

Postharvest quality of peaches harvested from integrated and conventional production systems

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Abstract – Over three years the postharvest quality of 'Marli' peaches harvested from the integrated (IFP) and conventional production (CFP) systems was evaluated. The peaches were harvested from commercial orchards of *Prunus persica* at two locations close to the city of São Jerônimo, RS, Brazil, and stored at 0.5°C for 10, 20 or 30 days. The peaches were evaluated at harvest, at retrieval from storage and after ripening periods at 20°C. No differences in fruit weight losses were determined. Decay incidence was low, and no differences were detected amongst systems in both 2001 and 2002 seasons, but in the 2000 season CFP peaches were more decayed. Flesh firmness of peaches from the IFP system were greater than CFP fruits in the years 2000 and 2001. In 2002, firmness changed little during storage and ripening. Peaches from the IFP in 2000 had higher titratable acidity and lower soluble solids. In the 2000 season, flesh browning was observed in decayed fruits, always at ripening after 20 or 30 days of cold storage. Chilling injuries such as browning, woolliness and leatheriness occurred in 2002. There were no differences amongst systems related to peach quality.

Index terms: *Prunus persica*, stone fruits, storage, chilling injuries.

Qualidade pós-colheita de pêesegos cultivados em sistema de produção integrada e convencional

Resumo – A qualidade pós-colheita de pêesegos 'Marli', cultivados nos sistemas de produção integrada (PIF) ou convencional (PCF), foi avaliada durante três anos consecutivos. Os pêesegos foram colhidos em duas áreas distintas, em pomares comerciais, no Município de São Jerônimo, RS, e foram armazenados a 0,5°C por 10, 20 ou 30 dias. Os pêesegos foram avaliados na colheita, nas retiradas do armazenamento e após os períodos de amadurecimento a 20°C. Não foram observadas diferenças na perda de peso entre os sistemas de produção. A ocorrência média de podridões foi baixa e sem diferenças entre os sistemas em 2001 e 2002, mas em 2000, os pêesegos da PCF apresentaram mais podridões. A firmeza da polpa foi superior nos pêesegos da PIF em 2000 e 2001. Em 2002, a firmeza pouco variou durante a armazenagem e o amadurecimento. Pêesegos da PIF apresentaram, em 2000, menores teores de sólidos solúveis e maior acidez titulável. Em 2000, observou-se escurecimento de polpa em frutos com podridões, sempre no amadurecimento após 20 ou 30 dias em frio. Danos por frio na forma de escurecimento, lanosidade e retenção de firmeza ocorreram em 2002. Não ocorreram diferenças entre os sistemas de produção quanto à qualidade dos pêesegos.

Termos para indexação: *Prunus persica*, frutas de caroço, armazenagem, danos por frio.

Introduction

Consumer demands for better fruit quality in the market are increasing. Nowadays, beyond fruit characteristics there is more attention to the possibility of environmental problems deriving from agricultural practices. Therefore, in recent years, much attention is being paid to alternative forms of

agriculture, in order to obtain high-quality food in an environmentally compatible manner (Carbonaro & Mattera, 2001). Therefore, growers have become more interested in integrated fruit production (IFP) systems. In Brazil, IFP systems are at different stages of development for many fruit species. Peaches are the second species for which an integrated production system is being developed.

IFP production systems intend to offer to consumers high quality fruit with low risk of chemical residues. The objective of the stone fruit integrated production system is to produce high quality peaches, plums and nectarines with little or no environmental damage. This is also a way to obtain consumer confidence and to maintain export markets for fruits (Deckers, 2000).

At the beginning, there were many concerns about the outcome of such a production system. Growers, extensionists and researchers had worries, which proved not to be true over time. By now, there is enough information available to produce peaches with much less environmental impact and with a minimal risk of agrochemical residues in the fruit, though there is a lot of work to be done to provide this information to consumers.

Nowadays, most of the work with stone fruit IFP systems is more concerned with aspects such as yield, fruit size, pest and disease control, number of agrochemical sprays, agrochemical selectivity, amongst other evaluations dealing with preharvest factors. However, there is little information available on postharvest quality of fruit harvested from IFP production systems. Flesh firmness, soluble solids, titratable acidity, susceptibility to chilling injuries and dehydration are important variables to be determined from IFP fruit.

