THE DEVELOPMENT AND USE OF COLD TREATMENT IN THE EXPORT OF FRESH CITRUS FROM SOUTH AFRICA

V Hattingh, TG Grout, SD Moore, JH Hofmeyr, PJR Cronje*

**Citrus Research International, Department of Conservation Ecology & Entomology, Stellenbosch University, South Africa*

The Development and use of Cold Treatment in the Export of Fresh Citrus from South Africa

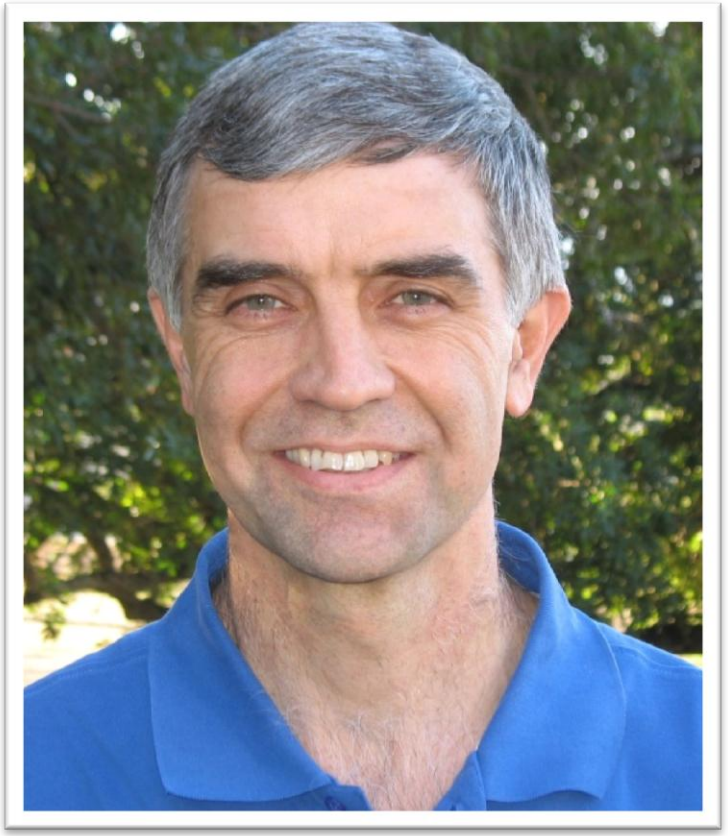
V Hattingh*, TG Grout, SD Moore, JH Hofmeyr, PJR Cronje

***Citrus Research International, Department of Conservation Ecology & Entomology, Stellenbosch University, South Africa**

citrus research international

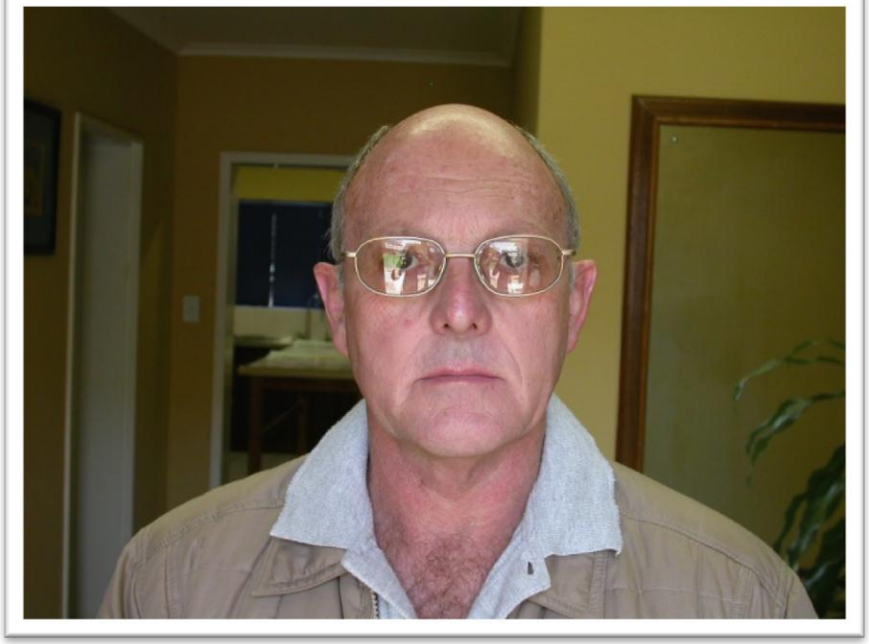
Co-authors

Tim Grout
Citrus Research International,
Nelspruit, South Africa



Sean Moore
Citrus Research International,
Port Elizabeth, South Africa

Co-authors



Hendrik Hofmeyr
Citrus Research International,
Citrusdal, South Africa

Paul Cronje
Citrus Research International &
Department Horticulture,
University Stellenbosch,
South Africa

