Ripening patterns of South African export 'Hass' avocado hold-back samples from commercial 1-methylcyclopropene (SmartFresh^{SM}) applications

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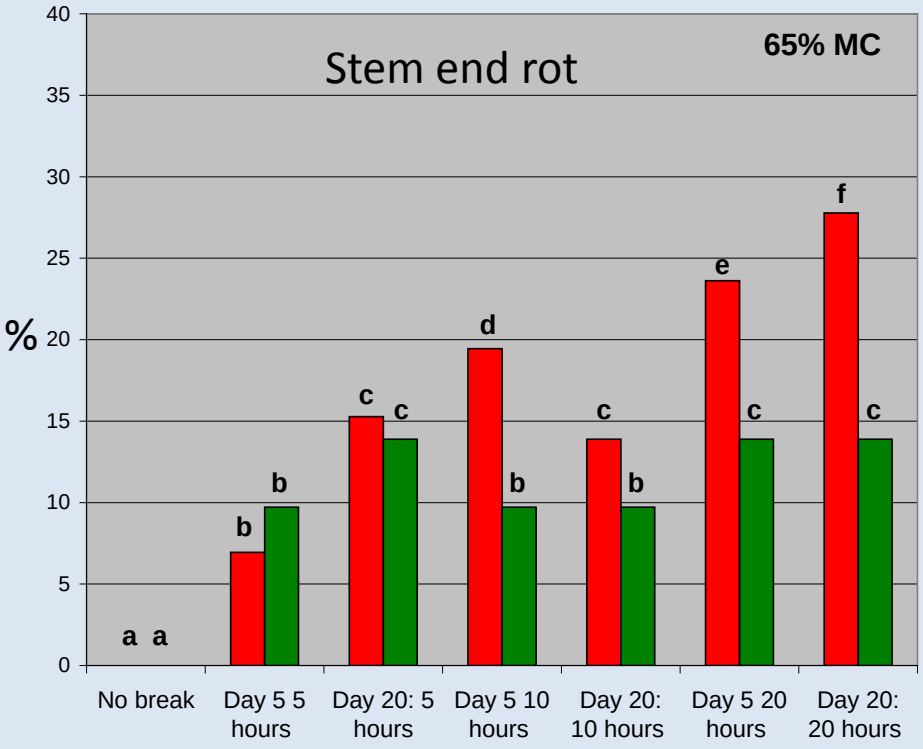
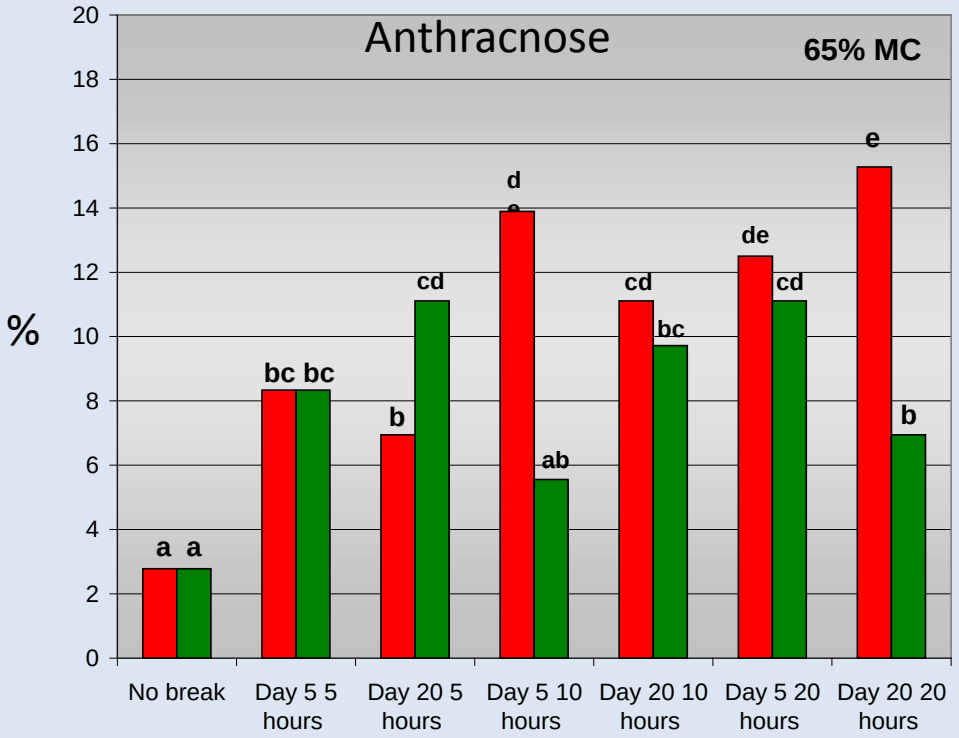

Stem end rot
65% MC
%
40
35
30
25
20
15
10
5
0
a a
b b
c c
d b
c b
e c
f c
No break
Day 5 5 hours
Day 20: 5 hours
Day 5 10 hours
Day 20: 10 hours
Day 5 20 hours
Day 20: 20 hours


Anthracnose
65% MC
%
20
18
16
14
12
10
8
6
4
2
0
a a
bc bc
b cd
d
e ab
cd bc
de cd
e b
No break
Day 5 5 hours
Day 20 5 hours
Day 5 10 hours
Day 20 10 hours
Day 5 20 hours
Day 20 20 hours

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COMMERCIALIZATION OF SMARTFRESH℠ (1-METHYLCYCLOPROPENE; 1-MCP) IN THE SOUTH AFRICAN AVOCADO INDUSTRY

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Abstract

The plant growth regulator 1-methylcyclopropene (1-MCP), marketed as SmartFresh℠ (Agrofresh Inc, USA), is a widely registered ethylene inhibitor used to delay the ripening of fruit. It is used worldwide to retain the quality of certain fruit types of which apples is the most important. In contrast with apples, the commercialization of SmartFresh℠ in avocados proved to be quite complicated. South Africa was the first avocado exporting country to successfully commercialize this new technology. This article deals with commercialization trials conducted with South African export avocados during the 2000 to 2008 avocado export seasons. Reference is also made to current research being conducted to upgrade the technology.

Introduction

1-Methylcyclopropene (1-MCP) is an ethylene inhibitor that binds to the ethylene receptors of plant cells and slows down the ripening of certain fruit types such as apples, pears, plums, tomatoes, persimmons and melons (Watkins, 2006). The compound is used at low rates, has a non-toxic mode of action, is chemically related to naturally occurring substances and was approved by the United States Environmental Protection Agency (Anonymous, 2002). Commercialization on edible crops was undertaken by AgroFresh, Inc., a subsidiary of the Rohm and Haas Company (Philadelphia, PA), under the trade name SmartFresh℠.

Worldwide SmartFresh℠ is used to retain the quality of, especially, apples during storage (Watkins, 2006). Although a number of research studies demonstrated that SmartFresh℠ effectively slows down the ripening of avocados (Feng et al., 2000; Hofmann et al., 2001; Jeong et al., 2002; Maré et al. 2002; Jeong et al., 2003; Hershkovitz et al., 2005; Adkins et al., 2005 & Woolf et al., 2005) commercialization proved to be quite complicated. South Africa was the first avocado production country to successfully commercialize the new technology. In this paper, the various trials performed during the commercialization process are dealt with in chronological order as from 2000 to 2008. Reference is also made to assistance rendered to other avocado export industries as well as research currently being conducted to further upgrade the technology.

Laboratory based trials conducted during the 2000 and 2001 seasons

The initial laboratory based commercialization trials were commissioned by Rohm and Haas in 2000 when a powder formulation of SmartFresh℠ (SmartFresh℠, active ingredient: 0.14%) was applied at rates of 0, 225, 500 and 1000 nl l-1 to the 'Fuerte', 'Pinkerton', 'Hass', 'Edranol' and 'Ryan' cultivars (Lemmer et al., 2002; Lemmer & Kruger, 2003). The experimental samples were all within the prescribed South African Avocado Growers' Association (SAAGA) export maturity guidelines (Bekker et al., 2008). All applications were made at both 5 and 10°C for 25 hours so as to establish to what extent the effectiveness of the application is influenced by application temperature. The fruit were stored for 26 days at 6°C after which they were ripened at room temperature. The mean number of days required to ripen each fruit (DTR) was recorded whereafter it was dissected and a detailed quality evaluation performed.