The objective of this work was to evaluate the postharvest quality and storability of peaches harvested from an IFP system, compared to peaches harvested from a nearby grove conducted in the conventional system (CFP) during three years.

Material and Methods

The experiments were conducted with a white flesh peach (*Prunus persica*) cultivar Marli from 2000 through 2002. The peaches were harvested mid December from a private grove located close to the city of São Jerônimo, State of Rio Grande do Sul, Brazil. After harvest, peaches were transported to a packinghouse for quality selection. Selected fruits were placed in 10 kg plastic boxes, and were immediately transferred to cold rooms at 0.5°C with 90% relative humidity.

Both IFP and CFP areas were of about 1 hectare. In the IFP system, cultural practices were implemented according to the recommended norms for integrated stone fruit production (Normas..., 2001). In the CFP system, the area was managed according to commonly

used practices of the grower. More informations about the production systems are available in Guerra (2004).

Peaches were cold stored for up to 30 days. Samples were retrieved from storage after 10, 20 or 30 days, and kept for two or three more days at 20°C. In the postharvest laboratory conditions, peaches were analysed for percentages of weight and decay losses, chilling injury incidence, fruit size, epidermal color, flesh firmness, soluble solids (SS), titratable acidity (TA) and market life. Red color of the skin (%) was determined visually. Lightness (L^*), hue angle and chroma were measured on the greenest portion of the peel with a Minolta CR300 colorimeter. Soluble solids (°Brix) were determined with a table refractometer. TA (% malic acid) was assessed by titration with 0,1N NaOH up to pH 8,1. Flesh firmness was measured at two opposite sites with an Effegi hand penetrometer, equipped with a 7,9 mm Magness-Taylor plunger. Chilling injuries, such as flesh browning and bleeding, woolliness and leatheriness were visually assessed after splitting the peaches. Flesh browning and flesh bleeding, a brown coloration or red pigment accumulation near the pit extending out into the flesh, were classified on a scale: 1, healthy (pulp with no browning or bleeding); 2, slight (up to 25% of the pulp is affected); 3, moderate (25–50% of the pulp is affected); 4, severe (>50% of the pulp is affected). Peaches with pulp of a corky appearance and firmness beyond 40N after ripening were classified as leathery. Woolliness was determined after hand-squeezing one half of the peaches to classify it according to the following scale: 1, healthy (abundant juice liberation); 2, slight (moderate juice liberation); 3, moderate (slight juice liberation); 4, severe (without juice). Peaches with a dry appearance, and little or no juice after hand-squeezing, were classified as woolly. Juicy fruits without signs of woolliness, browning and leathery flesh were classified as healthy.

From each production system and for every storage period, three replicates of 15 peaches each were harvested. The statistical analysis was performed using SANEST (Zonta & Machado, 1986), and the differences of averages were compared by the Tukey test at 5% probability.

Results and discussion

Peaches harvested from either production system had lower firmness with regards to quality and ripening parameters over the three years of evaluation in the year

2002. In 2000 and 2001, titratable acidity was lower (Table 1). Peaches harvested from the CFP and IFP systems did not differ in weight, in the three years of evaluation. IFP peaches harvested in 2002 lacked epidermal red color, in comparison to 2000 and 2001, independently of the production system.

Visual evaluation of peaches, performed after two or three days of ripening at 20°C, indicated that fruits were of good internal and external quality. Peaches from the 2000 and 2001 seasons were exceptionally of good taste, while peaches from the 2002 season lacked some sugar contents, which did not improve after the ripening period at 20°C.

Weight losses of peaches from either production system, at retrieval from storage periods, did not differ over the evaluation period. However, there were significant differences in weight losses after the ripening periods at 20°C (Table 2). At higher ambient temperatures, metabolism is hastened, and dehydration

as well is also more intense. Both, according to Deshpande & Salunkhe (1964), are responsible for fruit weight losses. Increases and differences in dehydration, mainly at ripening after 30 days of cold storage, might be the primary cause of rotted peaches as a consequence of the prolonged storage. However, even with small differences observed at ripening periods, the average dehydration percentages were not different amongst the two production systems.

