Avocado oil from Kenya – maximising yield and quality of cold-pressed avocado oil

Allan Woolf

Guinevere I Ortiz and Marie Wong

PFR: Steve Green, Chris Clark, Bob Fullerton, Brent Clothier, John Campbell, Grant Thorp, Edouard Perie, Andrew Barnett, Dale Yi, Dave Billing (& a host of BLs etc! ☺)

Olivado: Mary Kosgey, Michael Gitahi, Moses Ngahu, Bridget Mwangi, Sarah Murigi, Frederick Mwangi

1.
Avocado oil background

Cold-pressed extraction

Ripe Avocado

Washing

Destoner

Remove skin & stone

Grinder

Malaxer

Pomace (solids)
& water phases

Decanter centrifuge

Water

Disc centrifuge

Storage & Bottling

Avocado oil background

- Supply: Generally relies on reject fruit from fresh fruit market, often for export
- Key problem is obtaining reliable supply
- Biennial bearing a significant problem in avocado
- Thus Olivado started in Kenya in 2008 where small subsistence farmers had fruit going to waste

2.
Overview of the MFAT program

Avocado Development Programme – KAISP

- Five-year New Zealand's Aid Programme implemented by the avocado oil company Olivado and Plant & Food Research, with a 4-year extension
- Aim is to delivery benefits to small farmers / households from sale of fresh avocados for the production of high quality avocado oil
- Fair trade and organic
- Before Olivado:
  - NZD 3-6 cents/kg - "Dog food"
- Currently–
  - ≈ NZD 17-56 cents/kg
- (Also carrying out fresh fruit export)

The people

» About 1,700 smallholder suppliers, mainly in the Kandara District of Kenya

They are:

» About 45% women farmers

» Farm size about 1 ha

» Around 24 avocado trees. Large, old trees that are poorly managed

» Plus 1-2 animals (cows and/or goats)

» As well as bananas, coffee (low zone), tea (high zone), macadamias ...