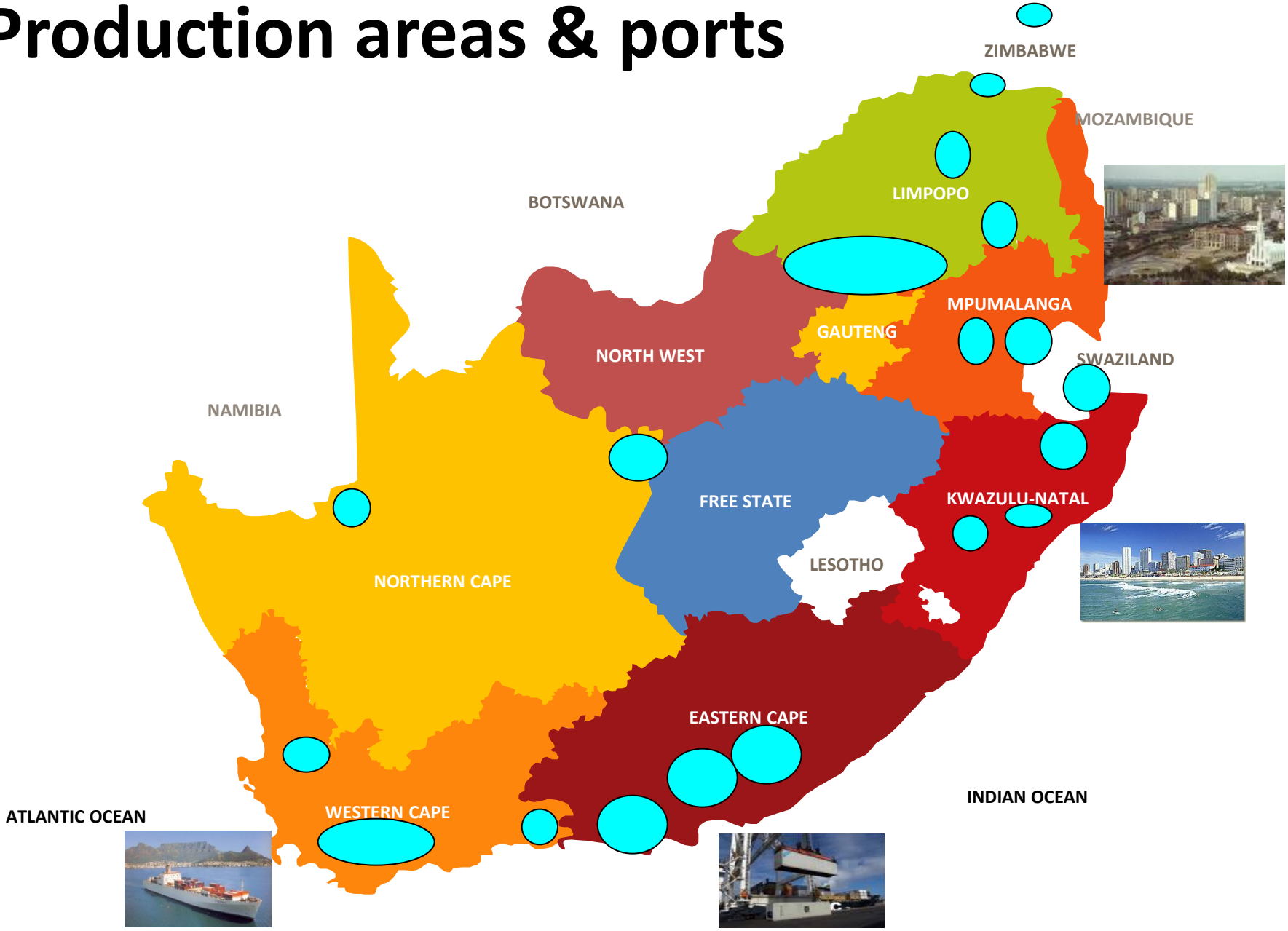
STRUCTURE

- Background – South African Citrus Industry
- Cold treatments developed
- Treatments taken up into export protocols
- Combination treatments under development
- Issues relating to the development of treatment conditions & export protocols
- Issues relating to practical implementation
- Conclusions