Despite weight losses up to 10%, during ripening periods, no symptoms of shrinkage were observed. Crisosto et al. (2004) concluded that only weight losses beyond 10% result in visible symptoms of dehydration.

The occurrence of decay of stored fruit, harvested in 2001 and 2002, from the two production systems was not significantly different during storage or ripening at 20°C. There were, however, differences in decay in peaches harvested in the 2000 season (Figure 1 A, B and C). In 2000, up to 81% fruits showed some symptom of decay in

Table 1. Quality and ripening parameters of 'Marli' peaches harvested from integrated fruit production (IFP) and conventional production (CFP) systems, over the years 2000, 2001 and 2002⁽¹⁾.

Parameter	2000		2001		2002	
	CFP	IFP	CFP	IFP	CFP	IFP
Weight (g)	113,0aA	119,0aA	124,7aA	120,6aA	132,0aA	119,6aA
Diameter (cm)	5,9bB	6,2aA	5,9aB	6,0aB	6,3aA	6,2aA
Color (%)	35aA	35aA	34aA	32aA	38aA	26,0aA
Firmness (N)	54,5aA	62,5aA	53,4aA	54,4aA	37,7aB	41,9aB
SS (°Brix)	11,4aA	10,2aA	11,0aA	10,5aA	12,1aA	11,0aA
TA (% malic acid)	0,26aB	0,21bB	0,29aB	0,30aB	0,38aA	0,39aA

⁽¹⁾Values, in each parameter, followed by same lower case letter in lines, in each harvesting season, and same capital letter in line, in all years, do not differ significantly according to Tukey test at 5% probability.

Table 2. Weight losses (%) during cold storage and ripening of 'Marli' peaches managed in the integrated (IFP) or in the conventional production (CFP) system, after up to 30 days of cold storage at 0.5°C, plus two or three more days at 20°C, along three years of evaluation⁽¹⁾.

Days of storage	2000		2001		2002	
	CFP	IFP	CFP	IFP	CFP	IFP
Storage at 0,5°C						
10	1,6a	1,9a	0,0a	0,0a	1,5a	0,8a
20	2,3a	2,3a	1,3a	1,8a	3,9a	3,8a
30	2,6a	3,3a	1,7a	2,4a	5,8a	6,1a
Mean	2,2a	2,5a	1,0a	1,4a	3,8a	3,6a
CV (%)	23,7		31,8		21,1	
Storage at 0,5°C and 20°C						
0 + R ⁽²⁾	8,6a	8,0a	4,7a	4,0a	3,6a	4,2a
10 + R	4,1a	4,0a	8,6a	8,4a	6,8a	6,7a
20 + R	5,7b	6,5a	6,2a	5,9a	5,4a	3,6b
30 + R	9,4a	8,1b	3,5a	3,7a	8,0b	9,9a
Mean	6,9a	6,7a	5,7a	5,5a	5,9a	6,1a
CV (%)	6,2		6,5		13,2	

⁽¹⁾Averages followed by the same letter in lines, in each year, do not differ significantly by Tukey test at 5% probability. ⁽²⁾R: 3 days at 20°C in 2000 and 2001, and 2 days in 2002.

either production system, after 30 days of cold storage. In contrast, in the following seasons, the percentages of rotted fruit were at maximum 6.3 and 4.4% for the IFP system and CFP system, respectively (Figure 1 D).

Brown rot (*Monilinia fructicola*) was the major cause of decay. Mitcham et al. (2000) concluded that brown rot is the most important decay problem of stored stone fruits. The authors suggested that infection occurs during the flowering period, but fruits become decayed only close to or after harvest. The higher percentages of rotted peaches, harvested from the IFP system, might result from the lower number of sprays in that system. Another indirect cause of more rotted peaches could

result from a higher incidence of codling moth (*Grapholita molesta*), whose damages facilitate the infection of fruit tissues.

In 2000, even though, high incidence of decay, during the ripening period at 20°C after 30 days of cold storage, is mostly attributable to latent infections or codling moth, some effects should be imparted to senescence. In 2000 as well as in 2001, three days at 20°C resulted in excessive ripening which led to higher susceptibility to handling damages and facilitated tissue colonization by fungi.