The results indicated that the SmartFresh℠ treatment causes slower ripening during the shelf life phase (Lemmer et al., 2002; Lemmer & Kruger, 2003). The study further showed that the sensitivity of the 5 cultivars varied in a dose related manner. 'Hass' responded least while the DTR of 'Ryan' was lengthened most by the treatment. The responses of the other 3 cultivars ('Fuerte', 'Edranol' and 'Pinkerton') were intermediate. Follow up trials performed during subsequent seasons (Lemmer & Kruger, 2004) has shown that the inhibitory effect on 'Pinkerton' ripening is actually more comparable to 'Ryan' than to 'Edranol' and 'Fuerte'. The observations tie in with previous respiration rate studies which showed that, of the 5 cultivars, 'Hass' has the highest respiration rate and 'Ryan' the lowest (Kruger, 1996), indicating that 'Hass' naturally ripens fastest and 'Ryan' slowest of the tested cultivars.

In four of the five cultivars, the application temperature did not significantly influence the effectiveness of the SmartFresh℠ application (Lemmer et al., 2002; Lemmer & Kruger, 2003). However, with the 'Ryan' cultivar, fruit treated at the higher application temperature took longer to ripen. This observation is probably related to the above respiration rate and SmartFresh℠ sensitivity results. (Since the binding process of the SmartFresh℠ to the receptors is a biochemical reaction, the higher application temperature may result in more effective binding.) Follow-up trials performed during subsequent seasons have shown that too large increases in DTR occur when the SmartFresh℠ is applied at room temperature (Lemmer & Kruger, 2004). Commercially, SmartFresh℠ is thus applied after the fruit have been cooled to the holding temperature, which is usually between 4 and 7°C depending on the cultivar and maturity of the fruit.

The SmartFresh℠ treatment did not affect the synchronization of pulp softening and skin darkening. Neither did it influence the incidence of certain physiological disorders such as external chilling injury (CI) and lenticel damage (LD). It did, however, significantly decrease the incidence of a commercially important internal physiological disorder known as diffuse mesocarp discoloration (DMD), greypulp or internal chilling in-

Background/M&M

- The ethylene inhibitor 1-methylcyclopropene (1-MCP; SmartFresh^{SM}) has been used since **2003** as a tool to retain the quality of South African avocados.
- The applications are mostly done in custom built **application rooms** and **collapsible tents** designed for the purpose. A percentage of applications are also performed in **shipping containers**.
- The **containers** are either parked at the **packinghouse** for the duration of the packing season **or** the application is performed ***en route*** to the harbour.
- With the exception of the latter scenario, it is possible to retain **hold-back samples** for quality control purposes.
- One carton each of control and 1-MCP treated fruit is usually **ripened** at **room temperature directly after the application** to establish whether the application was successful or not.
- A **second set** of cartons is often **stored for 30 days at ±5°C** before being **ripened at room temperature**.
- This presentation deals with the **ripening patterns** of **'Hass'** avocado fruit from **tent** applications made at three packinghouses during the **last 3 seasons**.


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Packinghouse locations

Mean number of days to ripen (M-DTR)

Packing-house	Season	M-DTR* (days)					
		Direct ripening			After 30 days storage		
		Number of applications	Treatment		Number of applications	Treatment	
			Control	1-MCP		Control	1-MCP
Kiepersol 1	2010	15	19.7 bc	24 a**			
Kiepersol 2	2010	41	18.2 c	21.3 ab			
Tzaneen	2008				48	10.7 b	12.5 a
	2009	28	14.7 d	18.3 c	25	10.4 b	13.1 a
	2010	56	13.7 d	12.8 d	53	10.5 b	9.4 c

First fruit to ripen (F-DTR)

Packing-house	Season	F-DTR* (days)					
		Direct ripening			After storage for 30 days		
		Number of applications	Treatment		Number of applications	Treatment	
			Control	1-MCP		Control	1-MCP
Kiepersol 1	2010	15	16.3 bc	20.6 a**			
Kiepersol 2	2010	41	14.6 d	17.6 c			
Tzaneen	2008				48	6.5 b	10.8 a
	2009	28	11.2 e	15.8 c	25	6.2 b	10 a
	2010	56	6.1 g	8.8 f	53	3.2 c	6.2 b

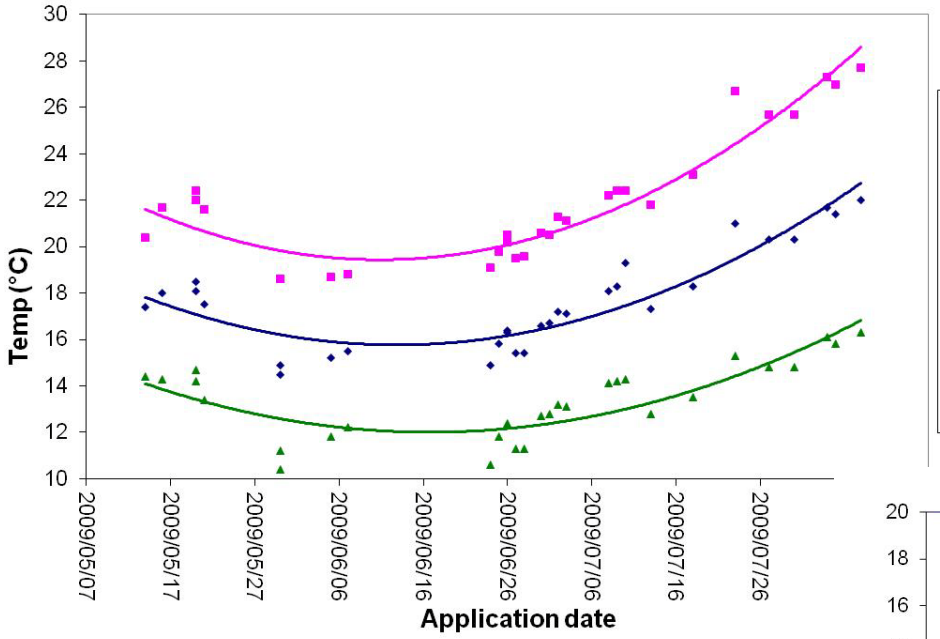
Last fruit to ripen (L-DTR)

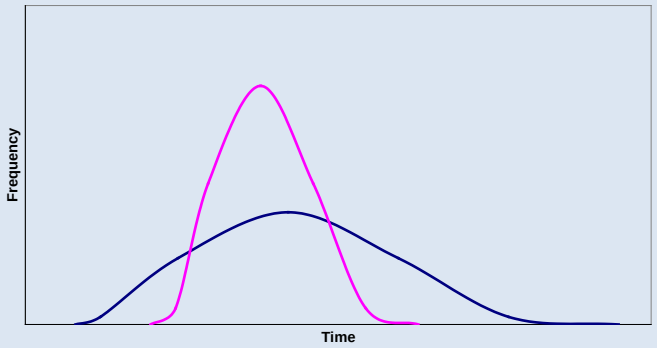
Packing-house	Season	L-DTR* (days)					
		Direct ripening			After storage for 30 days		
		Number of applications	Treatment		Number of applications	Treatment	
			Control	1-MCP		Control	1-MCP
Kiepersol 1	2010	15	24.1 ab	27.6 a**			
Kiepersol 2	2010	41	22.1 bc	25.2 a			
Tzaneen	2008				48	14.3 c	14 c
	2009	28	18.9 d	20.9 c	25	14.5 c	16.1 b
	2010	56	20.7 c	17.6 d	53	17.5 a	13.1 d