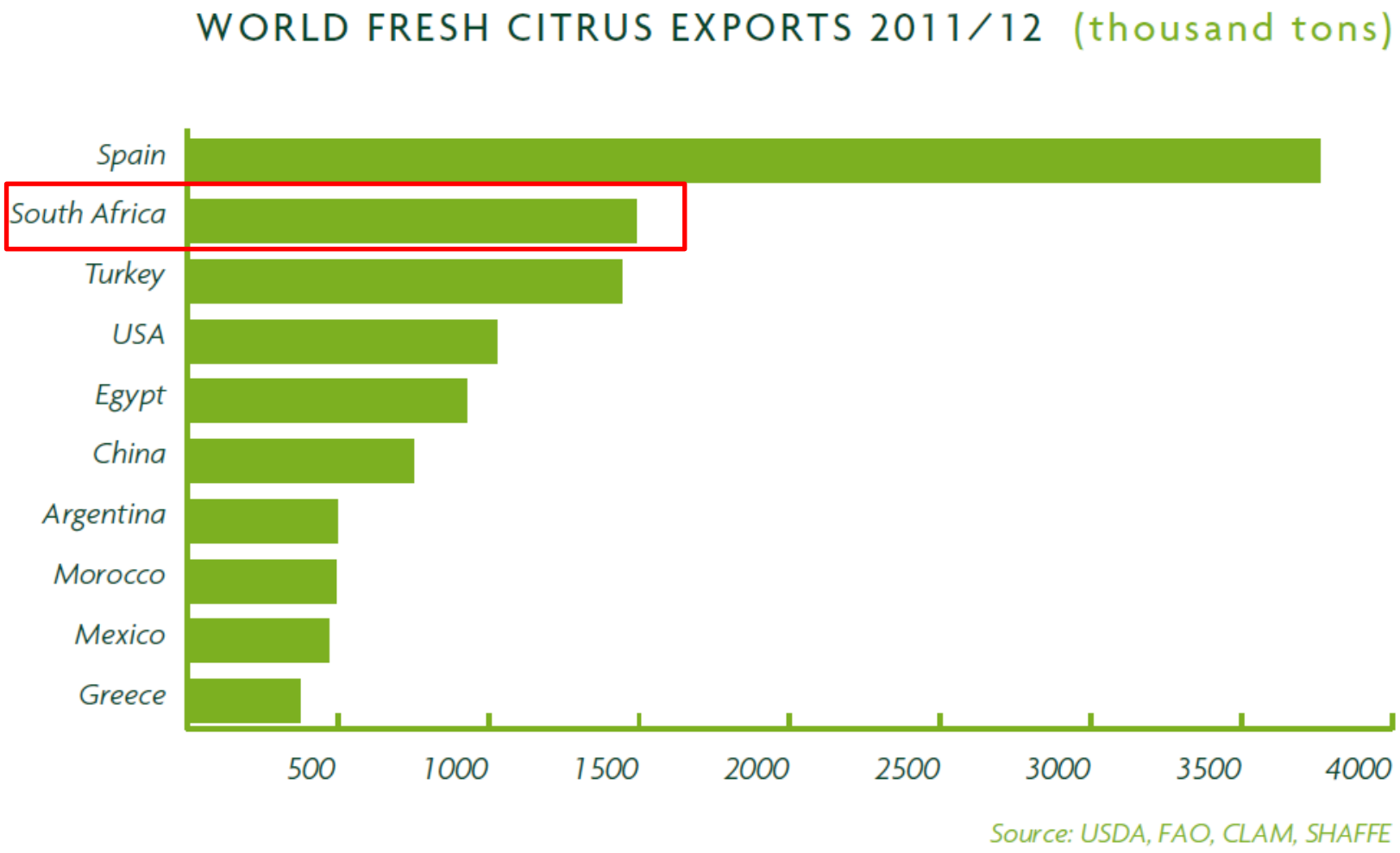
Background……


Arctic Ocean
GREENLAND
Arctic Ocean
NORTH AMERICA
EUROPE
ASIA
North Pacific Ocean
North Atlantic Ocean
MIDDLE EAST
North Pacific Ocean
CENTRAL AMERICA
AFRICA
Indian Ocean
SOUTH AMERICA
AUSTRALIA
South Pacific Ocean
South Atlantic Ocean
NEW ZEALAND
ANTARCTICA