Visual analysis of epidermal color showed some variation along evaluation periods. In none of the seasons,

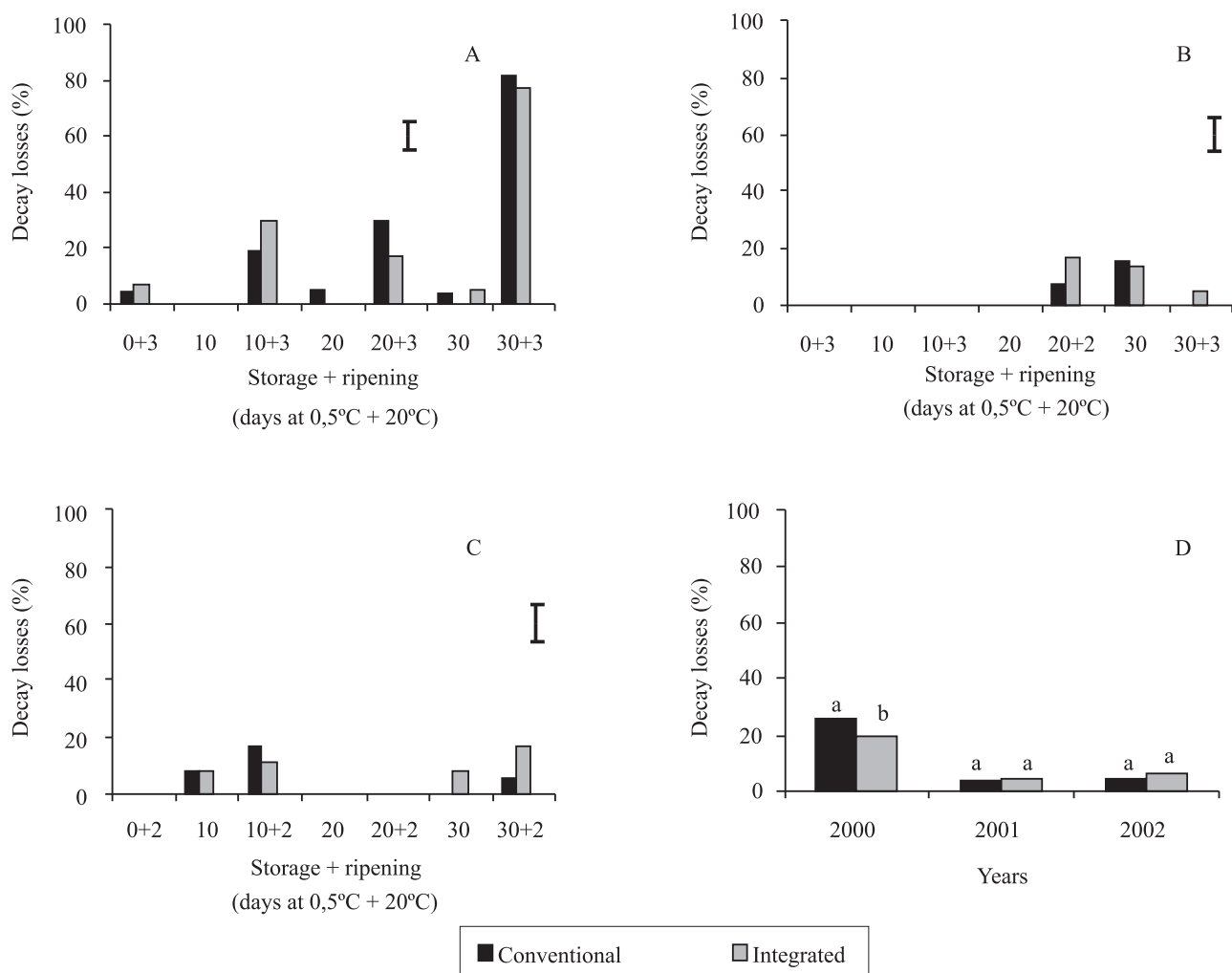


Figure 1. Decay losses of 'Marli' peaches managed in the integrated and conventional production systems in three years, 2000 (A), 2001 (B) and 2002 (C), and average values for every year (D), after 30 days of cold storage at 0.5°C, plus ripening period at 20°C. Vertical bar indicates the least significant difference.

however, statistical significance was determined from either production systems. In theory, there should have been observed differences in favor to the IFP system, in which the trees are summer pruned allowing more penetration of sun light into the tree canopy.

