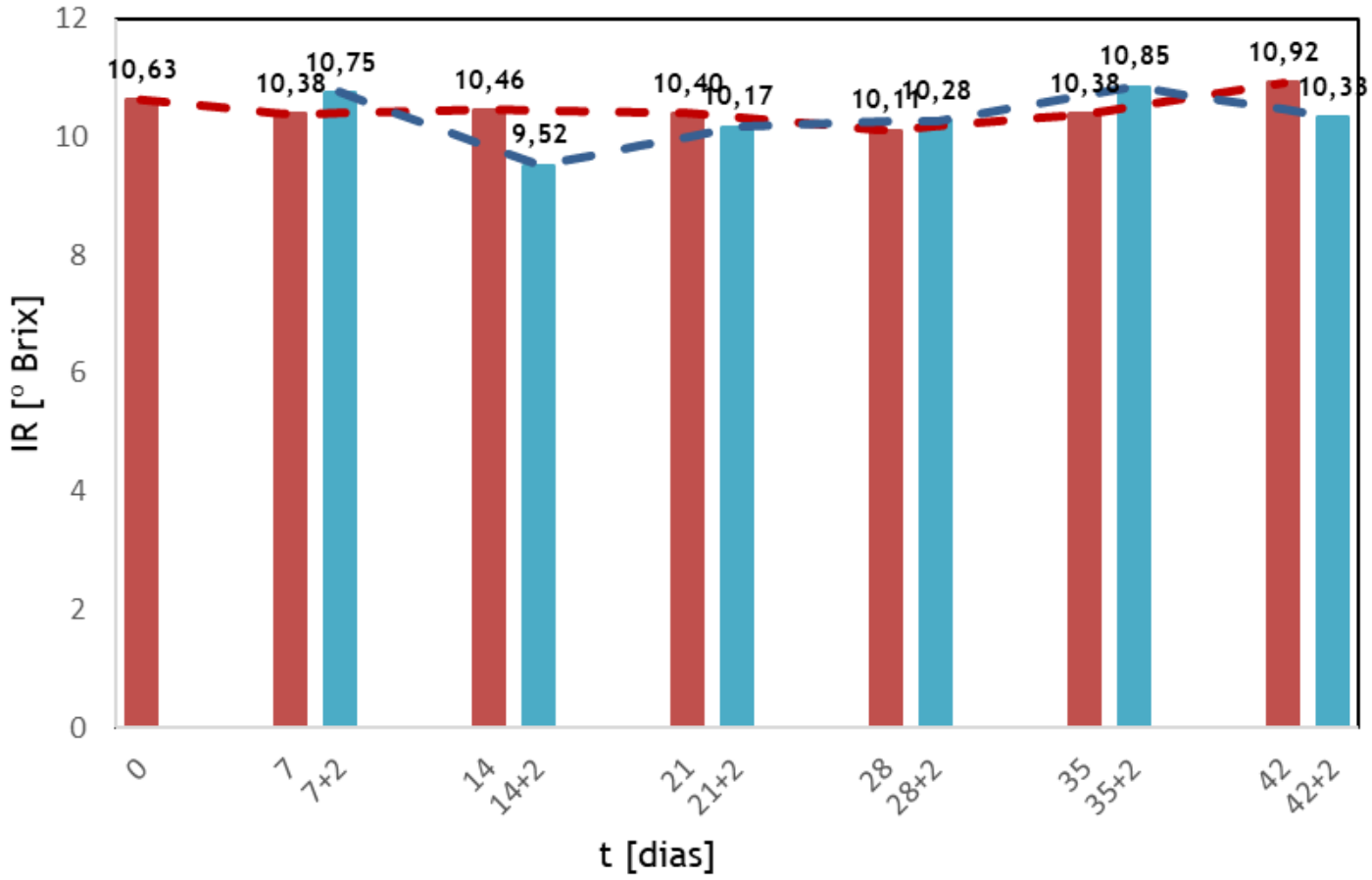
Results: Weight loss



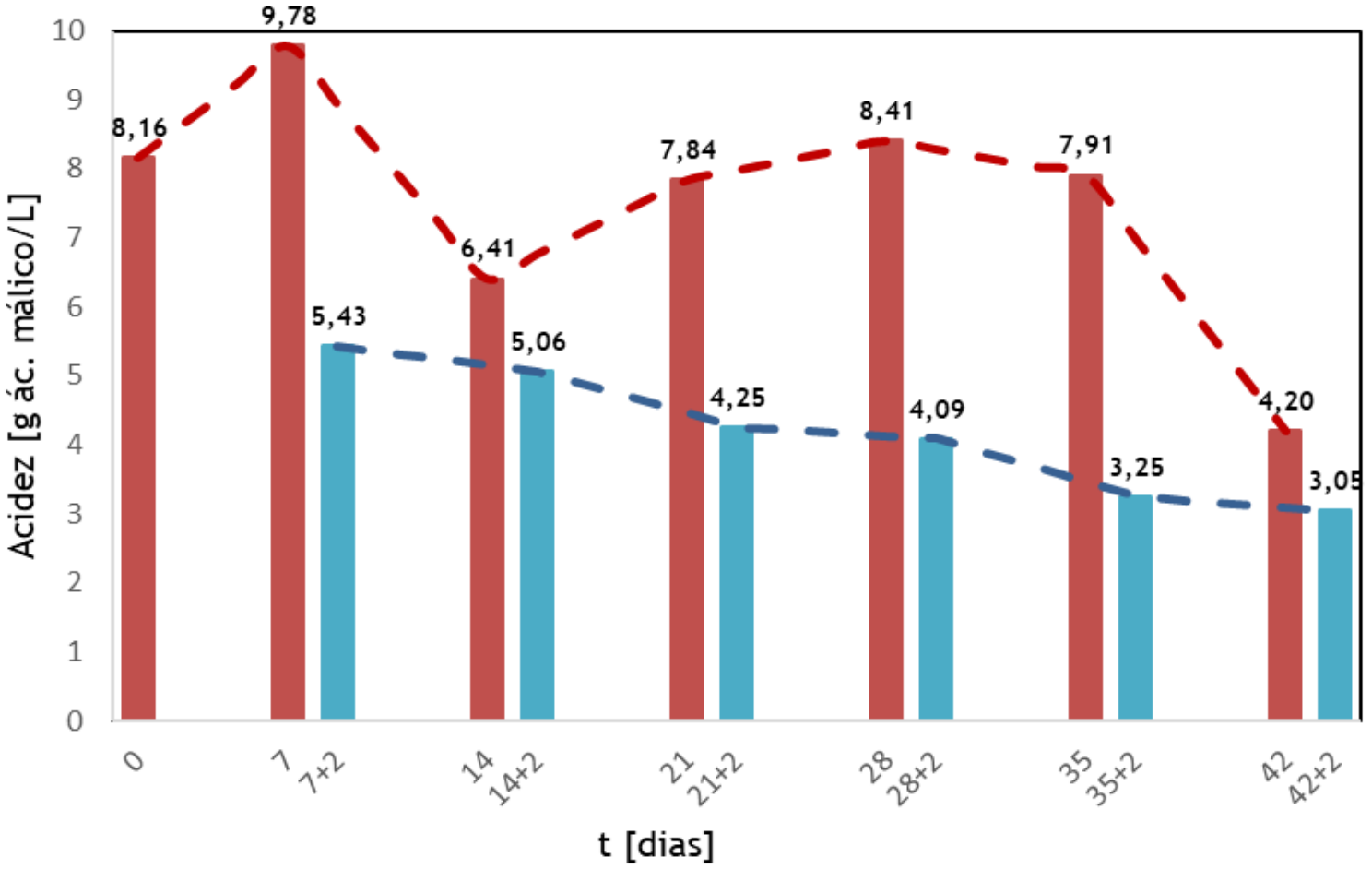
Results: Hardness



Results: Refractometric Ind.



Results: Acidity



Conclusions

- Review:
  - Ideal storage conditions:
    - Temperature between -0.5ºC and 2.2ºC
    - Relative humidity around 100%.

- Experimental work: Cooling conditions during a period of 44 days.
  - Average temperature between 0ºC and 2ºC
  - Relative humidity of 90ºC % to 100%.

- Chliling injury:
  - Damage occurs at 21 days, CI = 1 (slight damage)

Conclusions

- To maintain fruit quality during the marketing period:
  - it is necessary to implement techniques or treatments that delay the symptoms of chilling injury (increase quality).

- Is necessary to inform producers, transporters, receivers and consumers on short-term techniques to reduce the development of symptoms caused by chilling injury.

- Thus, the research of new and better techniques to delay the development of the chilling injury must continue to be investigated.

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