» Key challenges: soil health, tree management, pests & disease, post-harvest

3.
Various teams / delivery areas

Water can be scarce – irrigation not possible

Harvesting teams



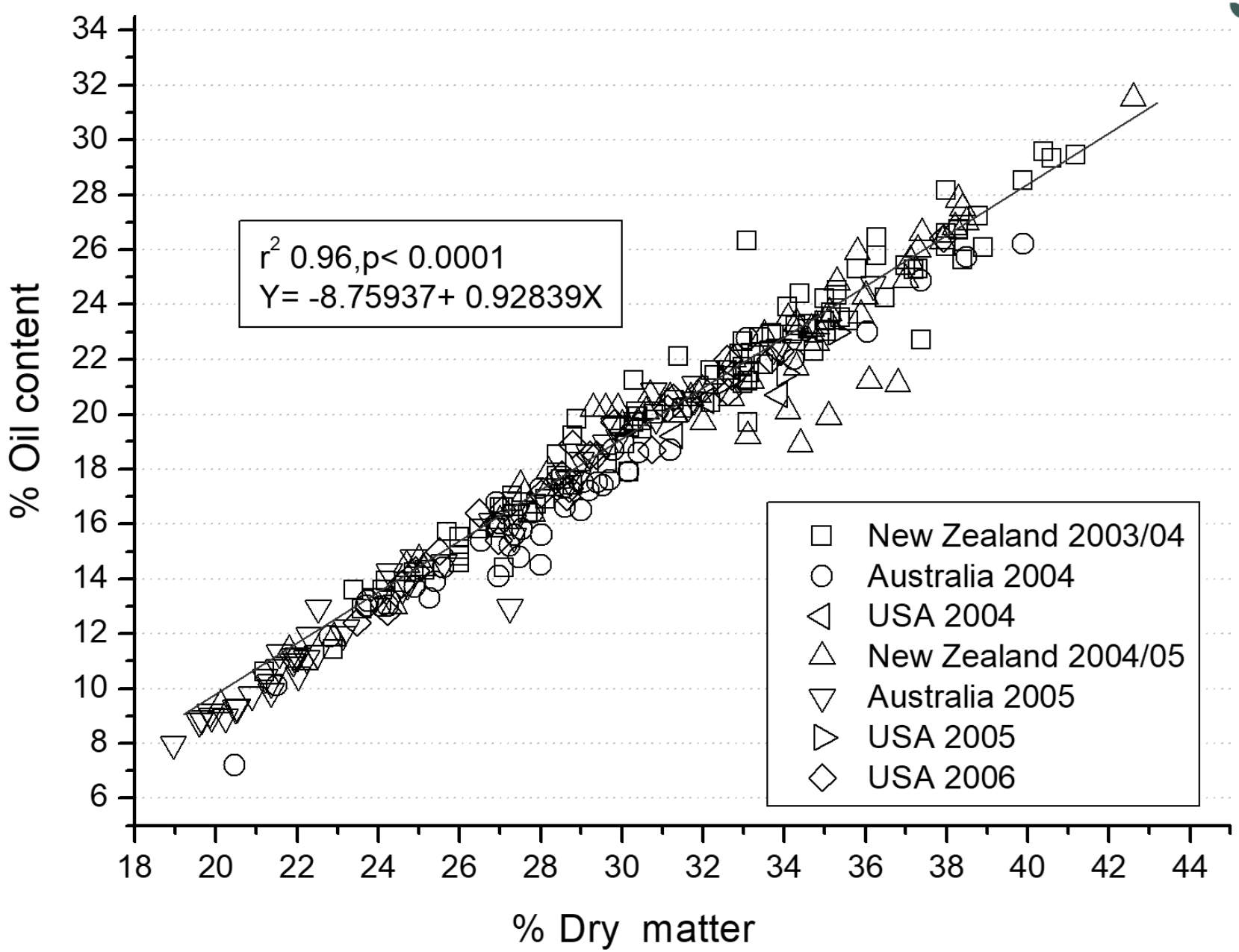

Training the trainers

4. Postharvest aspects

4A.
Maturity & harvest timing

Maturity (dry matter) vs oil content

- Highly correlated
- Independent of climate

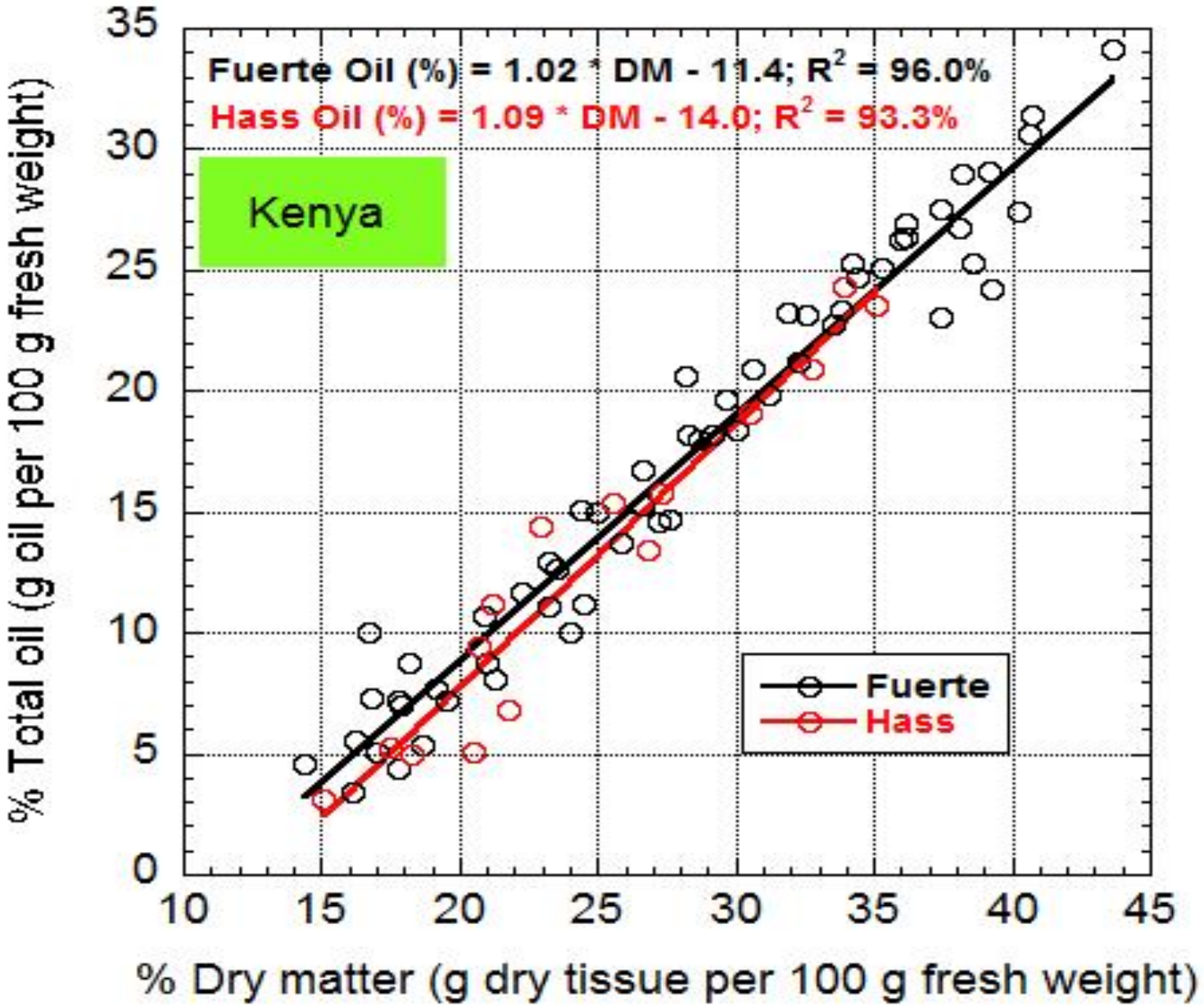


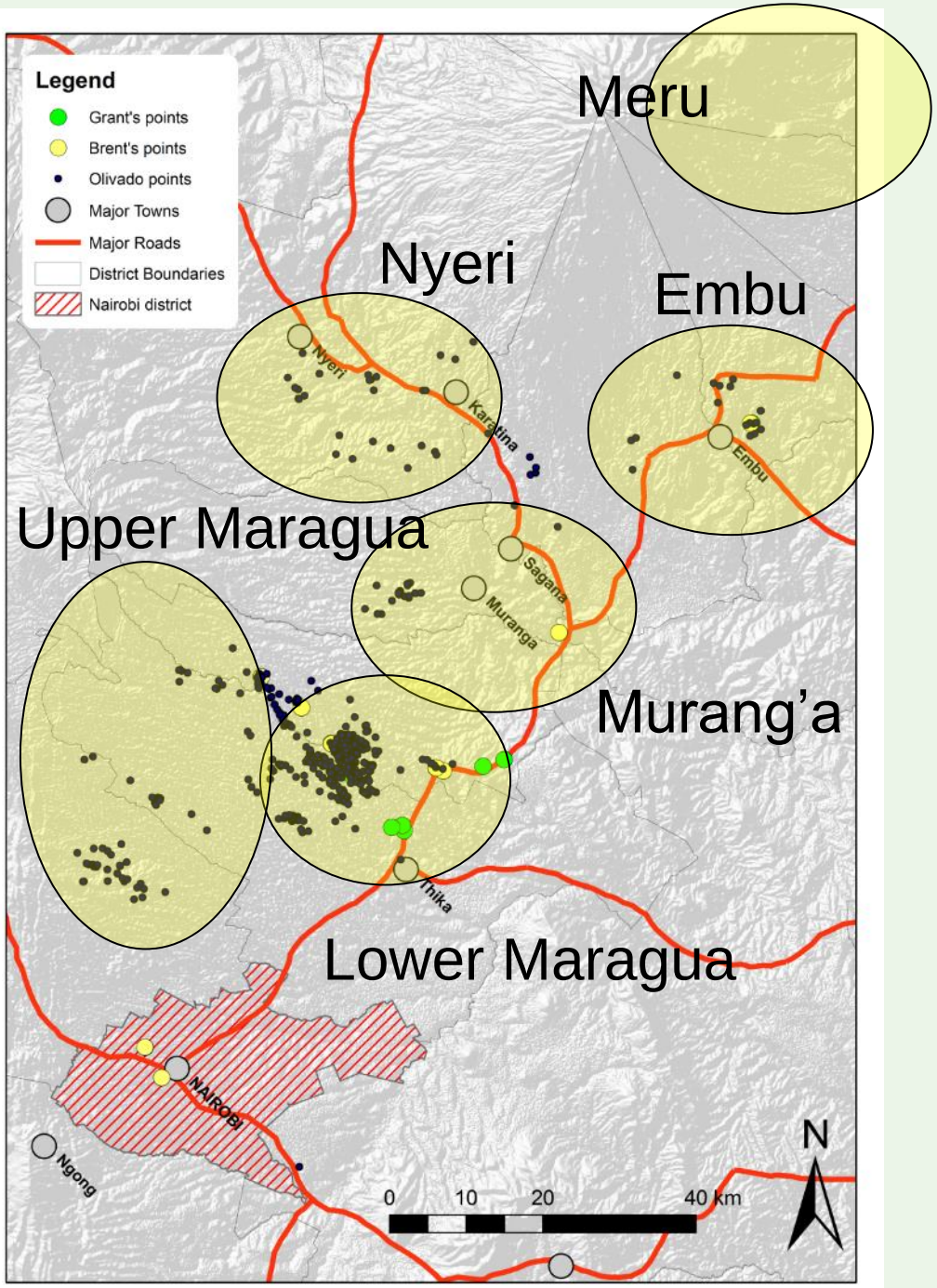
Setup a dry matter monitoring and measurement system

Dry matter protocol

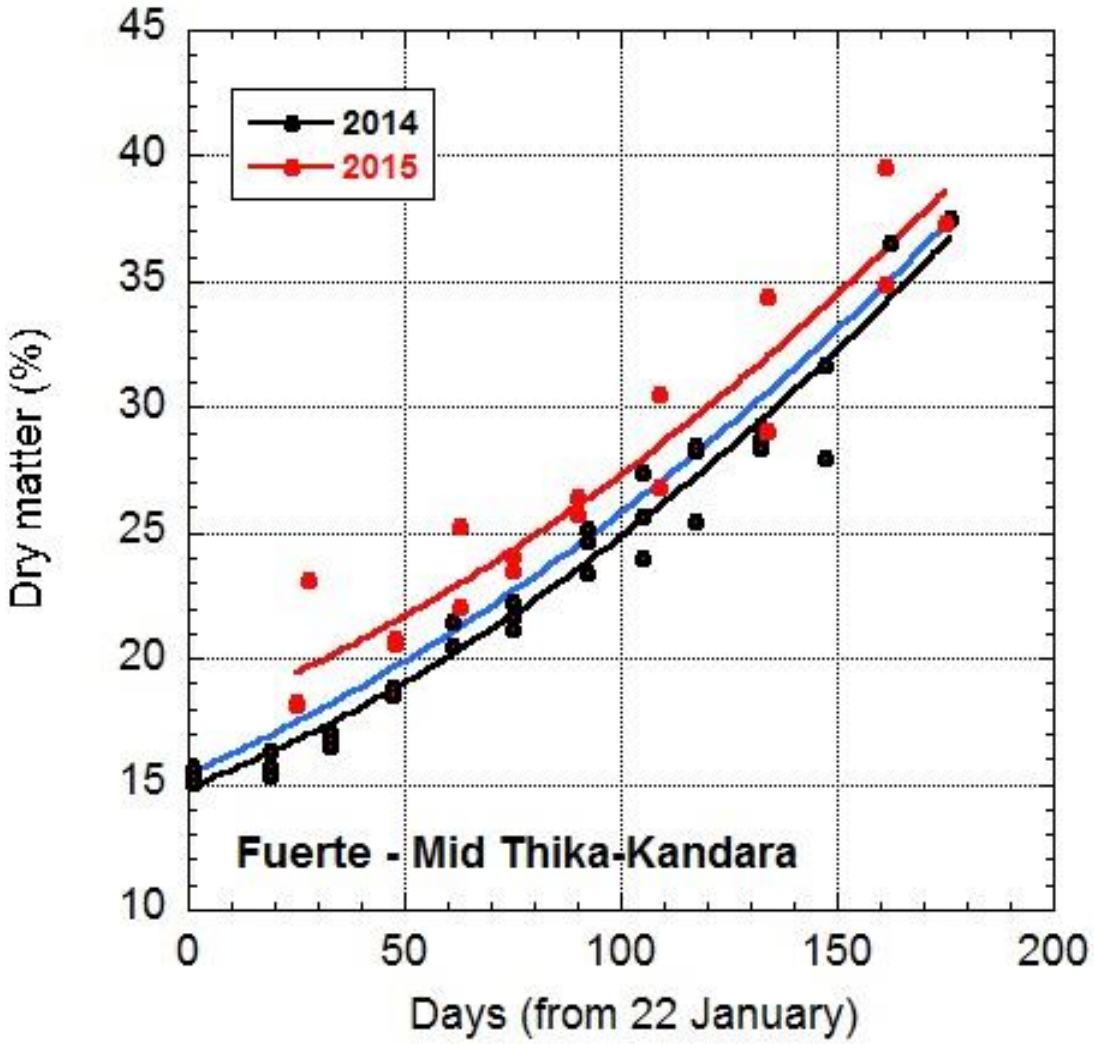
- Tree sampling protocol
- 2-3 week sampling
- 6 growing regions
- Multiple growers/location
- Carried out over 2 seasons
- Confirmed oil – DM correlation

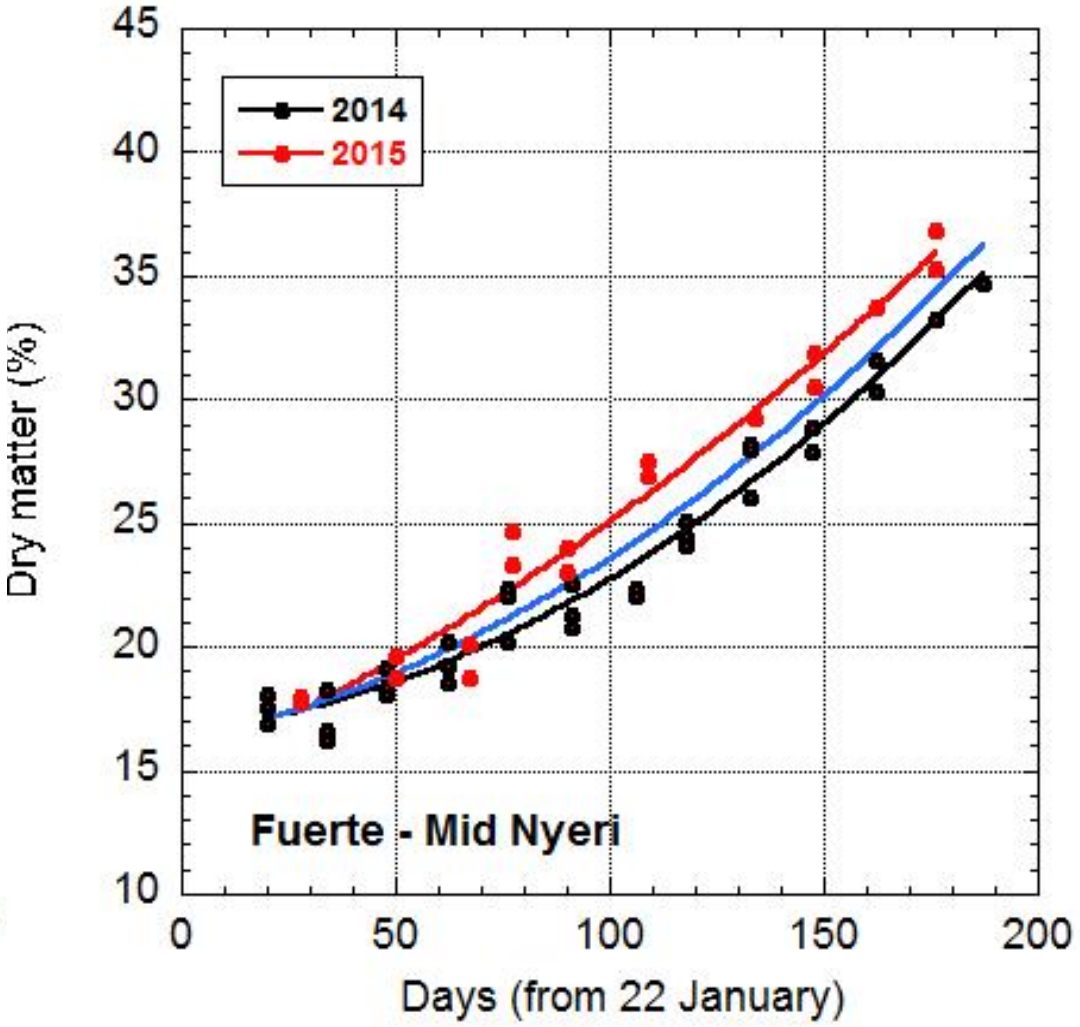
Dry matter vs oil content




Legend
Grant's points
Brent's points
Olivado points
Major Towns
Major Roads
District Boundaries
Nairobi district
Meru
Nyeri
Embu
Upper Maragua
Murang'a
Lower Maragua
Nyeri
Karatina
Embu
Sagana
Muranga
Thika
NAIROBI
Ngong
0
10
20
40 km
N

Dry matter over time





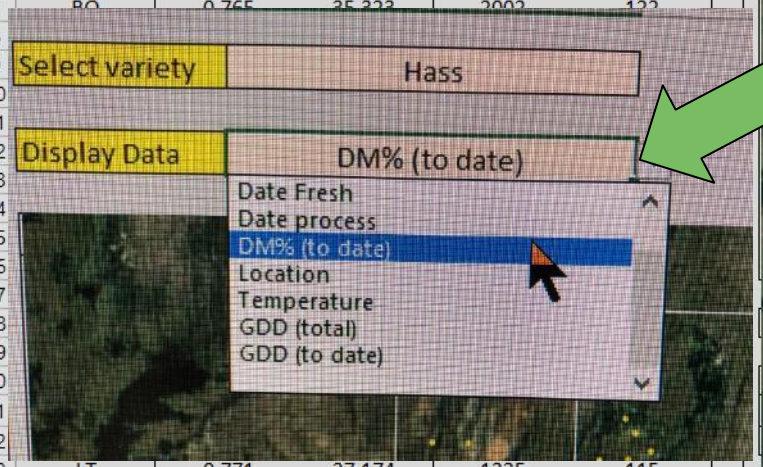
Date for fruit processing for oil - >30%