According to Van Blaricom & Senn (1967), red epidermal color of peaches results from anthocyanin synthesis. Anthocyanin synthesis is stimulated by direct light incidence onto fruit surface and by increased download of carbohydrates from well illuminated leaves nearby (Salisbury & Ross, 1994). Francisconi et al. (1992) worked with the same cultivar Marli, and concluded that summer pruning significantly enhanced red color of peaches, an effect not observed in the present work.

Results of fruit ground color measured with the colormeter are not significantly different with regards to lightness (L^* value) and chroma, in every harvesting season and storage period (Figure 2). Hue angle was only different after three more days of ripening at 20°C, after harvest (Figure 2 D).

Fruit size and weight did not differ over the evaluation period (Tables 1 and 3). Fruit weight varied from 108,5 to 123,1 g. Fruit diameter was about 6 cm. These values indicate a relative small fruit and are below the potential of the cultivar.

Peaches of the 2000 and 2001 seasons, harvested from IFP trees, were firmer than CFP peaches (Figure 3 A and C), and along the storage periods fruit firmness diminished constantly. In the year 2002, peaches

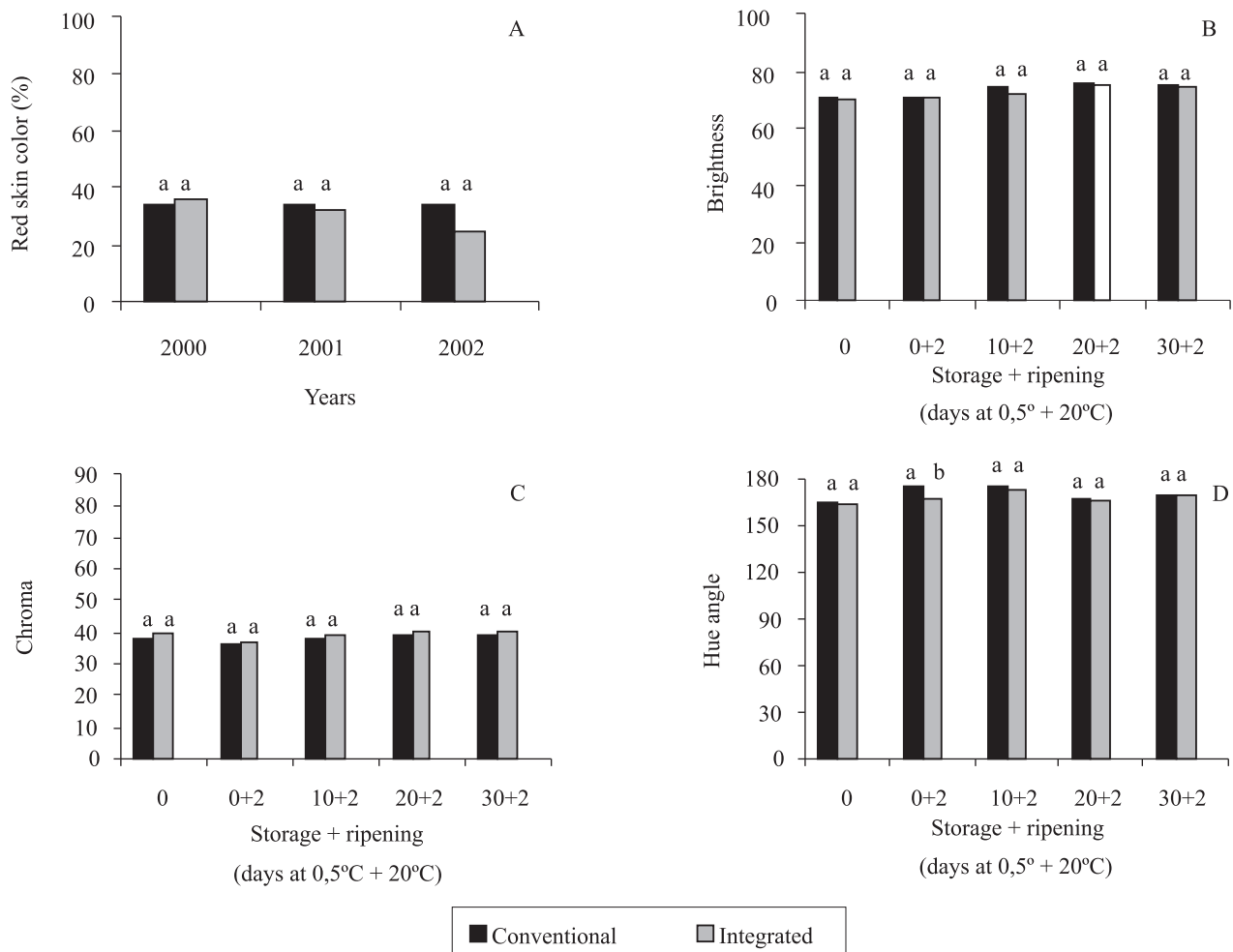


Figure 2. Average percentage values for red skin color, over the evaluation seasons (A), brightness (B), chroma (C) and Hue angle (D) of 'Marli' peaches managed in the integrated and conventional production systems only for the 2001 season (B, C, D).

were less firm in comparison to previous seasons. In that season, there were significant differences in flesh firmness between IFP and CFP peaches, only after 20 days of storage of 0.5°C. Firmness ranged between 40 and 50N (Figure 3 E).

During the ripening periods, after storage in 2000 and 2001, firmness decreased and peaches of both production systems reached adequate flesh firmness values (Figure 3 B and D). In 2002, only after 10 days of cold storage plus two more days at 20°C, peaches reached eating firmness of about 5N (Figure 3 F).

Soluble solids varied only a little between production systems along evaluation periods (Table 3). Same results had been observed by Nunes et al. (2004), who worked with the same cultivar also harvested from integrated and conventional production systems. With regards to titratable acidity, peaches harvested in 2000 and 2001 from the IFP system were more acid than CFP fruits (Table 3). In the following season, no significant differences in acidity were determined.