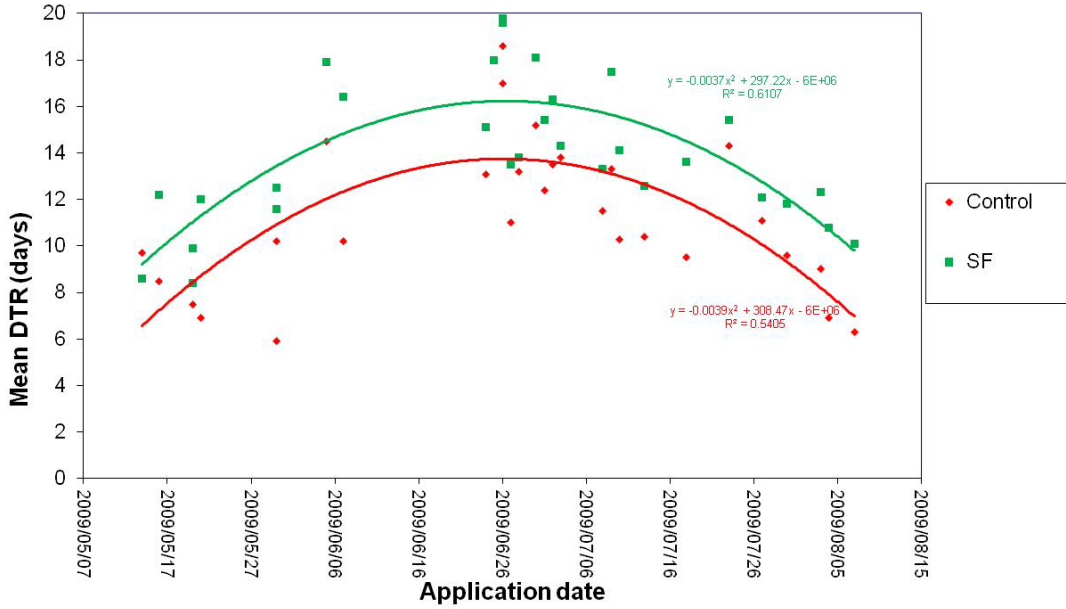
Mean standard deviation (M-STD)

Packing-house	Season	M-STD* (days)					
		Direct ripening			After storage for 30 days		
		Number of applications	Treatment		Number of applications	Treatment	
			Control	1-MCP		Control	1-MCP
Kiepersol 1	2010	15	2.4 c	2.1 c**			
Kiepersol 2	2010	41	2.4 c	2.3 c			
Tzaneen	2008				48	2.5 b	1.3 e
	2009	28	2.3 c	1.8 d	25	2.5 b	1.9 d
	2010	56	4.5 a	2.5 b	53	4.4 a	2.1 c