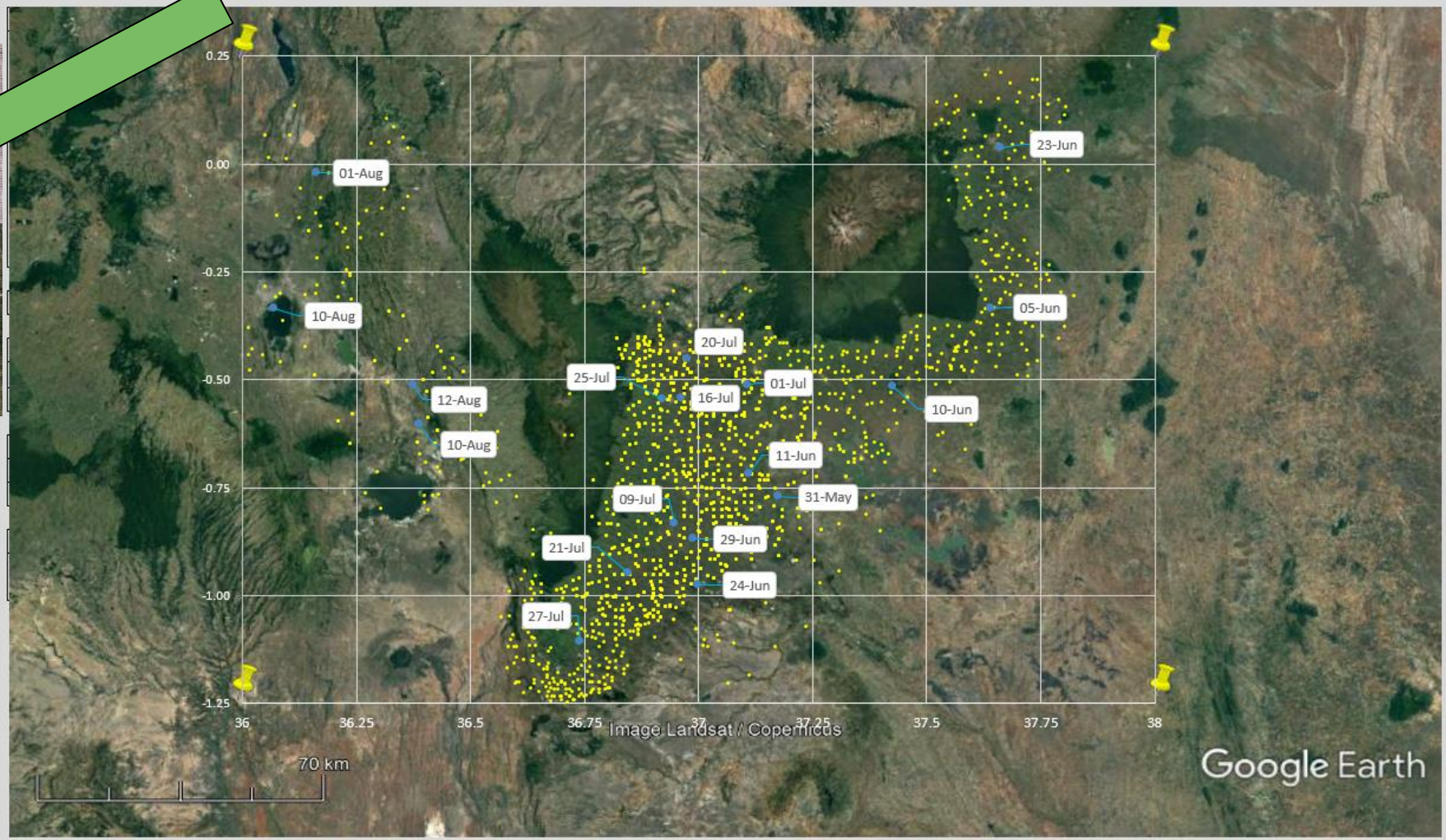
Select variety	Hass
Display Data	Date process

select a date		
day of month	4	04-Mar
month of year	3	

sheet - it is copied from the Village location worksheet - inactive here

Label	Latitude	Longitude	Altitude	std Alt.
LT	-0.771	37.174	1325	115
ME	0.037	37.662	1582	316
MU	-0.720	37.110	1448	152
NA	-0.335	36.069	2109	197
NG	0.002	34.523	1353	114
NM	0.502	34.840	1606	171
NV	-0.604	36.388	2107	104
NY	-0.451	36.976	1883	162
NZ	0.451	34.629	1395	60
OT	-0.542	36.964	1837	184
SI	0.236	34.542	1348	57
SU	-0.019	36.162	2012	282
TK	-0.976	36.999	1594	97
UM	-0.545	36.921	1931	159
UT	-0.948	36.848	1887	176
VH	0.283	34.923	1723	191

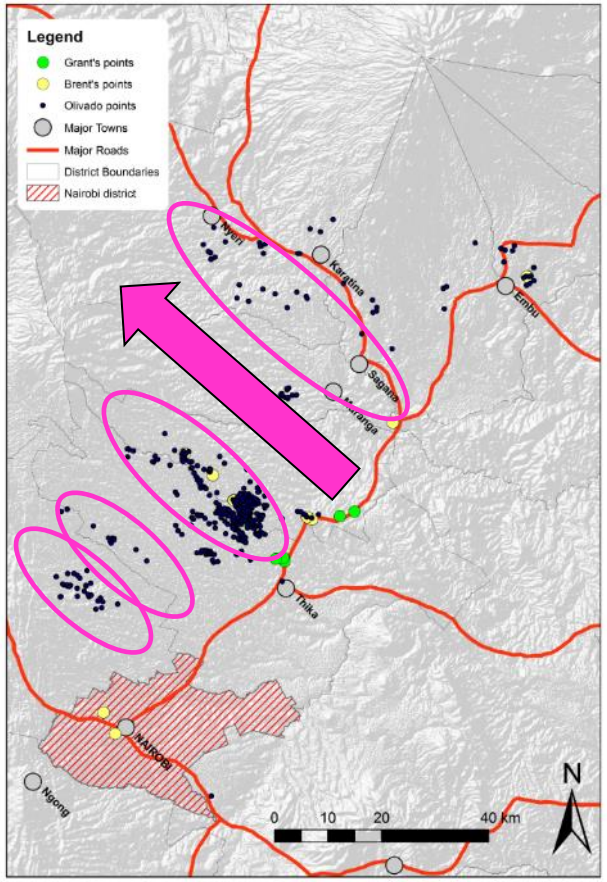




Central Highlands DM | Rift Valley DM | Village DM

Knowing DM over time and more latterly the TTH calculator

- More predictable and “plannable” harvesting
- Clear DM and thus harvest date goals
- Improved yield – 30% increase once implemented
- Decision support tool (i.e. model)



Outcome 1:

Harvest planning now possible !

Fresh fruit outcome: Maturity and reputation is really important

Agriculture> Sub-sector has been attracting investors

Early harvesting cuts Kenya avocado prices

Local products' value drops in Dubai by more than half in March

BY GERALD ANDAE
gandae@ke.nationemedia.com

The price of Kenyan avocados in Dubai dropped by more than half in March attributed to consequences of exports of an immature crop.

The Directorate of Horticulture indicates the price per kilogramme declined from 35 dirhams (Sh945) to 16 dirhams (Sh432) in the month.

This came on the back of low quality avocado inflows aided by unscrupulous businessmen following high demand of the fruit in the world market.

"The price of our avocado dropped by over half because of concern over the low quality of the crop," said the outgoing head of the directorate, Mr Zakayo Magara.

He, however, added that the issue had been addressed and the prices had started rebounding. Fruits are expected to reach the previous highs soon.

He said the avocado meant for export is supposed to have a fat content of not less than 11 per cent, but traders were exporting pieces with as low as seven per cent.

Agriculture and Food Authority (AFA) was forced to suspend exports last year to curb the shipping of an immature crop to the world market, which was hurting Kenya's produce.

"We were concerned that our avocado would be blacklisted abroad because of harvesting immature fruit; this is the reason we placed the ban," AFA said in February.

The ban was lifted the same month following as harvesting began in some parts of the country.

A ban on the Fuerte variety was lifted on February 1, while that of Hass was waived in March, allowing traders to resume exports.

Foreign investors have been financing the avocado sub-sector in Kenya because of its low-risk environment, wide market access and improved infrastructure.

The Netherlands Trust Fund launched a $1 million project in 2016 to enhance the export competitiveness of Kenya's avocado sector.

The horticulture sector is one of the largest sources of foreign exchange earnings for the country, bringing in Sh101 billion in 2016.

> The price of our avocado dropped by over half because of quality concerns as traders exported a low quality crop,"
>
> **Outgoing head of the directorate Zakayo Magara**

"The price of avocado dropped by over half because of quality concerns as traders exported a low quality crop" (2018)

DM minimum for ‘Hass’ varies depending on growing region and/or market standard

Country	DM (%)	Comments
Australia	23%	Increased from 21%
California	20.8%	An increase was debated hotly
Peru	22%	
Chile	23%	
Israel	22%	
Mexico	20.8%	Dictated by USA primarily
New Zealand	**24%**	Average of 24 and 18/20 fruit sample > 20.8%
South Africa	**25%**	
Kenya	**22%**	

DM minimum for ‘Hass’ varies depending on growing region and/or market standard

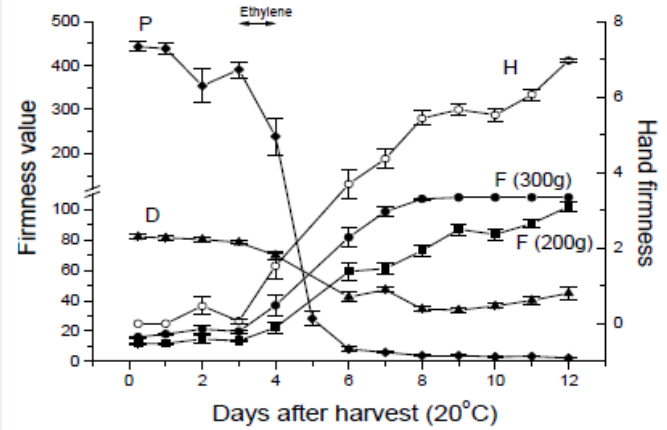
Country	DM (%)	Comments
Australia	23%	Increased from 21%
California	20.8%	An increase was debated hotly
Peru	22%	
Chile	23%	
Israel	22%	
Mexico	20.8%	Dictated by USA primarily
New Zealand	**24%**	Average of 24 and 18/20 fruit sample > 20.8%
South Africa	**25%**	

<u>(Unplanned) Outcome 1b:</u>

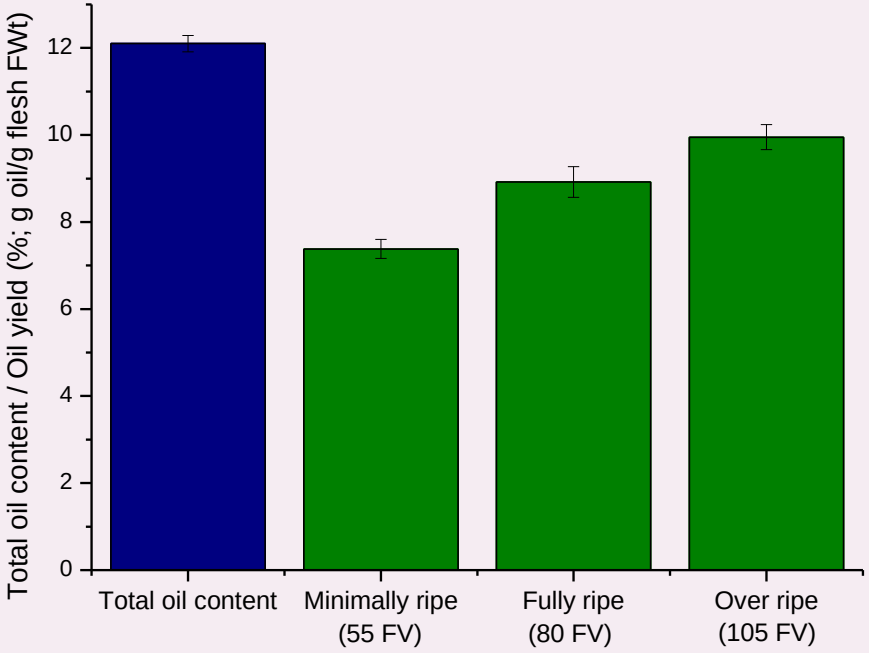
- Improved export quality & thus importer/consumer reputation
- Also increases maturity (thus oil content) for oil extraction