Lower soluble solids contents and higher titratable acidity of IFP peaches, in the 2000 season, probably resulted from less ripe fruit. Over the whole evaluation period, IFP peaches were a little less ripe at harvest, when compared to CFP peaches. An effect confirmed also through flesh firmness values, although the peaches were harvested always on the same days. Differences in orchard management, derived from production systems, might affect ripening processes and result in the observed quality differences.

Injuries resulting from low temperatures were observed in every season (Table 4). Different expressions of chilling injuries, such as flesh browning, flesh bleeding, woolliness and leatheriness were observed. Flesh browning occurred in peaches of both

production systems, in the 2000 season and in all fruits with rot development. In the last evaluation season, injuries were less intense. Intensity of damages was low, except for 30 days of cold storage plus two or three more days at 20°C.

Browning in fruits is an oxidative process, catalyzed by polyphenoloxidases, in which phenolic compounds are oxidized and polymerized to brown pigments (Artés et al., 1998). These phenolic compounds are the first defense line, responsible for fruit resistance to pathogen attack, and a degree of tissue resistance is believed to be dependent of the amount of phenolic compounds oxidized by phenolases (Carbonaro & Mattera, 2001). Amiot et al. (1995) mentioned that agrochemicals could modulate phenolics biosynthesis, and according to that, browning intensity of 'Marli' peaches of the IFP system, in the 2002 season, might be related to higher amounts of phenolics derived from less agrochemical sprays.

Red flesh around the kernel was high from the beginning of the evaluations, though dropped off with longer storage periods (Table 4). Fernández-Trujillo et al. (1998) indicated that redening of the flesh precedes flesh browning. Guelfat-Reich & Bem-Arie (1966) mentioned the same effect. However, Crisosto et al. (1999) worked with 'Summer Bright' and 'Summer Fire' nectarines, and concluded that the presence of red flesh did not affect fruit flavor, and the disorder seemed to be more related to fruit ripening than to chilling injuries. The results of the present experiment corroborate Crisosto et al. (1999) remarks, because the red flesh presence had not influenced the eating quality of 'Marli' peaches and could be more related to the ripening process itself than to chilling injury symptoms.