Production areas & ports

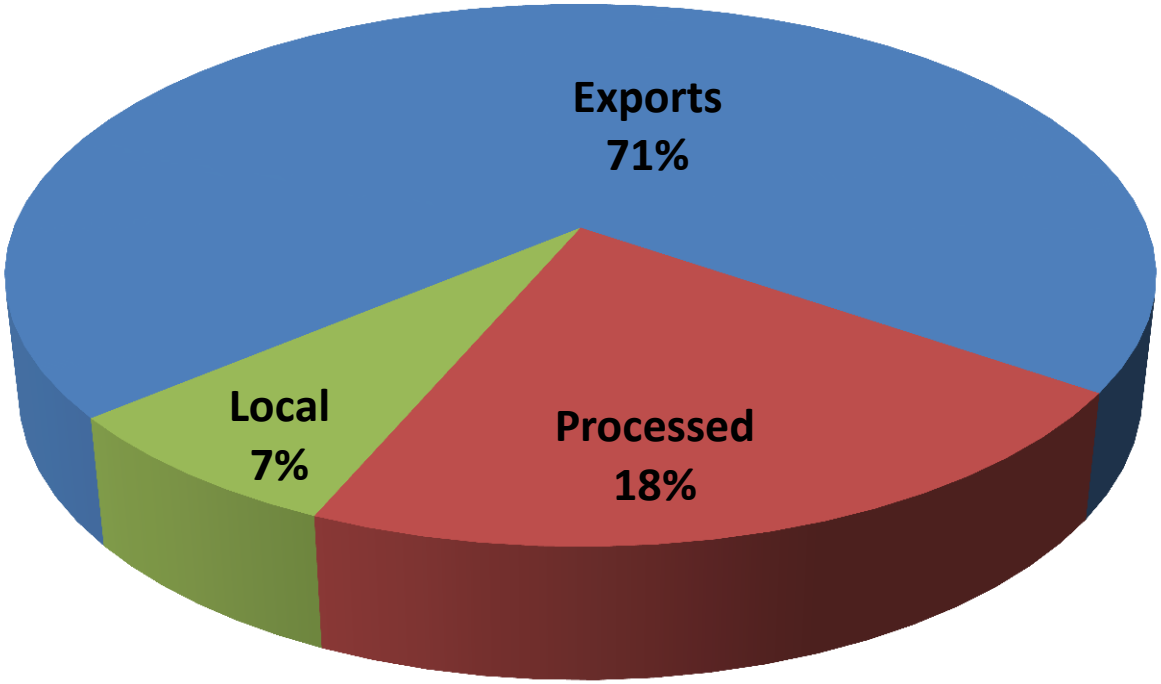


World fresh citrus exports 2011/12 (thousand tons)