4B.
Fruit quality and oil quality

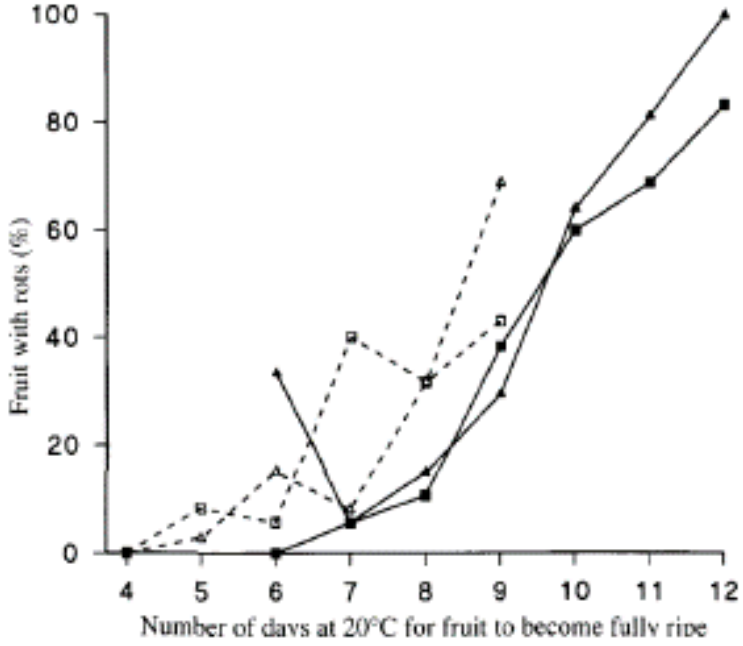
Oil yield vs quality – it's a balance!



Yield – Riper/softer fruit will yield more oil



Quality – Riper fruit has more chance of disorders, particularly rots, and thus reduced quality



Yang S, et al. 2018. The impact of fruit softening on avocado cell microstructure changes monitored by electrical impedance and conductivity for cold-pressed oil extraction. Journal of Food Process Engineering.

Key quality aspects and challenges

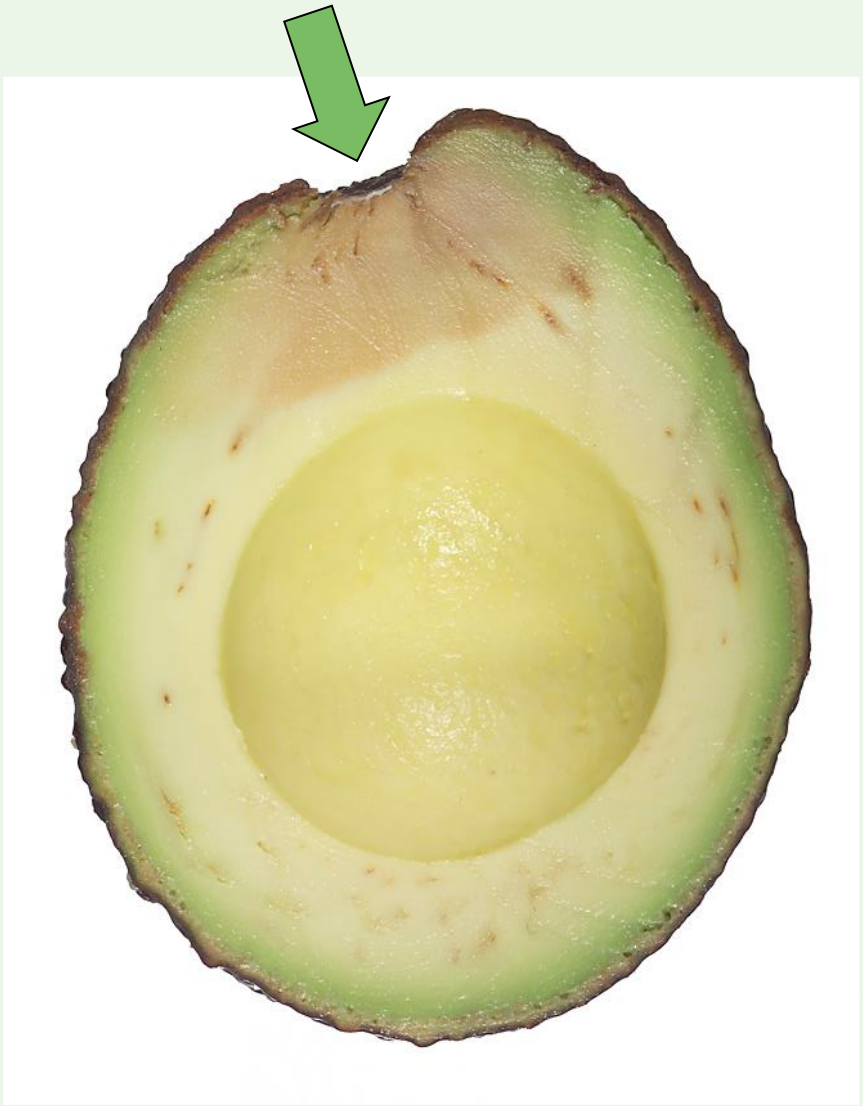
- Ripe rots
- Stem end rots
- Bruising
- Poor quality fruit leads to poor quality oil

Variable rate of ripening leads to increased rots

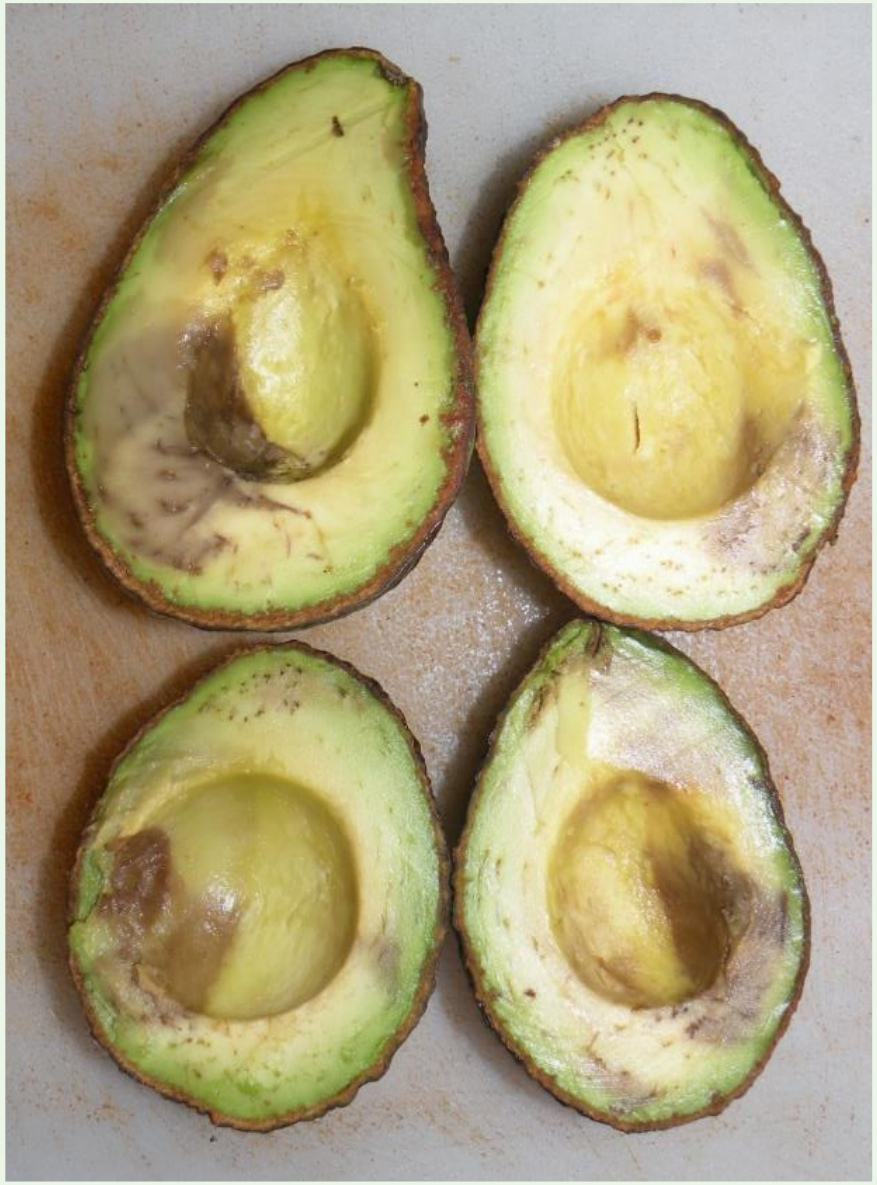
New rot: Fusarium

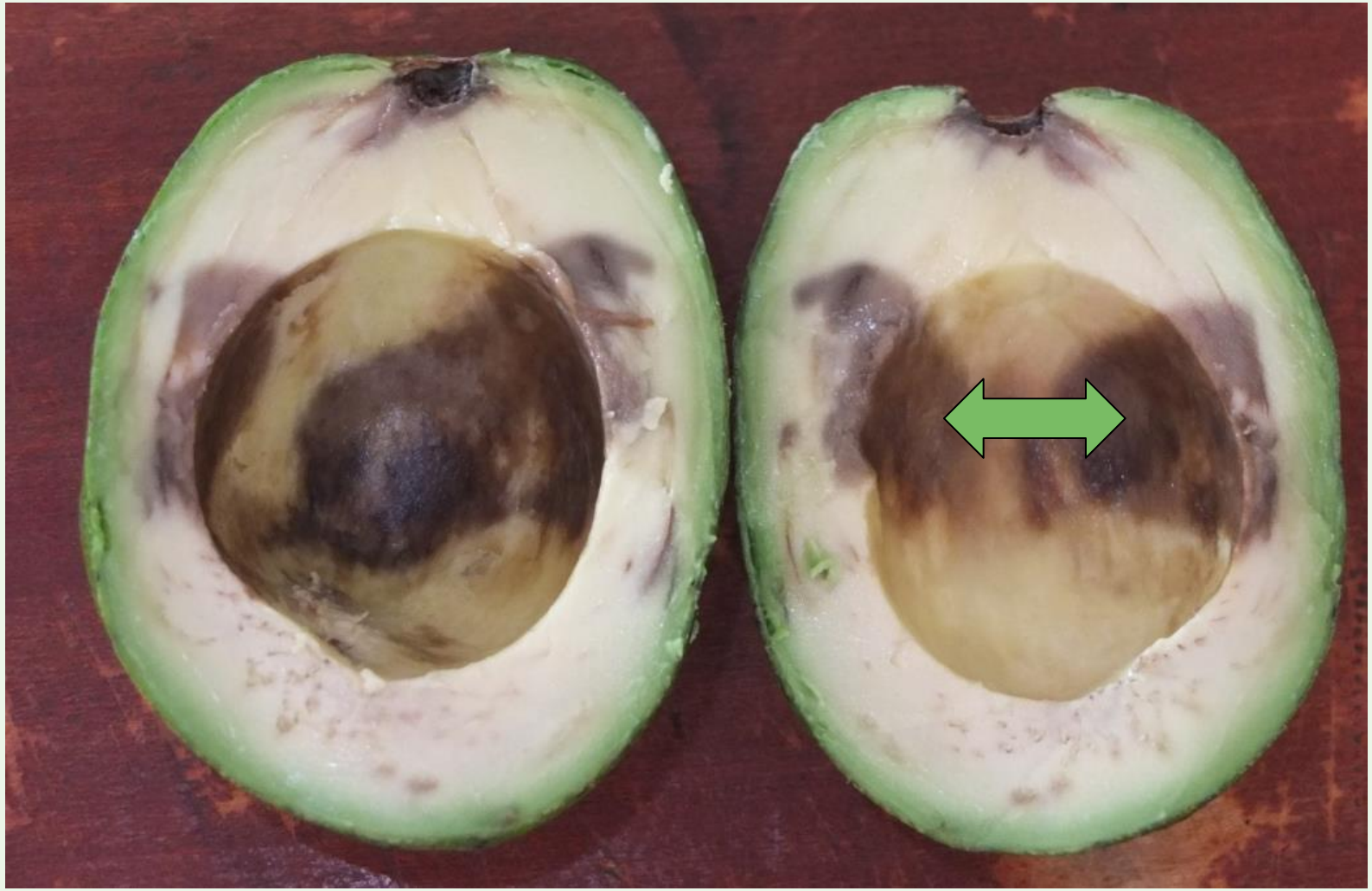
- Soil related
- Possibly *F. solani. F equiseti* or *F.oxysporum*