The percentage of peaches with woolliness symptoms was low over the storage and ripening periods (Table 4).

Table 3. Weight, diameter, soluble solids (SS) and titratable acidity (TA) of 'Marli' peaches harvested from integrated and conventional production systems, during three years, and cold stored for 30 days at 0.5°C (CS), plus two to three days in air at 20°C for ripening (R)⁽¹⁾.

Parameter	2000			2001			2002		
	CFP	IFP	CV (%)	CFP	IFP	CV (%)	CFP	IFP	CV (%)
Weight (CS)	108,5b	115,3a	5,1	121,0a	114,6a	7,4	123,1a	117,9a	6,0
Diameter (CS)	6,0b	6,2a	1,4	6,2a	6,1a	2,7	6,0a	6,0a	5,8
SS (CS)	12,0a	10,8b	2,5	10,7a	10,4a	4,0	11,5a	11,3a	5,4
SS (R)	12,9a	11,3b	2,2	10,6a	10,4a	3,9	11,3a	11,0a	7,3
TA (CS)	0,17b	0,19a	8,5	0,23b	0,25a	7,8	0,27a	0,29a	13,0
TA (R)	0,23b	0,30a	10,7	0,28b	0,31a	7,8	0,25a	0,22a	15,2

⁽¹⁾In each parameter, same letter in line, in each year of production, have no significant difference by Tukey test at 5% probability; CV: coefficient of variation.

High flesh firmness values, close to 30N, did not facilitate the determination of the disorder. Moreover, high firmness of peaches, transferred to air after 20 or 30 days of cold storage, could well characterize another chilling

injury symptom, which is mainly known as leatheriness. A corky flesh and the peaches inability to loose flesh firmness, after retrieval from cold storage after 20 or 30 days at 0.5°C, are clear indications of injured tissues.