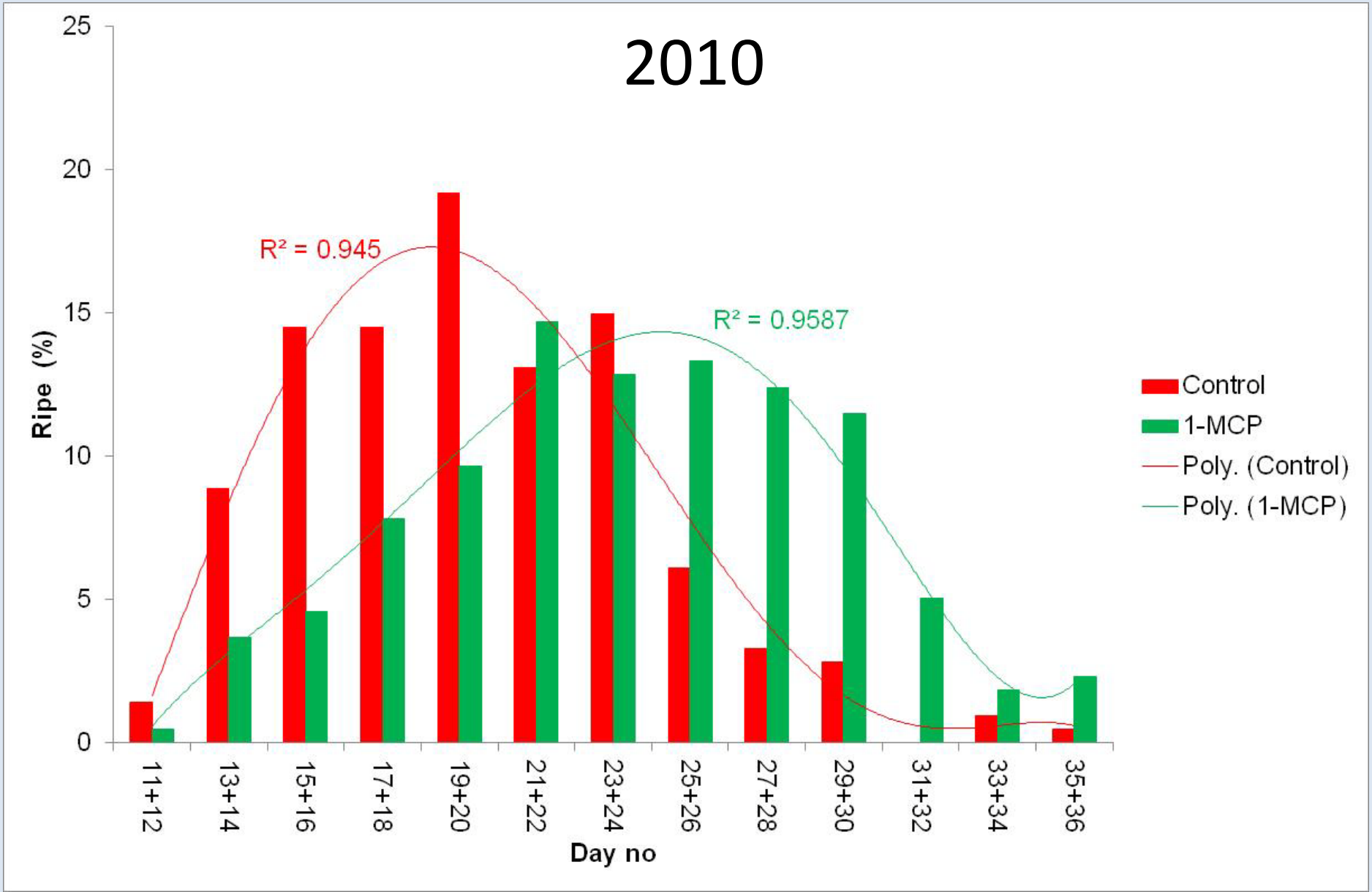
Effect of ripening temperature



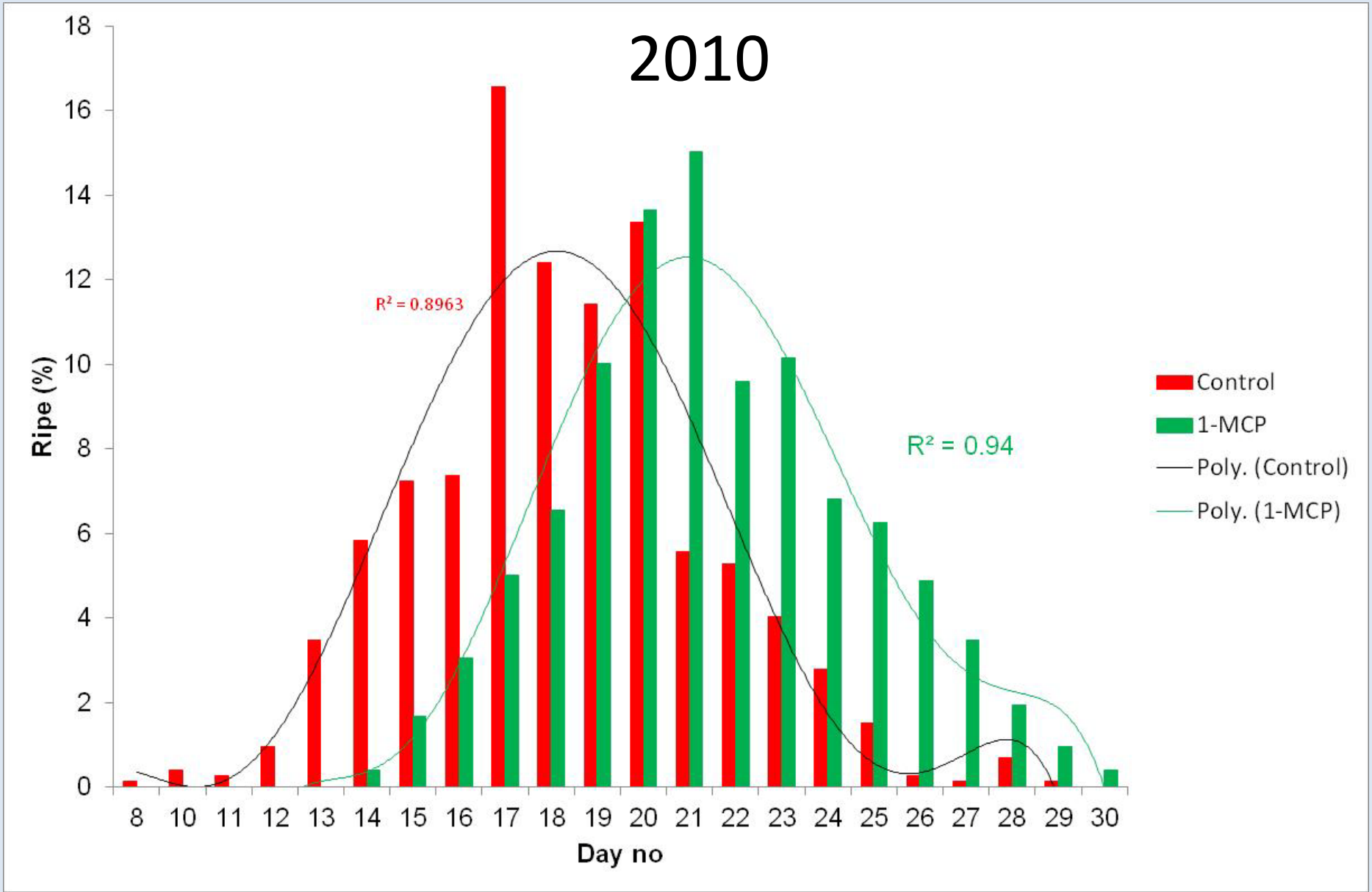




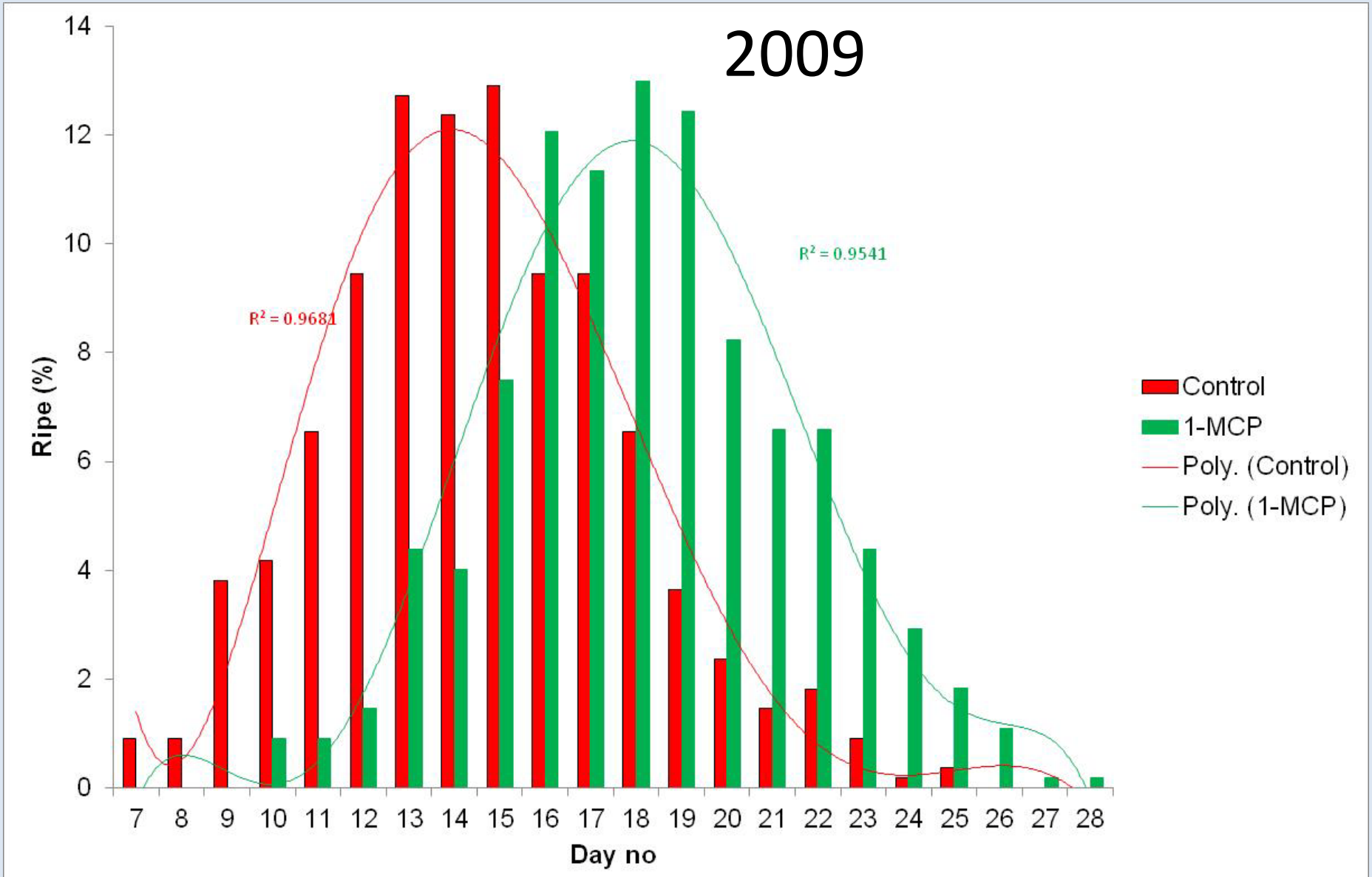