Stem end rots



Bruising





Effect of rots on oil quality – see Roy Wang Posters - SO3 & SO4

Results

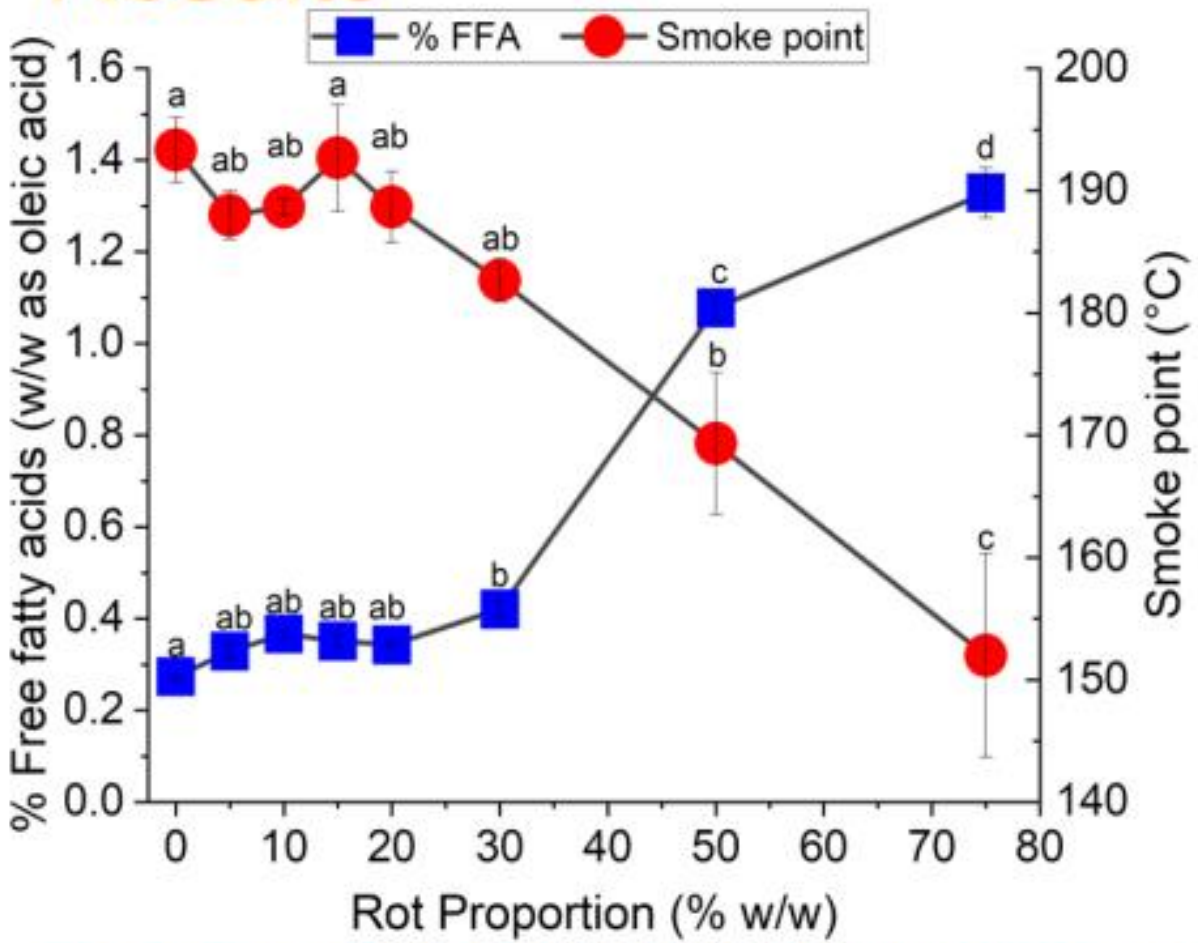


Fig 3. *The effect of rot proportion on %FFA (n=6) and smoke point (n=3) of cold-pressed oil (Mean ± SEM).*

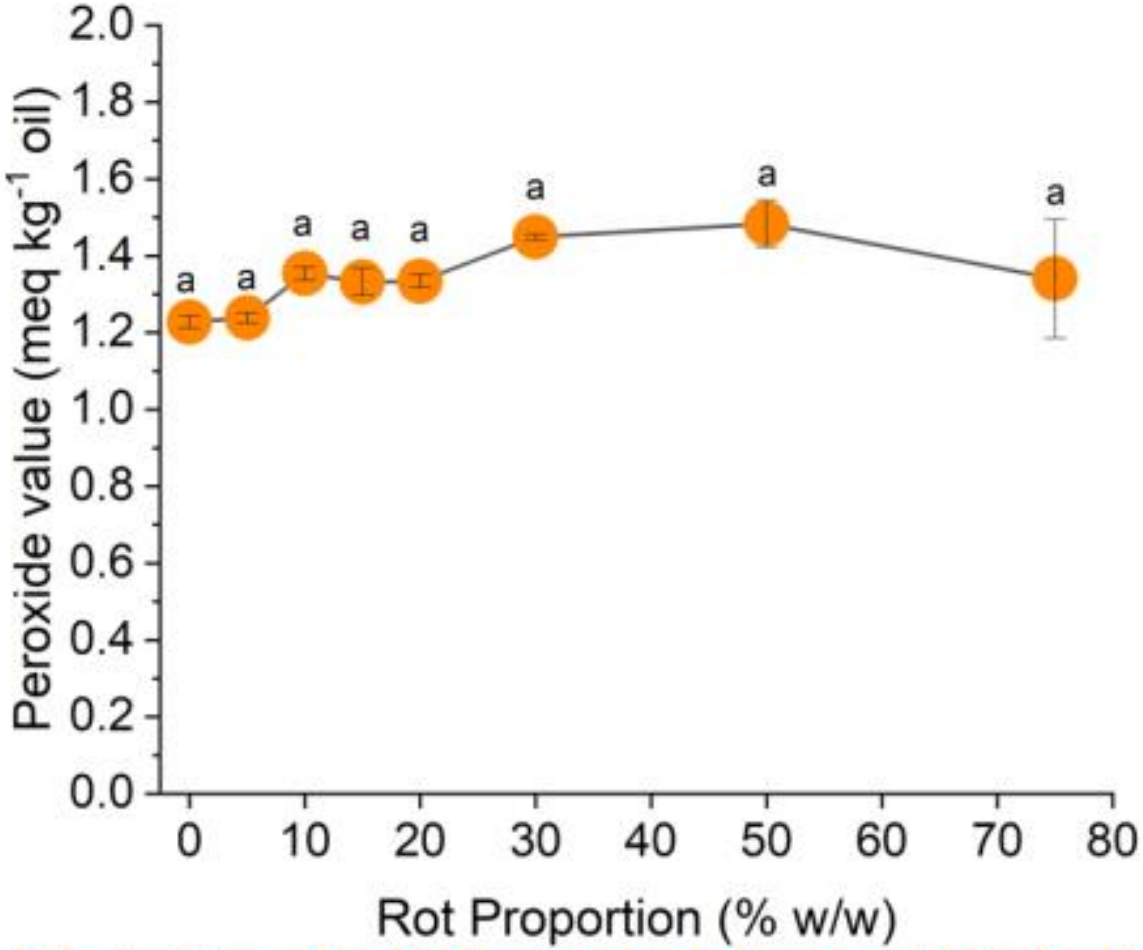


Fig 4. *The effect of rot proportion on PV of cold-pressed oil (Mean ± SEM, n=6).*

4C.
Ripening protocol

Coolstores / ripening rooms

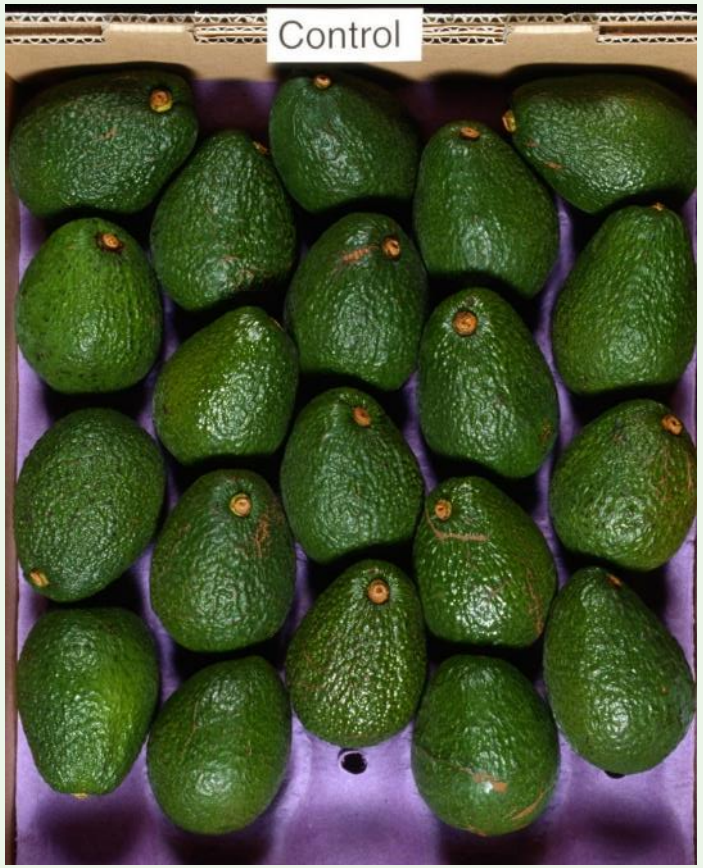
- 18 tonnes / room
- 16 rooms
- Relatively low airflow
- “Leaky”
- Variable cooling efficacy

Goal of ripening protocol

Need predictable, rapid ripening to optimum firmness with minimal fruit to fruit variability, and very good fruit quality