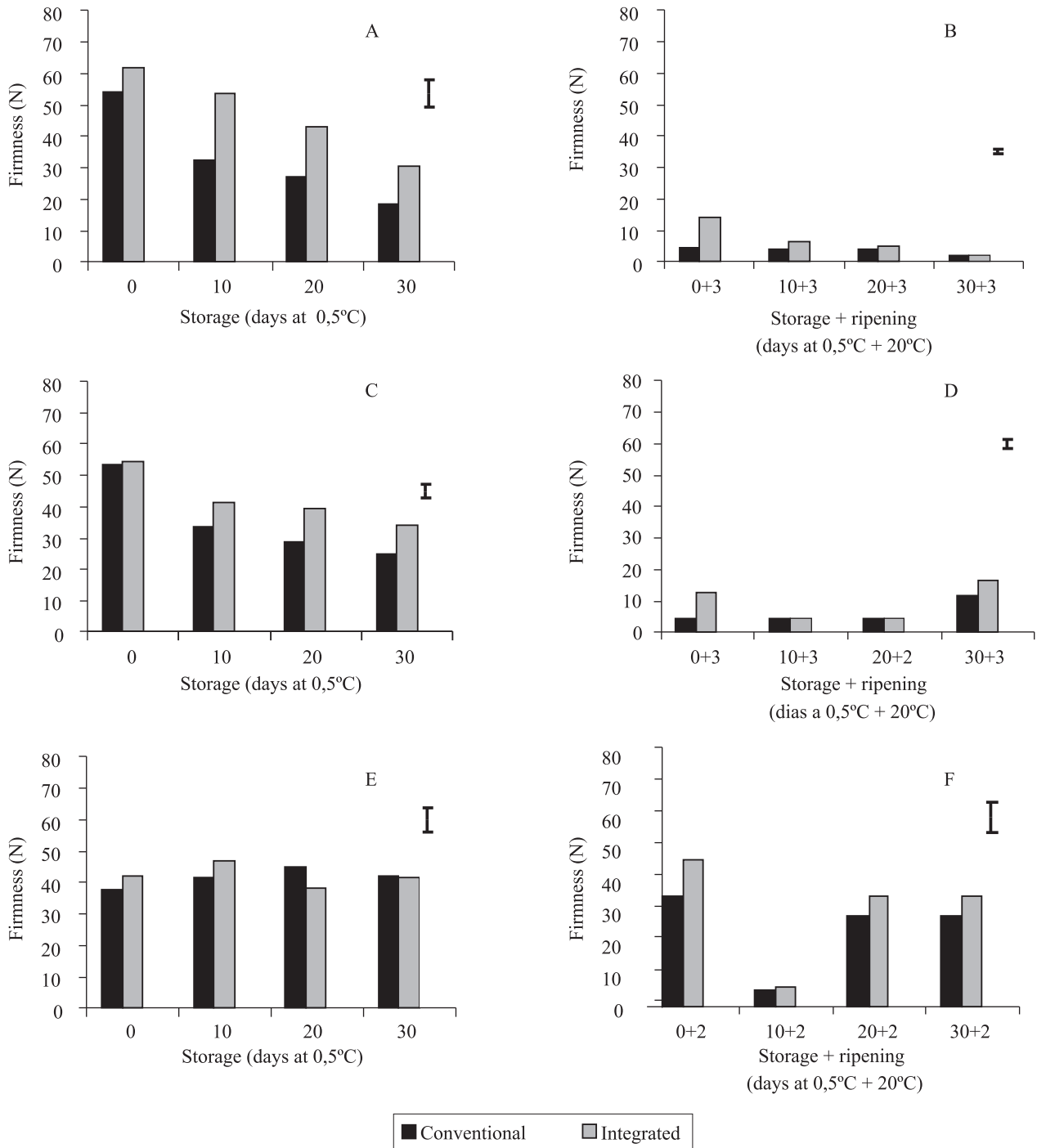


Figure 3. Flesh firmness of 'Marli' peaches harvested from integrated and conventional production systems in three years, 2000 (A and B), 2001 (C and D) and 2002 (E and F), after 30 days of cold storage at 0.5°C, plus two or three days of ripening at 20°C. Vertical bar indicates the least significant difference.

Table 4. Chilling injuries of 'Marli' peaches harvested from integrated and conventional production systems, after up to 30 days in refrigerated storage at 0.5°C, plus two or three more days in air at 20°C for ripening⁽¹⁾.

Days at 0,5°C and 20°C	Browning				Redenish				Woolliness		Leatheriness	
	2000		2002		2001		2002		2002		2002	
	CFP	IFP	CFP	IFP	CFP	IFP	CFP	IFP	CFP	IFP	CFP	IFP
0 + R ⁽²⁾	0,0a	0,0a	0,0a	0,0a	33,3a	26,7a	20,0b	53,3a	0,0a	0,0a	0,0a	0,0a
10 + R	0,0a	0,0a	0,0a	0,0a	33,1a	20,0a	13,3a	33,3a	0,0a	0,0a	0,0a	0,0a
20 + R	0,0a	0,0a	0,0a	0,0a	20,0a	13,3a	26,7a	0,0a	0,0a	0,0a	55,5a	66,6a
30 + R	81,3a	77,7a	5,6a	27,8a	0,0a	0,0a	0,0a	0,0a	5,6a	0,0a	50,0a	72,2a

⁽¹⁾Values followed by the same letter in lines, in each chilling injury symptom and year, do not differ significantly by Tukey test at 5% probability.

⁽²⁾R: 3 days at 20°C in 2000 and 2001, and 2 days in 2002.

Luchsinger (2000), however, mentioned that temperature at 0°C produces a strong inhibition of flesh firmness breakdown, as a result of reduced ethylene synthesis, which delays woolliness symptoms. Ju et al. (2000) indicate that firmness retention in peaches occurs only with firmness values of more than 40N. In the present work, firmness values of that level in 'Marli' peaches showed symptoms of firmness retention.

Increases in roted peaches and incidence of chilling injuries after 20 days should be indicative as the maximum cold storage period at 0.5°C for 'Marli' peaches either for the IFP or the CFP system. Market life of 'Marli' peaches, over the three years of evaluation, was influenced in every year by a different condition. In the first season, higher incidence of decay was the major cause for discarded fruits. In the last season, chilling injuries together with decay were responsible for diminished market life.

Conclusions

1. Production of peaches, in an integrated fruit production system, does not result in lower fruit quality in comparison to the conventional production system.

2. Besides having no quality differences, the occurrence of physiological disorders is also similar amongst both production systems.

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