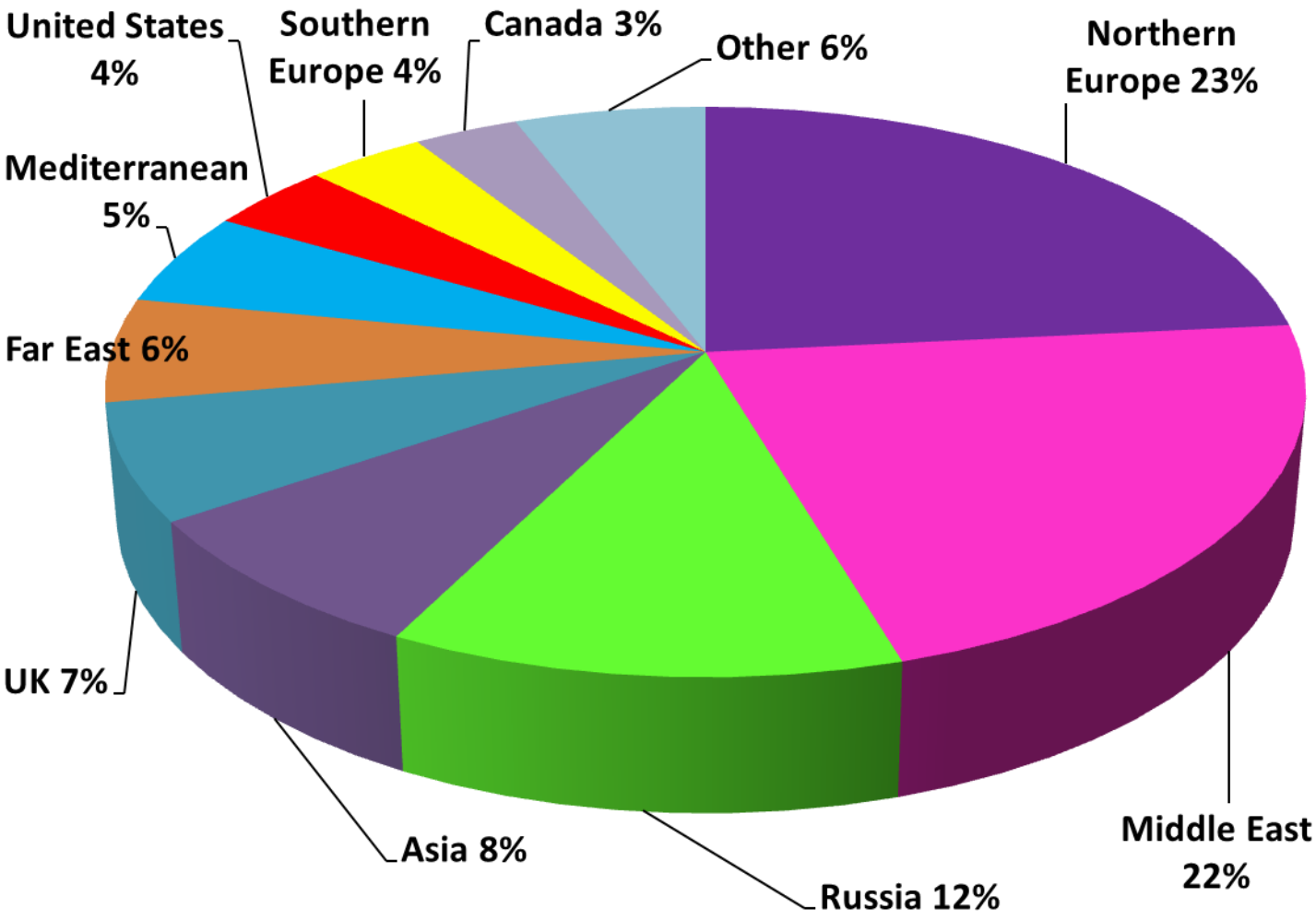


Dependence on exports

(volumes)



Export markets



Cold treatments developed

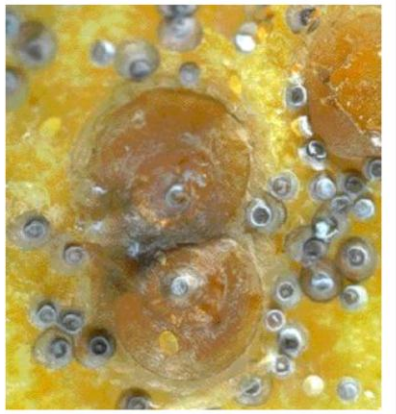
- *Ceratitis capitata & Ceratitis rosa*
- *Bactrocera invadens*
- *Thaumatotibia leucotreta*
- *Aonidiella aurantii*

***Ceratitis* species**

Bactrocera invadens

Thaumatotibia leucotreta

Aonidiella aurantii



Cold treatment
Ceratitis capitata
(development date)

A: 12 days at -0.6˚C ± 0.6˚C (1969)
Grapefruit, oranges & lemons

B: 14 days at T < 0˚C (2007)
Mandarins

C: 16 days at T < 1.4˚C (2008, 2011)
Oranges, Grapefruit, lemons & mandarins

Cold treatment
Ceratitis rosa

- Equivalent to *C. capitata,* validated with a 12 day at -0.5˚C ± 0.5˚C treatment (2001, 2007)

Cold treatment
Bactrocera invadens

- 16 days at T ≤ 0.9˚C (2011)