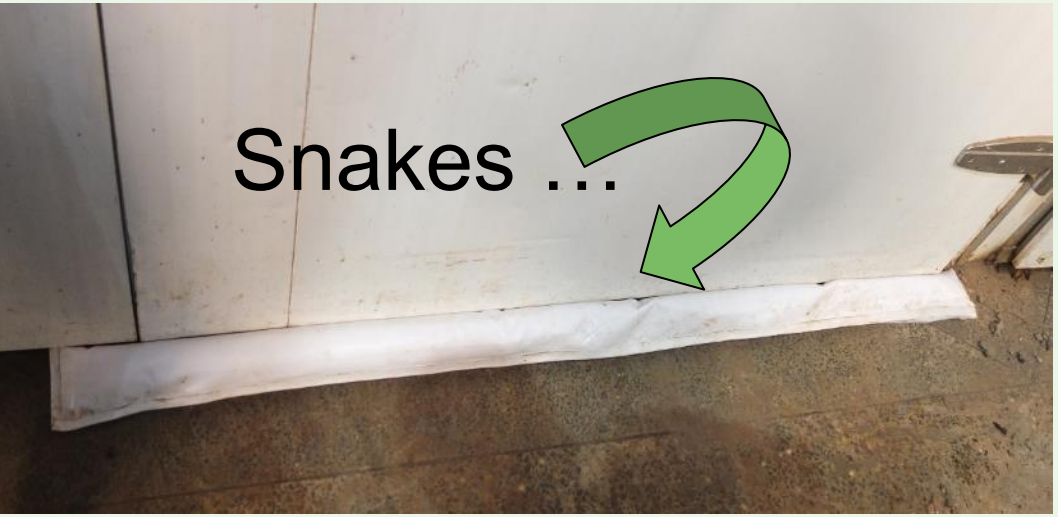
Goal of ripening protocol

- Need predictable, rapid ripening with minimal fruit to fruit variability, and good fruit quality
- Ethylene treatment is the main way to hasten ripening



Goal of ripening protocol

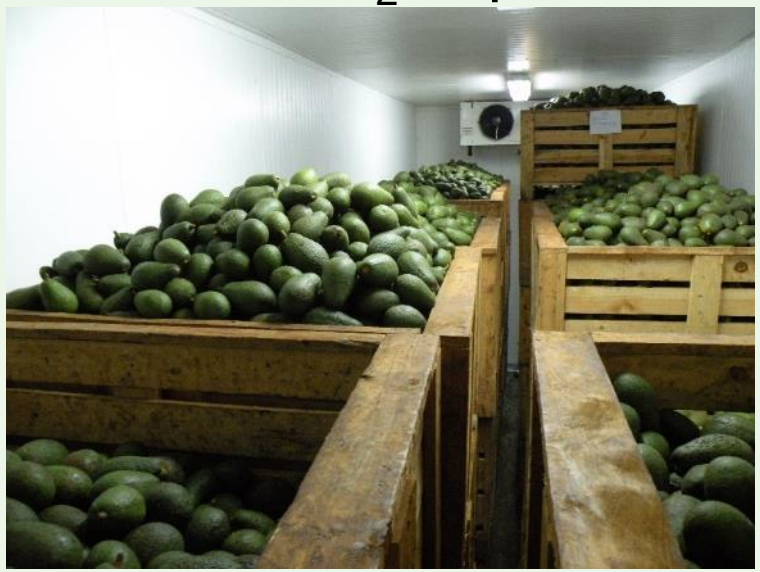
- Need predictable, rapid ripening with minimal fruit to fruit variability, and good fruit quality
- Ethylene treatment is the main way to hasten ripening
- Organic fruit can’t use artificial ethylene (EU rules !)
- So developed system to use already ripening avocado fruit to produce “natural” ethylene

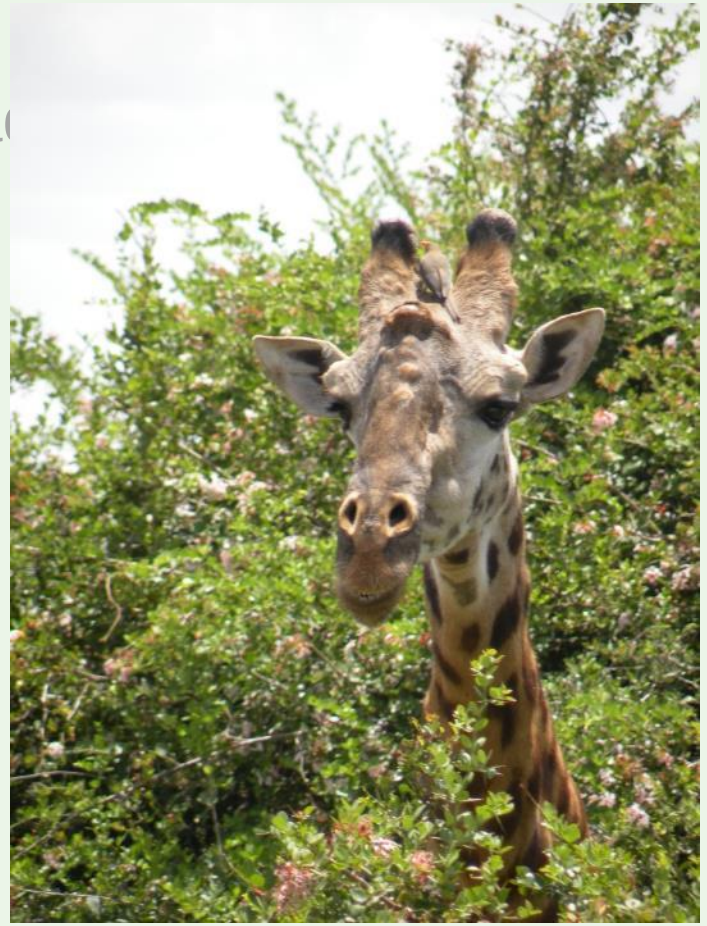


Goal of ripening protocol

- Need predictable, rapid ripening with minimal fruit to fruit variability, and good fruit quality
- Organic fruit can't use artificial ethylene (EU rules !)
- So developed system to use already ripening avoca "natural" ethylene
- Challenges of CO_2 accumulation / O_2 depletion

(Bad for fruit & H&S risk)





Gas atmosphere monitoring – ethylene, CO_2 and O_2

Ripening room spreadsheet system

» Detailed logging of timing, temperature, atmospheres, venting etc, time to ripen

Unrestricted Access

Q12 | 19

	A	B	C	I	J	K	L	M	N	O	P	Q	R	S	
1				Reading coolstore control box		Atmospheres									
2	Date / day	Date fruit into coolstore	Days in coolstore	Coolstore reading (°C)	Set Temp (°C)	Ethylene (ppm)	O_2 (%)	CO_2 (%)	Predicted CO2	Vent Room 10 mins	Coolstore temp (IR of bin wood at door)	Fruit temp (IR of bin fruit at door)	Approx firmness (by hand) - 10 fruit	Approx. days till ripe	Comments
3															
4	i.e. Today !!!!!	e.g. July 2nd	Time since fruit moved in	e.g. 18	e.g. 20	Dräger measurement (Aim for 3-5ppm ethylene on day one)				For Safety	After venting	After venting	Approx average firmness	Estimate the days until reach stage 5 (include a range if needed)	e.g. how is fruit Plastic or snak
5	17-Apr	16-Apr	1	18.1	18	0	19.6	5	2.4	YES	19	19	0-1	7	
6	18-ARIL		2	18.6	18	1	19.3	5	2.7	YES	19	19	0-1	6	
7	19-Apr		3	20	20	2	17.8	5	4.1	YES	21	21	1 TO 2	5	
8	20-Apr		4	20.9	20	4	12.6	5	9.2	YES	21	21	2 TO 3	4	
9	21-Apr		5	22.4	22	9	11.9	5	9.9	YES	22	23	3 TO 4	3	
10	22-Apr		6	22.9	22	11.2	11.6	5	10.2	YES	23	23	4 TO 5	2	
11	23-Apr		7	23.4	22	9	12.4	5	9.4	YES	24	24	5..	1	
12	24--APRIL	23-Apr	1	18.2	18	0	19.7	3.7	2.3	YES	18	19	0-1	7	
13	25-Apr		2	18.9	18	2	17.5	5	4.4	YES	19	19	1 TO 2	6	
14	26-Apr		3	20.1	20	6	12.3	5	9.5	YES	20	20	1 TO 2	5	
15	27-Apr														
16	28-Apr														
17	29-Apr														
18	30-Apr														
19	1-May														
20	2-May														
21	3-May														
22	7-May														
23	8-May														
24	9-May														

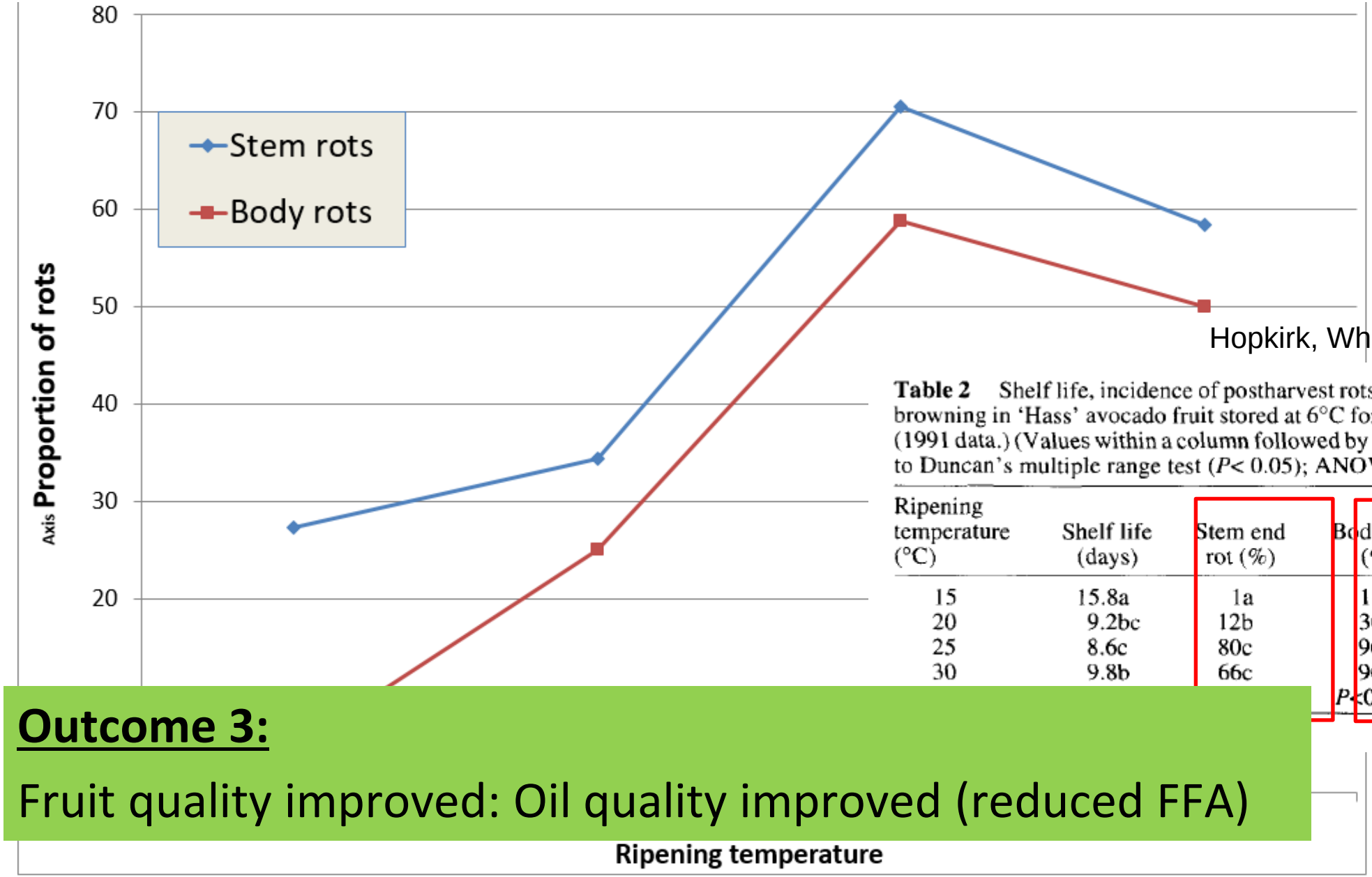
Rm7 | Rm8 | Rm9 | Rm10 | Rm11 | Rm14 | Rm12 | Rm13 | Rm15 | Rm16 | REVISED | Sheet3 | Sheet2

Outcome 2:

Fruit ripening controlled – better oil yield (stage of ripeness)

(and health and safety!)