Direct ripening: Kiepersol Packinghouse 1



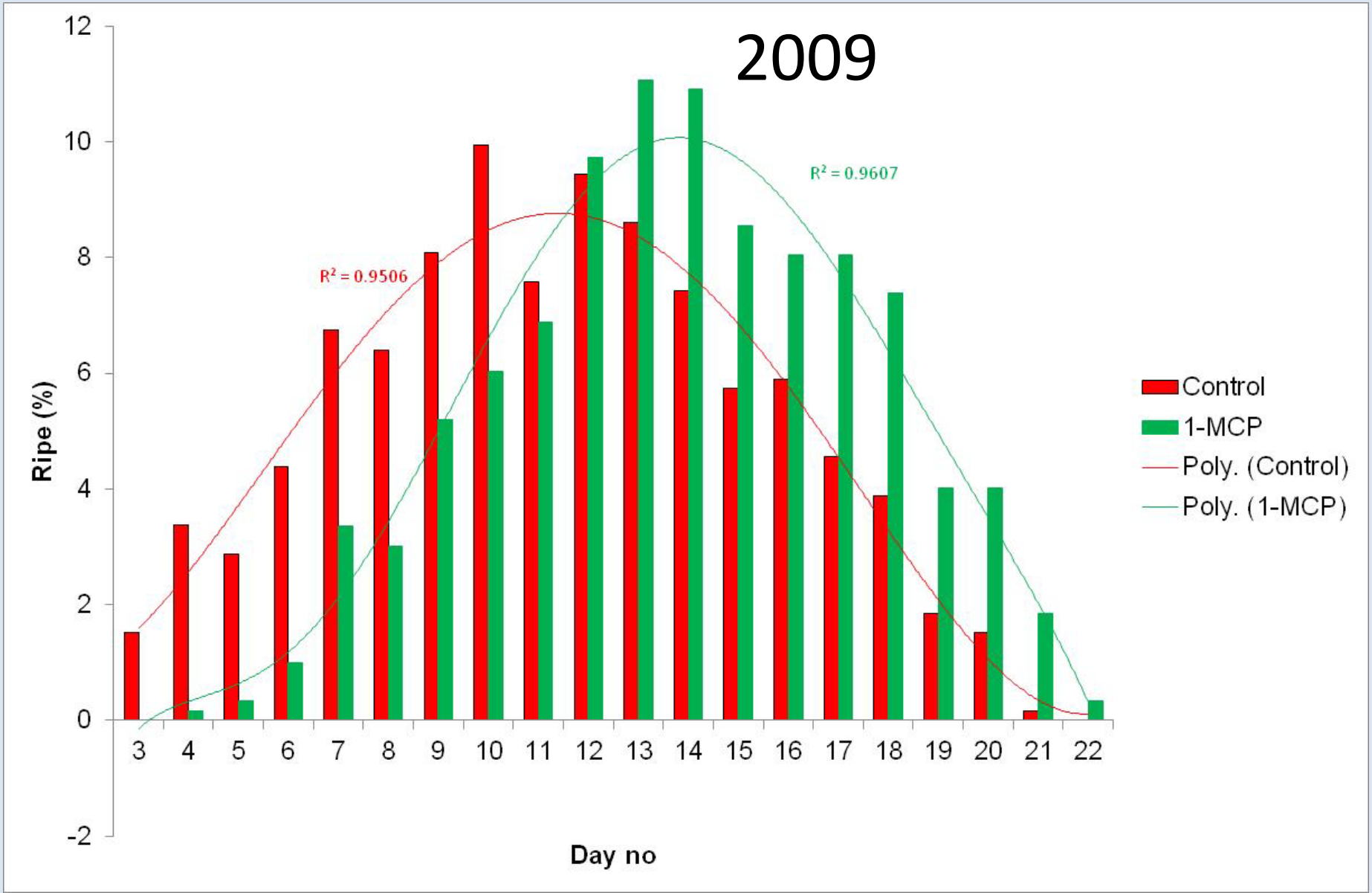
Direct ripening: Kiepersol Packinghouse 2