Overview of fruit fly trial procedures

- Determine development rates and most tolerant life stage
- Manually infest fruit with eggs, incubate at 26˚C for time to desired life stage, dissect control fruit & expose treatment fruit to cold with a step down process simulating large scale practice
- Monitor fruit pulp temperatures at a set point & minimise deviation during trial
- Dissect fruit to determine larval mortality
- 3 reps of 10 000 or more or 3 reps of 33 000 or more
- Use mean hourly or daily max probe readings to establish upper treatment threshold temperature

Cold treatment
Thaumatotibia leucotreta

- 22 days at T < -0.3˚C (1963, 1965, 1969)

- 22 days at -0.6˚C ± 0.6˚C (1998, 2005)

Overview of *T. leucotreta* trial procedures

- Determine development rate and most tolerant life stage
- Collect naturally infested fruit or inoculate medium with eggs & incubate at 26˚C for time to desired life stage, expose to cold with step down simulating large scale practice
- Monitor fruit pulp / medium temperature at a set point & minimise deviation during trial
- Dissect fruit to determine larval mortality / incubate medium until pupation
- 3 reps of 10 000 or more or 3 reps of 33 000 or more
- Use mean hourly or daily max probe readings to establish upper treatment threshold temperature

Cold treatment
Aonidiella aurantii

- 22 days at T < (+)0.5˚C (1999)

Overview of *A. aurantii* trial procedures

- Naturally infested fruit were collected in the field
- The population, including life stages, was estimated by sampling inspection arenas on the fruit surface
- Control fruit were held at 16°C while the treatment fruit were cold treated
- Control and treatment fruit were then held at 22°C for 10 days for dead individuals to become obvious
- Survival was determined by microscopic inspection of samples = inspection arenas on fruit surface
- Dead scales were visually distinct (dried out / discolored) from survivors
- 95 571 treatment individuals were assessed = all dead

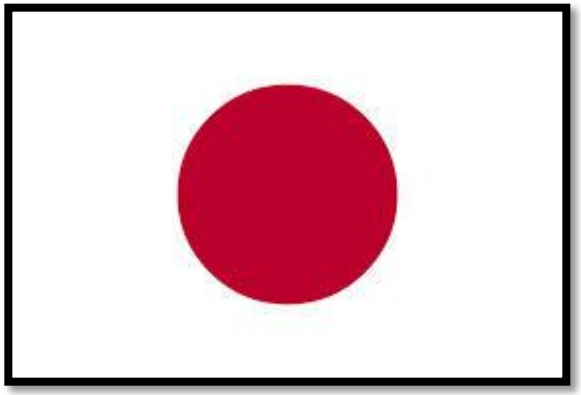
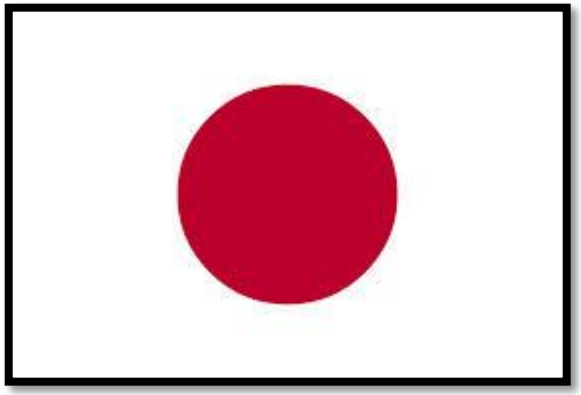
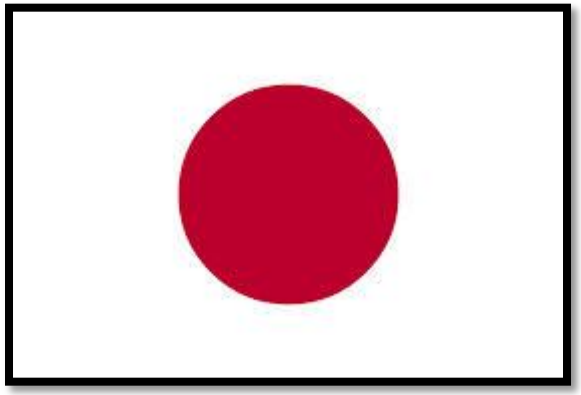
Overview of procedures for evaluating effects of cold treatment on fruit quality