Effect of ripening temperature on rots



Hopkirk, White et al., 1991

Table 2 Shelf life, incidence of postharvest rots, uneven ripening, int
browning in 'Hass' avocado fruit stored at 6°C for 10 days and then rip
(1991 data.) (Values within a column followed by the same letter do not
to Duncan's multiple range test ($P < 0.05$); ANOVA = analysis of vari

Ripening temperature (°C)	Shelf life (days)	Stem end rot (%)	Body rots (%)	Uneven ripening (%)
15	15.8a	1a	18a	0a
20	9.2bc	12b	30a	1a
25	8.6c	80c	96b	77b
30	9.8b	66c	96b	100c
			$P<0.001$	$P<0.001$

Outcome 3:

Fruit quality improved: Oil quality improved (reduced FFA)

Production planning whiteboard – tons / day, capacity

- Interface for ripening and processing teams
- Tons / day / store
- Ability to slow down or speed ripening if needed

<u>Outcome 4:</u>

Ripening time controlled: Better processing planning – better oil qaulity

Overall outcomes

1. Faster ripening lead to greater factory through-put (compared to 1 week coolstore before ripening)
2. Much more even ripening – thus greater yield and

less rots / ejects

3. Less double handling (bruising)
4. Increased fruit quality, thus oil quality
5. Greater training & systematic protocols means better

planning and changes to process as needed

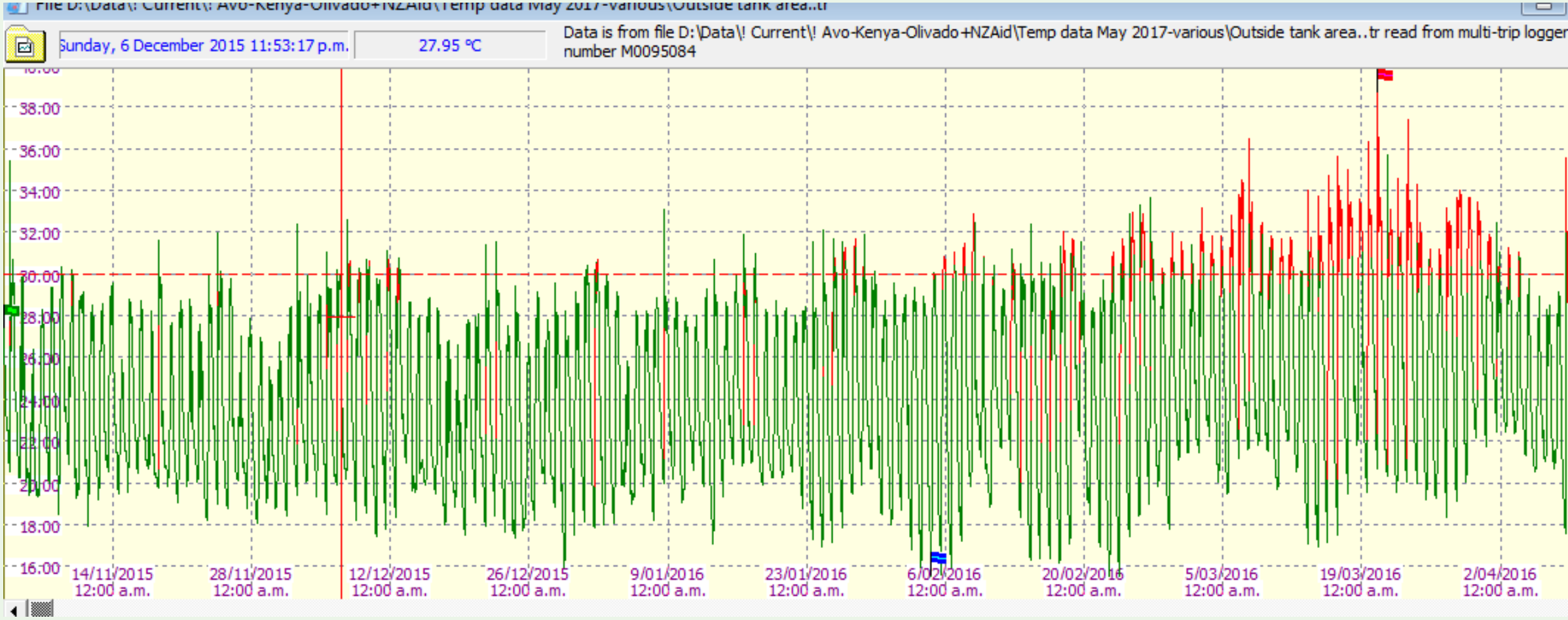
6. Greater control and predictability of processing
7. Better health and safety
8. Lower labour input (grading/moving fruit/management)
9. $ Greater profitability $