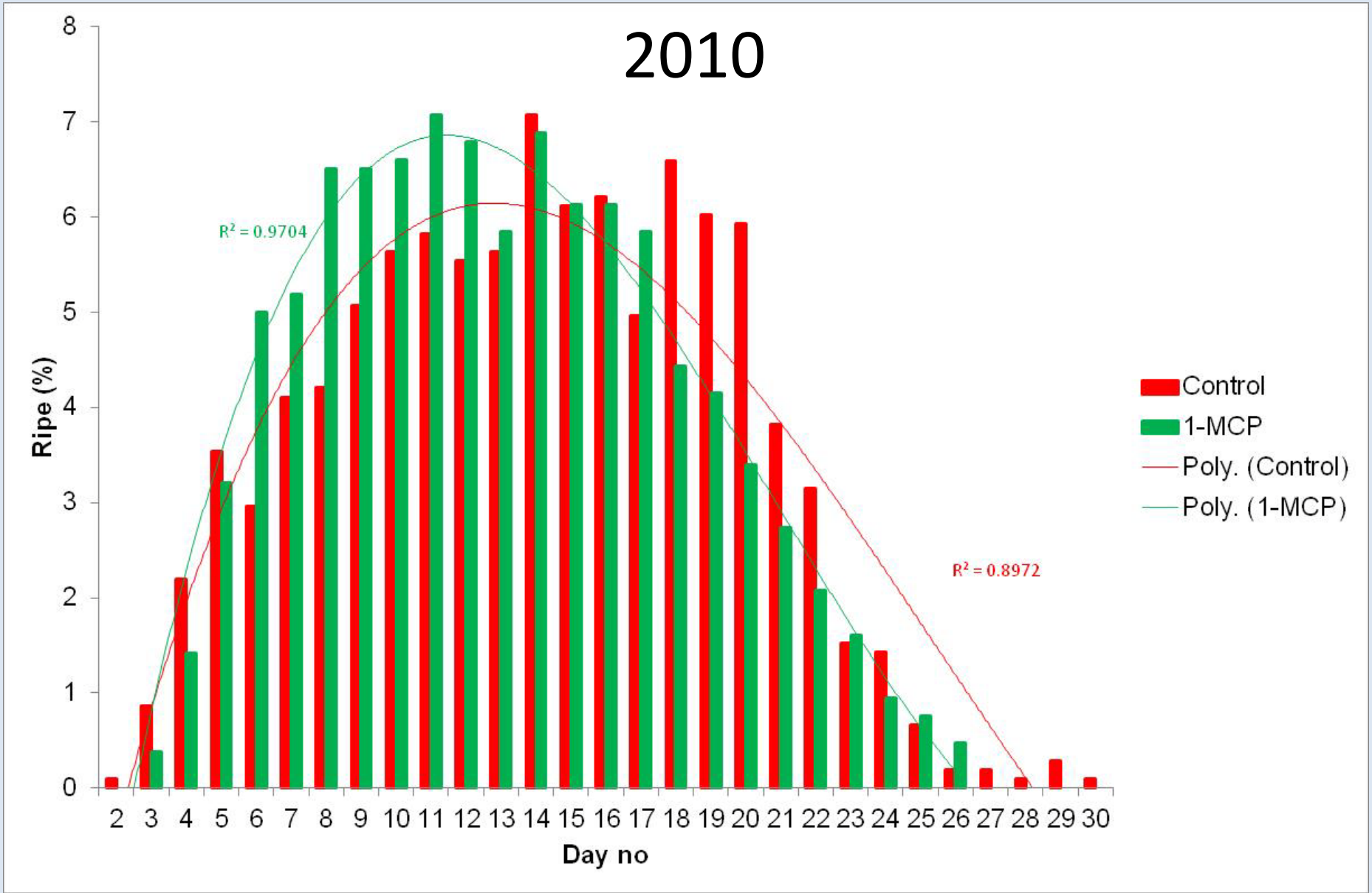
Direct ripening: Tzaneen Packinghouse



Post-storage ripening: Tzaneen Packinghouse

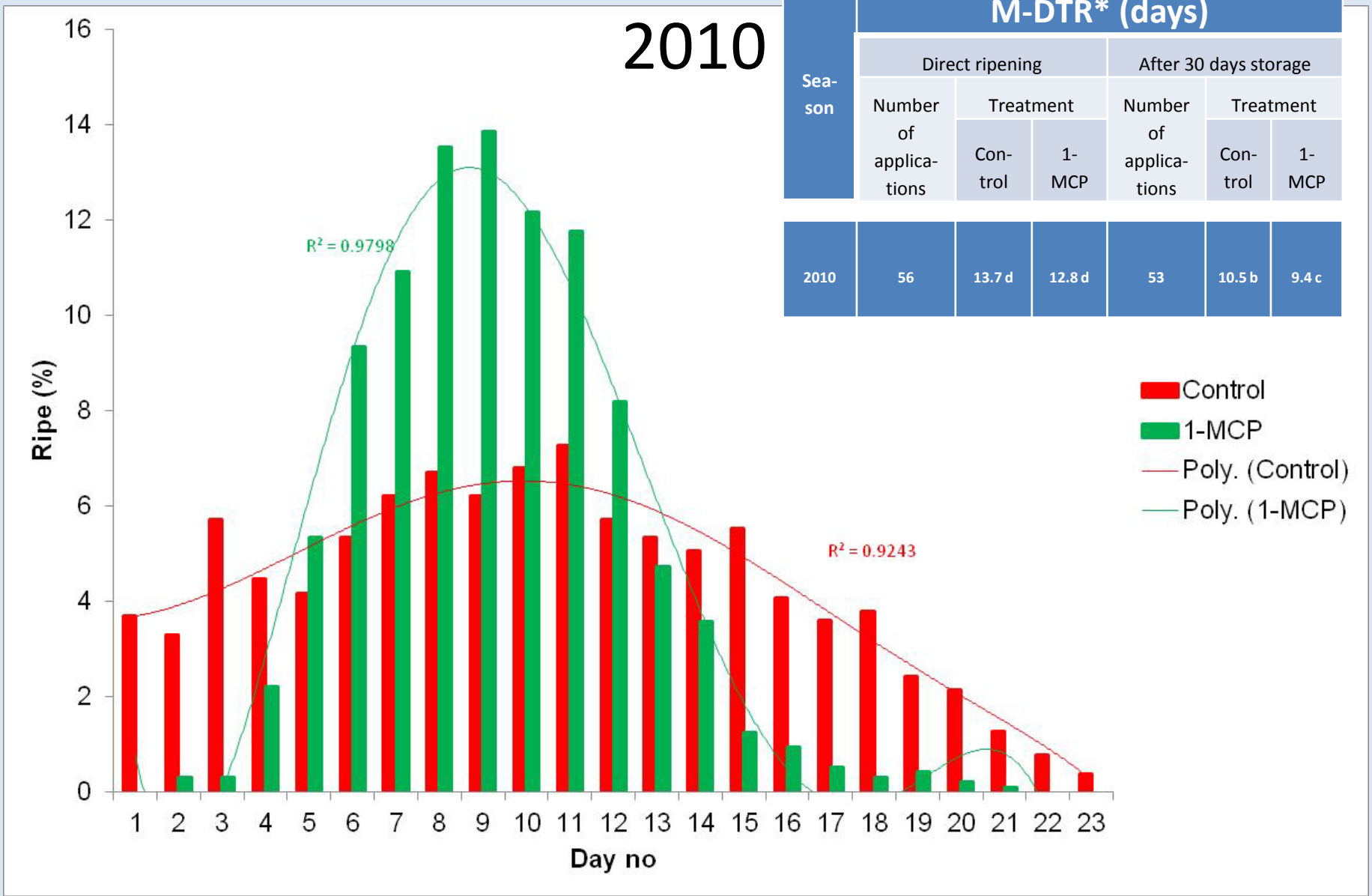


Direct ripening: Tzaneen Packinghouse

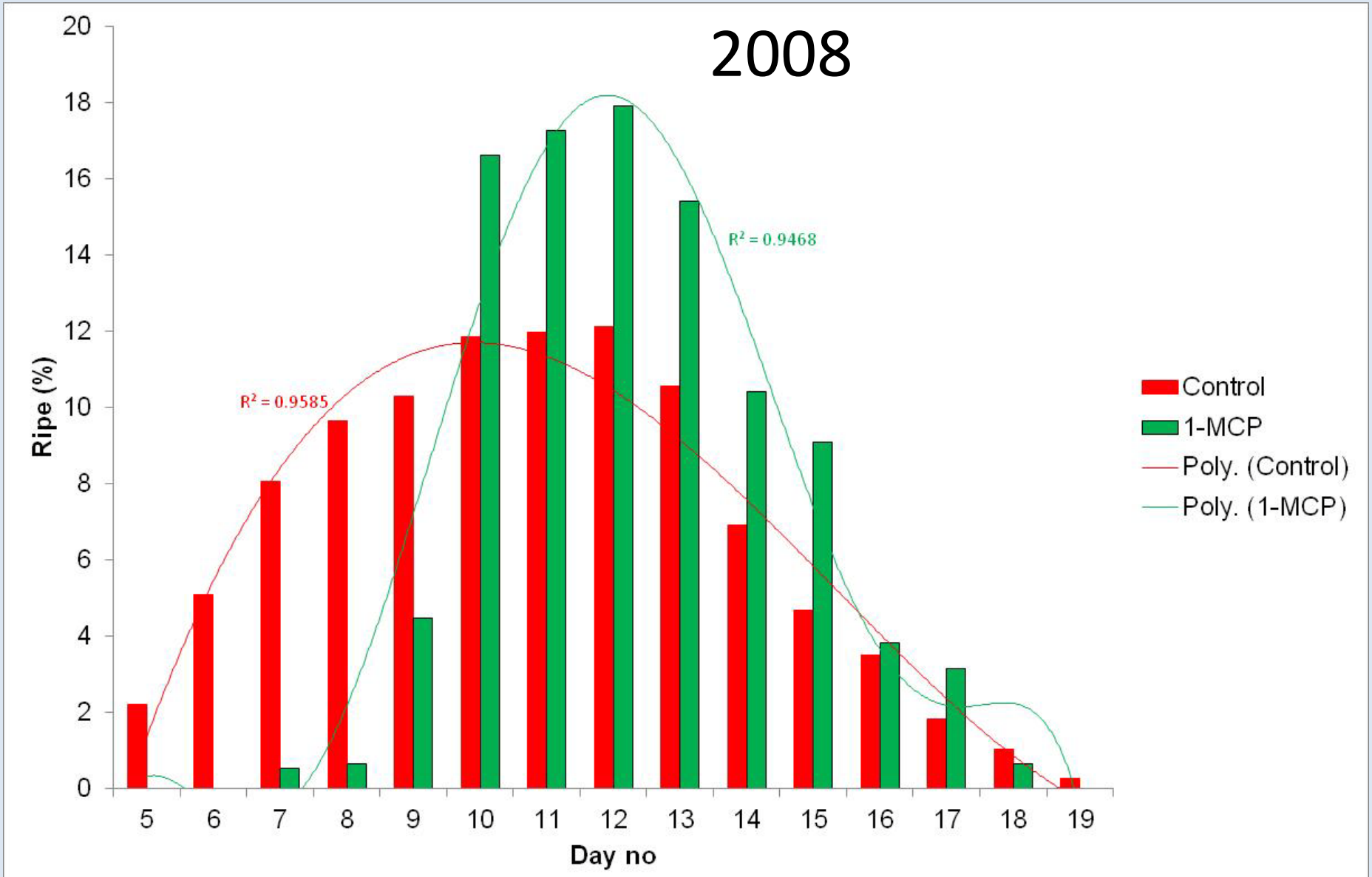


Post-storage ripening: Tzaneen Packinghouse

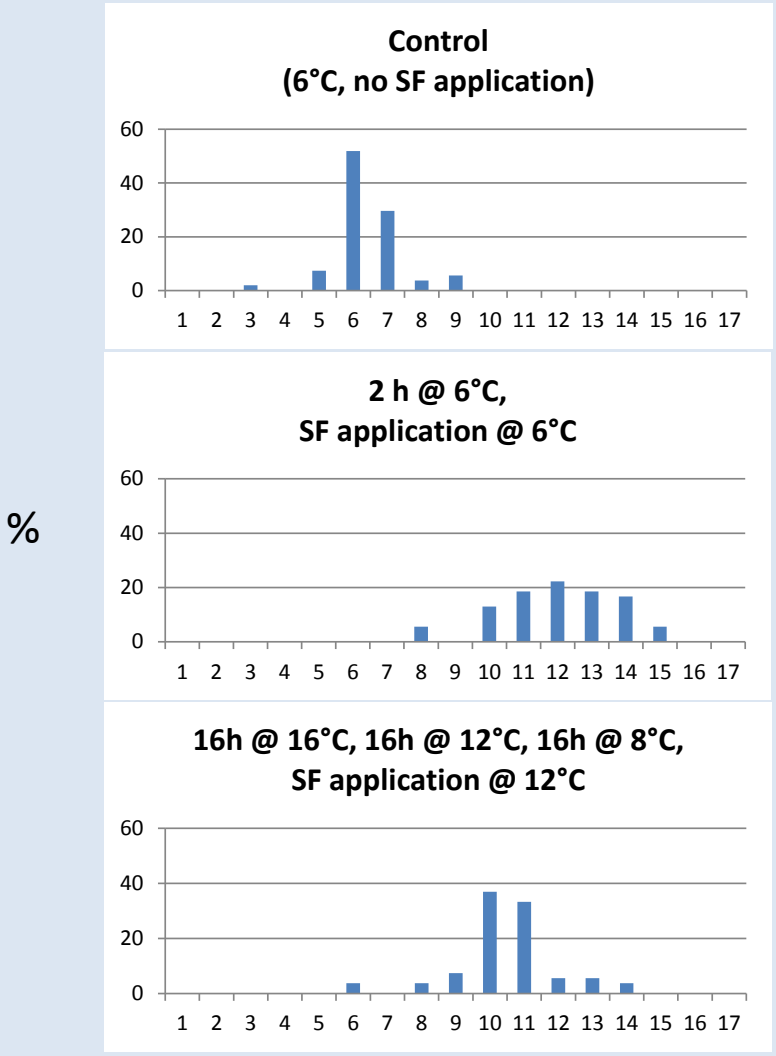
Season	M-DTR* (days)					
	Direct ripening			After 30 days storage		
	Number of applications	Treatment		Number of applications	Treatment	
		Control	1-MCP		Control	1-MCP
2010	56	13.7 d	12.8 d	53	10.5 b	9.4 c