- Use commercial quality fruit, with appropriate maturity
- Test sufficient quantities from different harvest times, include most sensitive types, eg. lemons
- Expose fruit using step down simulation of commercial practice in appropriate packaging
- After cold treatment, expose to simulated storage
- Evaluate sample repeatedly after various storage periods up to 4 weeks after treatment

Treatments taken up into protocols for export of citrus fruit from South Africa

Japan: Fruit Flies – *Ceratitis* species

- 12 days at -0.6°C ± 0.6°C for Sweet oranges, Grapefruit and lemons
- 14 days at T<0°C for Clementines (“mandarins”)

Treatments taken up into protocols for export of citrus fruit from South Africa

USA: *Thaumatotibia leucotreta*

- T107e (protocol followed by People's Republic of China, South Korea & Thailand)
  up to 2005: 22d at T< -0.3°C
- 2d added to citrus treatment in 2005 as a precautionary measure (T107k)



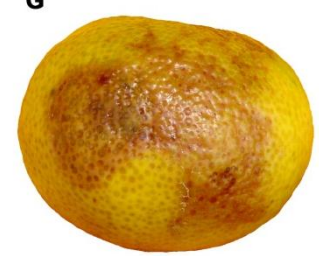
Combination Treatments Under Development

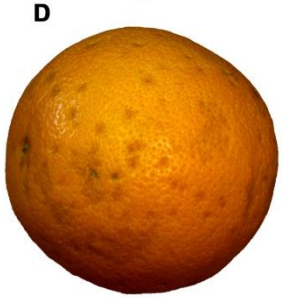
- *T. leucotreta*: (1) 60 Gy, (2) 16 days at T< 2.5˚C

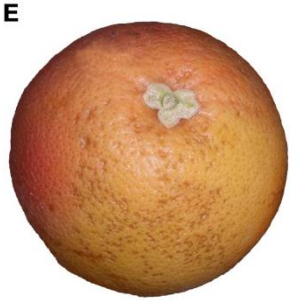
- *T. leucotreta*: systems approach, including T<2.5˚C for X days (X still to be determined)

Issues relating to the development of treatment conditions & export protocols

- Life stage end point assessment
- Converting trial temperature data into an upper treatment (protocol) threshold
- Pre-treatment cooling period
- Trials in natural hosts versus artificial culture medium
- Equivalency of validated treatments across fruit types
- Evaluation of fruit quality effects that are relevant to commercial application
  - Chilling injury incidence
  - Reduced shelf life (Internal quality and susceptibility to decay)
  - Colour loss
  - Freeze damage







Chilling injury

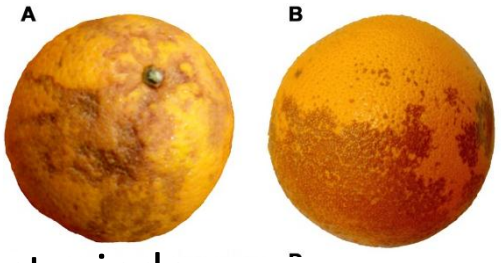
Freeze damage

Irradiation damage 750 Gr

Rind colour loss (7 vs. -0.6 C)

Issues relating to practical implementation

- Failure to complete uninterupted exposure to the treatment (upper T threshold)
- Inclusion of mandatory pre-treatment may result in excessive (both efficacy and fruit damage) exposure to cold
  - Forced air pre-cooling can result in chilling injury (scalding) and freeze damage
- Effectiveness of containers versus specialised Reefer vessels
  - Reefer vessels have better capacity to control temperature within protocol during voyage
  - Higher risk of chilling and freeze damage in container
- Unpredictability of chilling injury
  - Significant variation between cultivars
    Lemon>grapefruit>Navel>Valencia>Mandarin
  - Variation in susceptibility over the season reduces harvest window
    First and last harvest higher susceptibility
  - No technology available to prevent chilling injury



Conclusions

- Cold treatment is a valuable disinfestation procedure with widespread use in international citrus trade
- Differences in trial procedure during development may account for differences in established treatments (eg. life stage end point)
- There is inconsistency in converting treatment conditions to export protocols (eg. upper T thresholds & pre-cooling)
- Requirement to repeat validations across countries, fruit types and varieties is a barrier to wider implementation (greater equivalency recognition required)
- Cold has practical limitations due to port infrastructure needs, engineering constraints of containers & fruit sensitivity
- More comprehensive standard cold treatment guidelines would be valuable


13 10:41AM
1A MO
1A MO