4D.
Oil storage temperature and quality

Tank farm

- Logged temps

Ambient temperatures in Kenya



35C

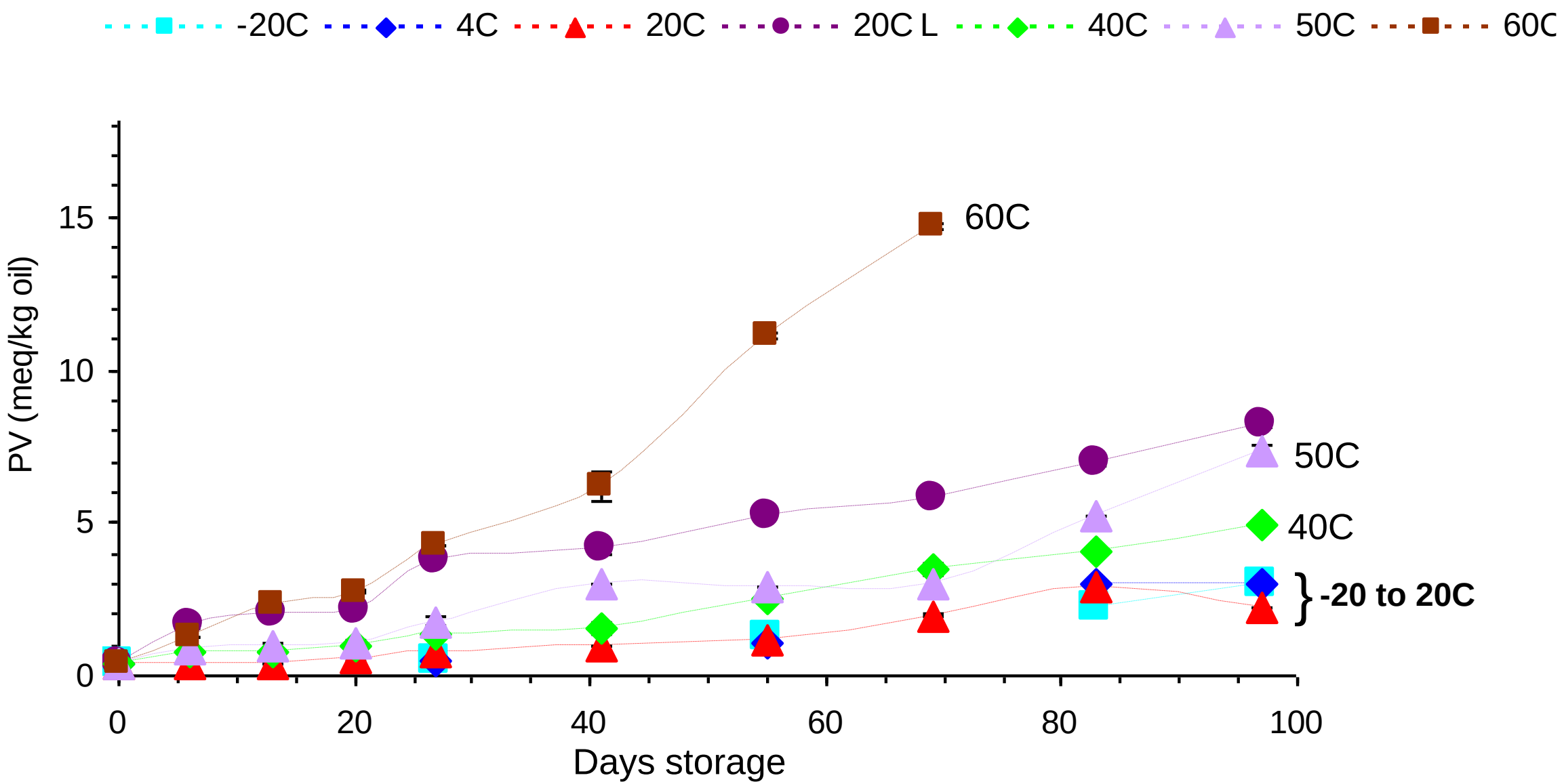
30C

25C

20C

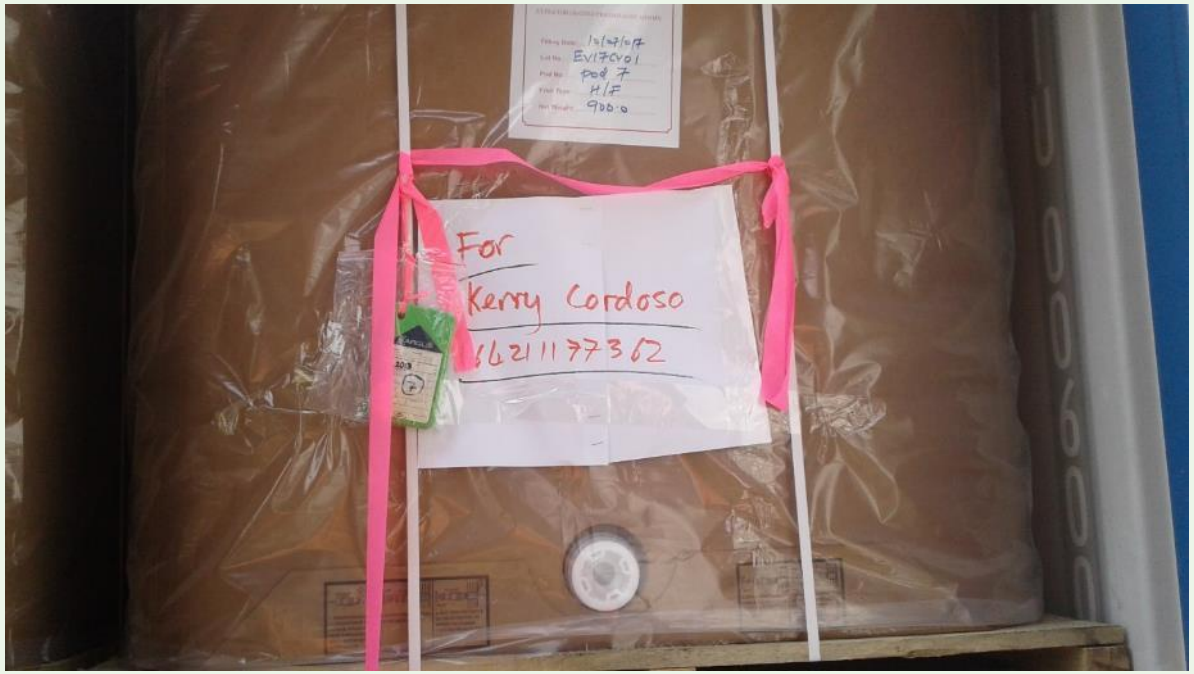
15C

Oil temperature and PV



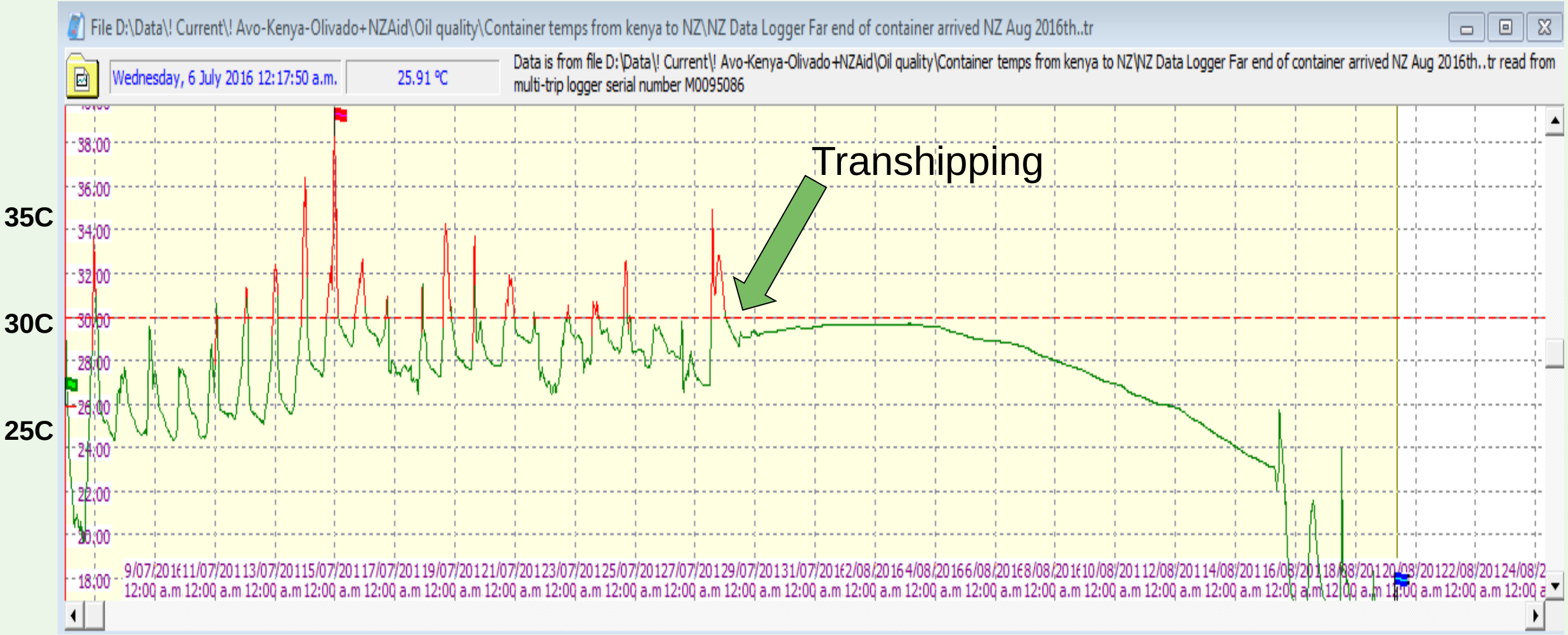
Low-tech solution

Seafreighting of extracted oil (non-refrigerated)

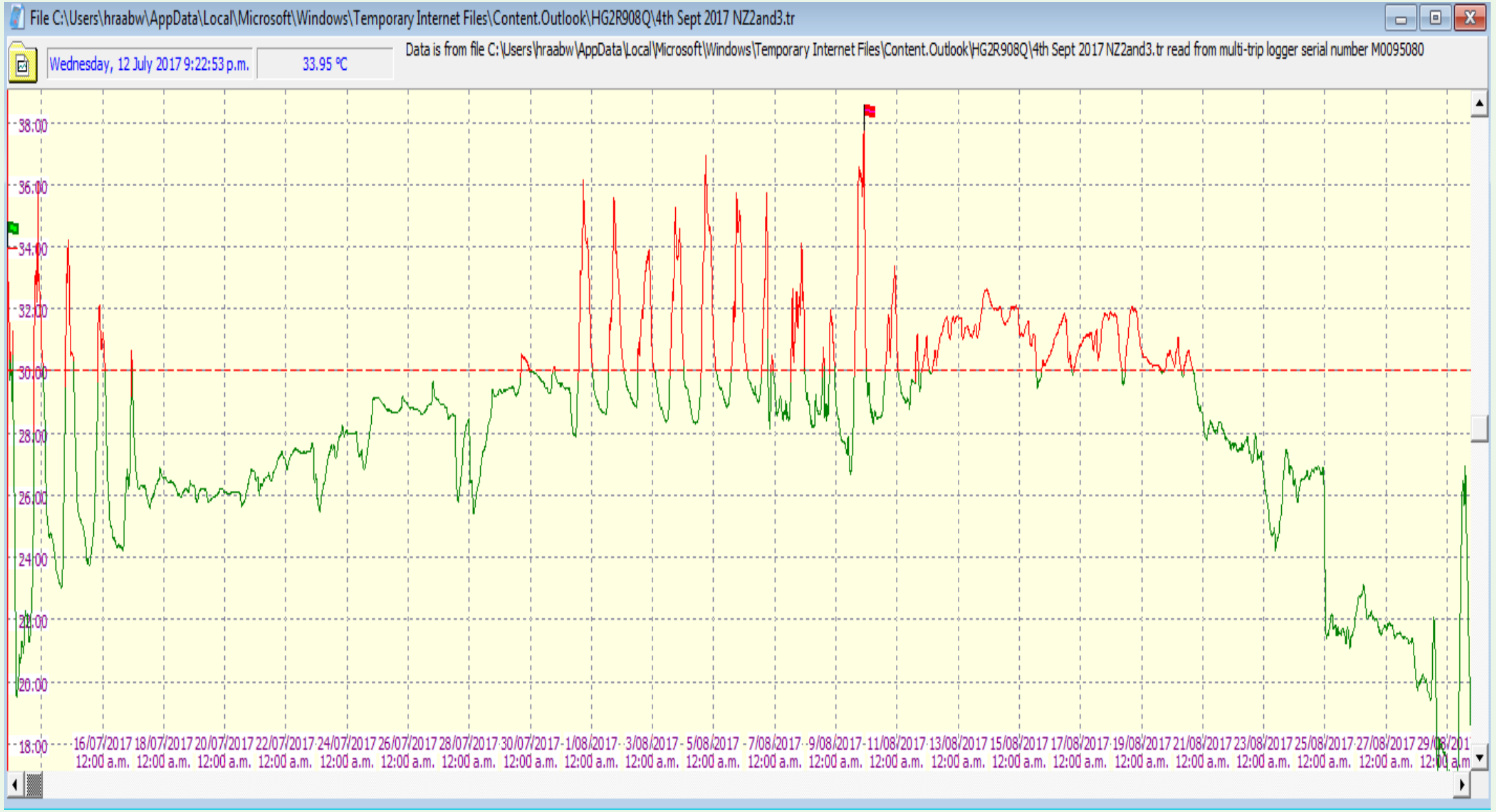


Container air temperatures - July

Kenya Singapore? NZ



Container temperatures - August



35C

30C

25C

Oil quality – PPP and DAGs

Cultivar	Country	Storage conditions	Storage time (months)	PPP	DAG
'Hass'	NZ	Fresh-early season	1	**0.6**	**90.3**
'Hass'	NZ	Tank - NZ	9	**2.1**	**61.7**
'Hass'	NZ-Other producer	Unknown	9	**1.4**	**58.5**

Oil quality – PPP and DAGs

Cultivar	Country	Storage conditions	Storage time (months)	PPP	DAG
'Hass'	NZ	Fresh-early season	1	0.6	90.3
'Hass'	NZ	Tank - NZ	9	2.1	61.7
'Hass'	NZ-Other producer	Unknown	9?	1.4	58.5
'Fuerte'	Kenya	Fresh-late season	1	0.9	76.1
'Fuerte'	Kenya	Kenya, barrels	10	9.2	28.1
'Fuerte'	Kenya	Kenya, barrels	10	9.1	27.4
'Fuerte'	Kenya	Shipped to NZ	11	15	27.7
'Hass'	Kenya	Shipped to NZ	11	10.7	28
'Hass'	Kenya	Shipped to NZ	7	15	27.8
'Fuerte'+ 'Hass'	Kenya	Shipped to NZ	11	17.8	28

Oil quality – PPP and DAGs

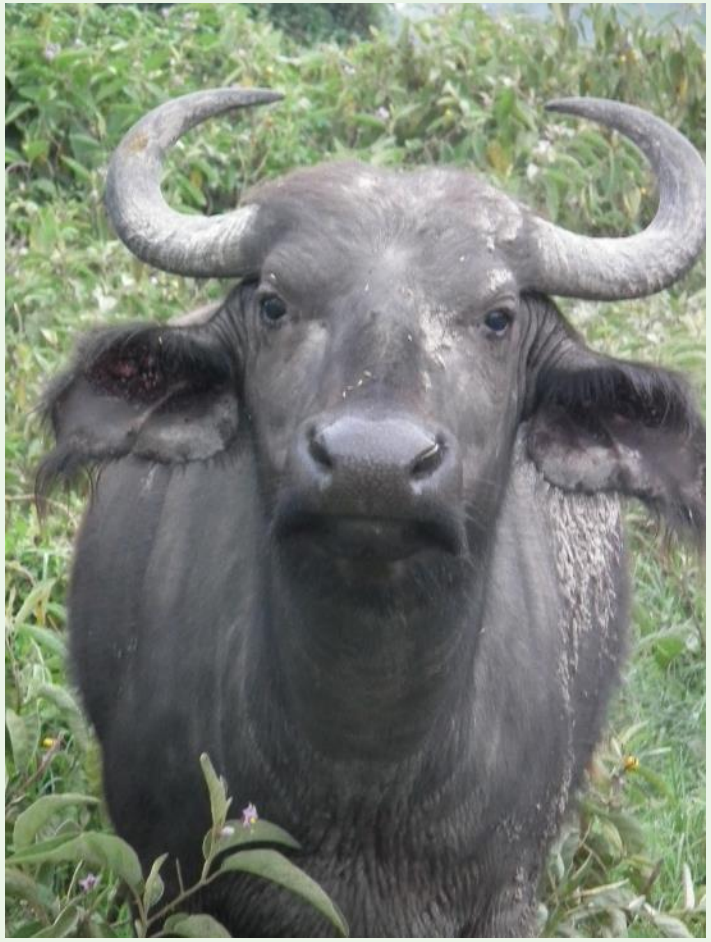
Cultivar	Country	Storage conditions	Storage time (months)	PPP	DAG
'Hass'	NZ	Fresh-early season	1	0.6	90.3
'Hass'	NZ	Tank - NZ	9	2.1	61.7
'Hass'	NZ-Other producer	Unknown	9?	1.4	58.5
'Fuerte'	Kenya	Fresh-late season	1	0.9	76.1
'Fuerte'	Kenya	Kenya, barrels	10	9.2	28.1
'Fuerte'	Kenya	Kenya, barrels	10	9.1	27.4
'Fuerte'	Kenya	Shipped to NZ	11	15	27.7
'Hass'	Kenya	Shipped to NZ	11	10.7	28
'Hass'	Kenya	Shipped to NZ	7	15	27.8
					28

Outcome 5:

Oil storage temperature important: Oil quality improved

Outcomes for oil storage and quality

- Improved “tank farm” temperature management
- Highlighted need for better shipping temperature management
- Oil quality improved



5. Concluding remarks

Do all things well

- Like all systems, it’s a case of doing a lot of things right that leads to best quality

Journey of life with our collaborators

Plant & Food Research
Rangahau Ahumāra Kai

Asante sana

Kia ora

plantandfood.co.nz

Allan.Woolf@plantandfood.co.nz

(soon to be Allan.Woolf@bioeconomy.nz !)