Post-storage ripening: Tzaneen Packinghouse



Effect of application temperature



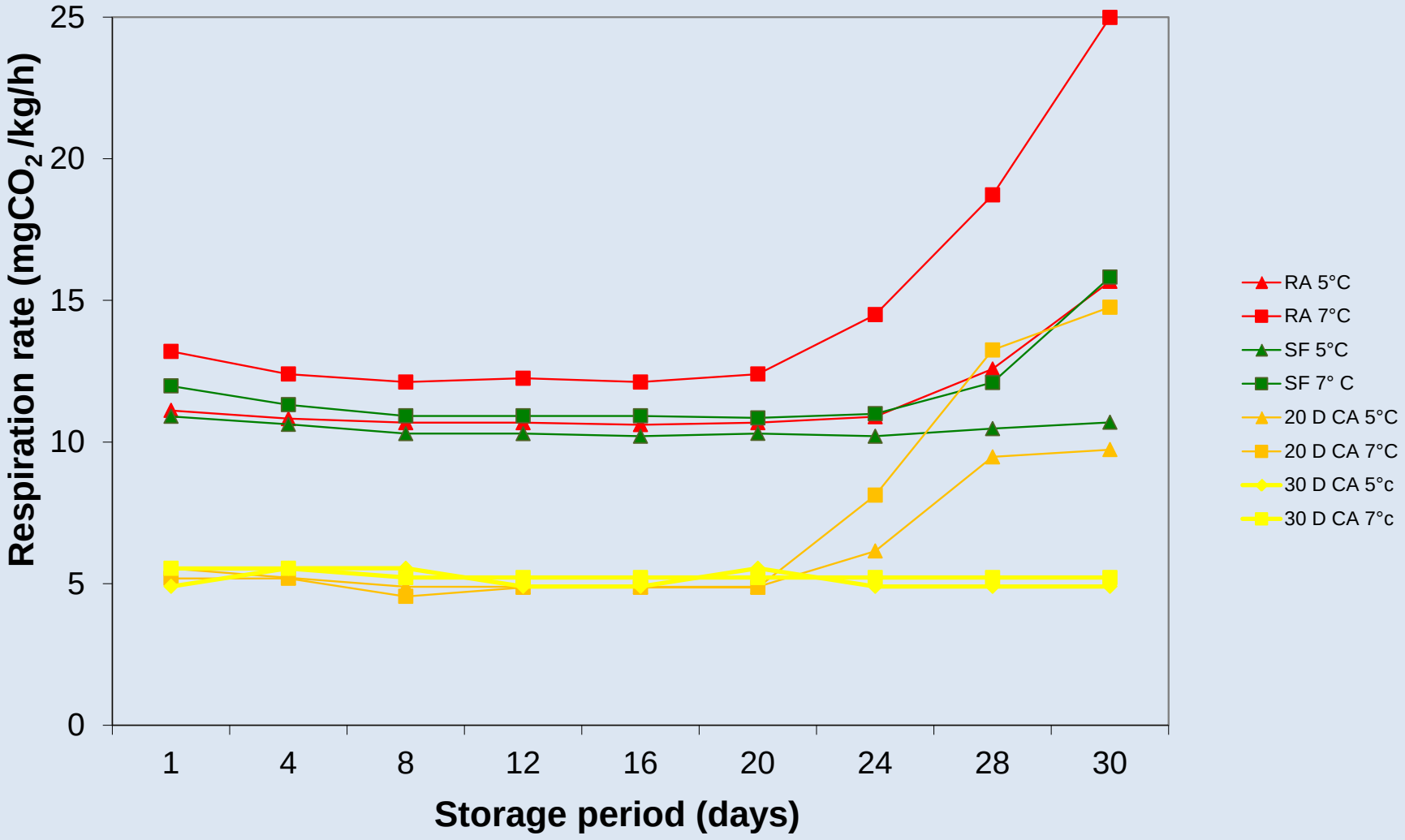
Effect of ripening temperature

Day No	Ripening room setting (°C)	Mean temp office (°C)	Min temp office (°C)	Max temp office (°C)
1	20.00	20.72	17.19	25.71
2	21.00	21.06	18.24	26.29
3	21.07	21.54	17.95	26.59
4	21.02	22.09	19.28	26.20
5	22.03	19.5	18.05	20.62
6	22.18	19.37	18.05	26.29
7	22.17	21.17	18.14	25.71
8	19.99	21.78	19.19	25.42
9	21.92	20.29	18.81	21.28
10	20.01	20.68	18.05	21.95
11	19.95	21.68	17.86	24.74
12	20.99	22.29	18.43	25.42
13	21.00	23.03	19.76	26.10
14	20.96	23.48	20.62	27.08
15	22.06	23.29	20.52	28.16
16	23.15	23.71	20.23	27.96
17	23.21	24.67	20.52	28.46
18	24.13	23.03	21.00	29.15
19	24.82	23.96	21.86	25.51
20	23.49	24.48	21.47	28.46
21	23.14	24.89	21.47	28.66
Ave.	**21.82**	**22.22**	**19.37**	**25.99**

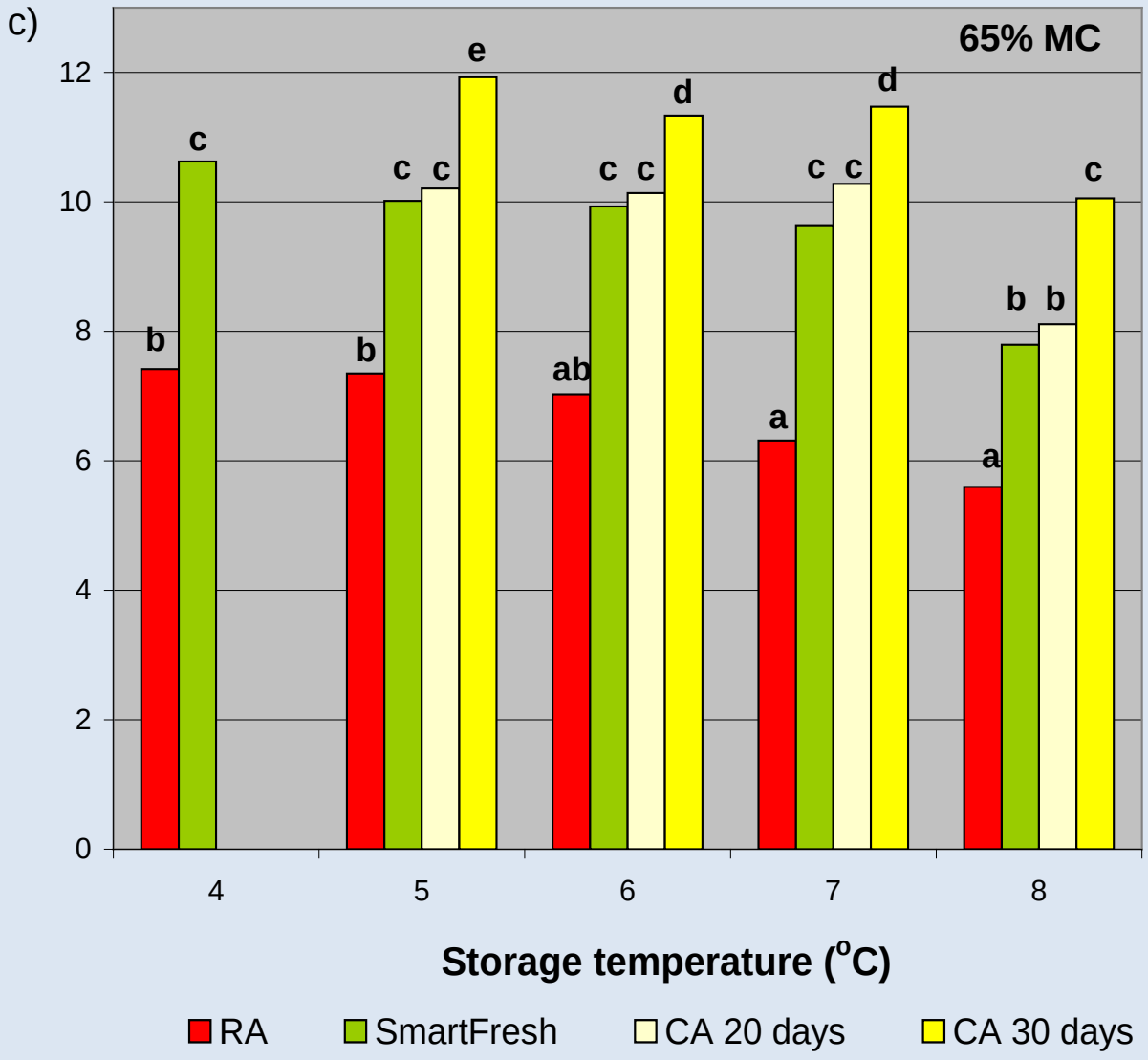
Treatment	Mean DTR (days)
Control: ripening room	14.1 a
Control: office	13.8 a
Smartfresh: ripening room	17.3 b
SmartFresh: office	16.7 b

Day number	Ripe fruit (%)			
	Control ripening room	Control office	SmartFresh ripening room	SmartFresh office
1				
2				
3				
4				
5	1.25	2.7		
6	2.5	2.7		
7				
8				
9				
10	1.25	10.81	3.84	
11	27.5	16.21	3.84	3.22
12	1.25			
13	12.5			
14	17.5	27.02	34.61	12.90
15				
16	7.5	10.81		22.58
17	16.25	5.40	17.30	22.58
18		24.32		38.70
19				
20	10			
21			32.69	
22				
23	1.25			
24	1.25		7.69	
25				

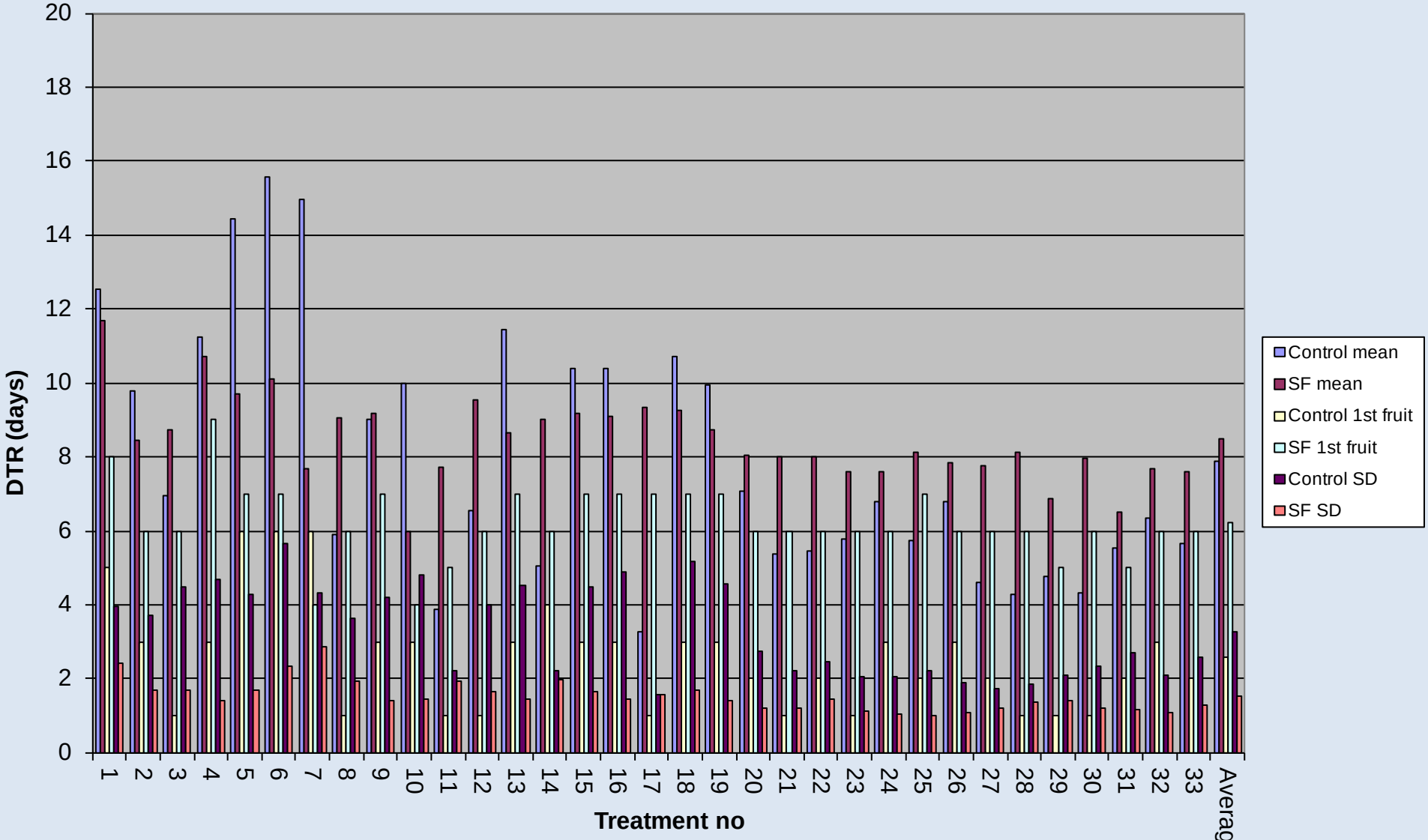
Respiration patterns



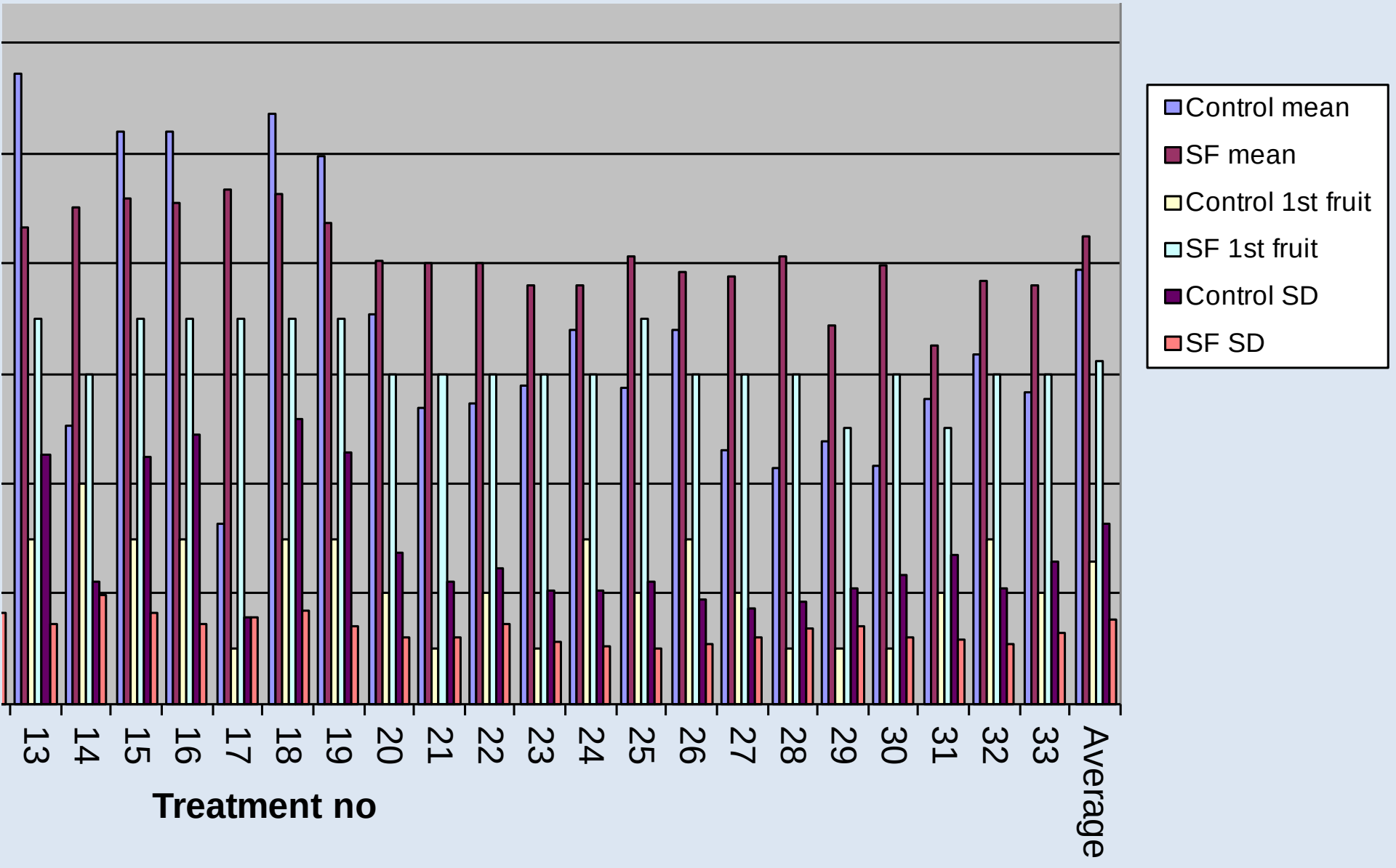
Days to ripen (m-DTR)



Ryan stored


DTR (days)
0
2
4
6
8
10
12
14
16
18
20
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
Treatment no
Control mean
SF mean
Control 1st fruit
SF 1st fruit
Control SD
SF SD

Ryan stored (continued)



Conclusions

- The results showed that a **fair amount** of **variation** occurred between packinghouses and seasons.
- However, in virtually all cases the **1-MCP** application **successfully slowed down** the **softening** rate of, especially, the **first fruit** in each sample to ripen.
- In **no** instance did the 1-MCP treatment **lengthen** the **range** of the combined seasonal ripening profile.
- Interestingly, in **certain instances** the ripening profiles of the **1-MCP** treatments were **more ripener/pre-packer friendly** than those of the regular atmosphere controls.
- The **trends** were **supported** by a **four year laboratory based study** during which the storage period related respiration rates of 1-MCP treated fruit were compared to those of control fruit that were stored under both regular and controlled atmosphere conditions.

Acknowledgements

- ARC
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- Afrupro Exporters
- Letaba Packinghouse
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- Koeltehof Packinghouse

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