



# Avocado: Ready to Enjoy

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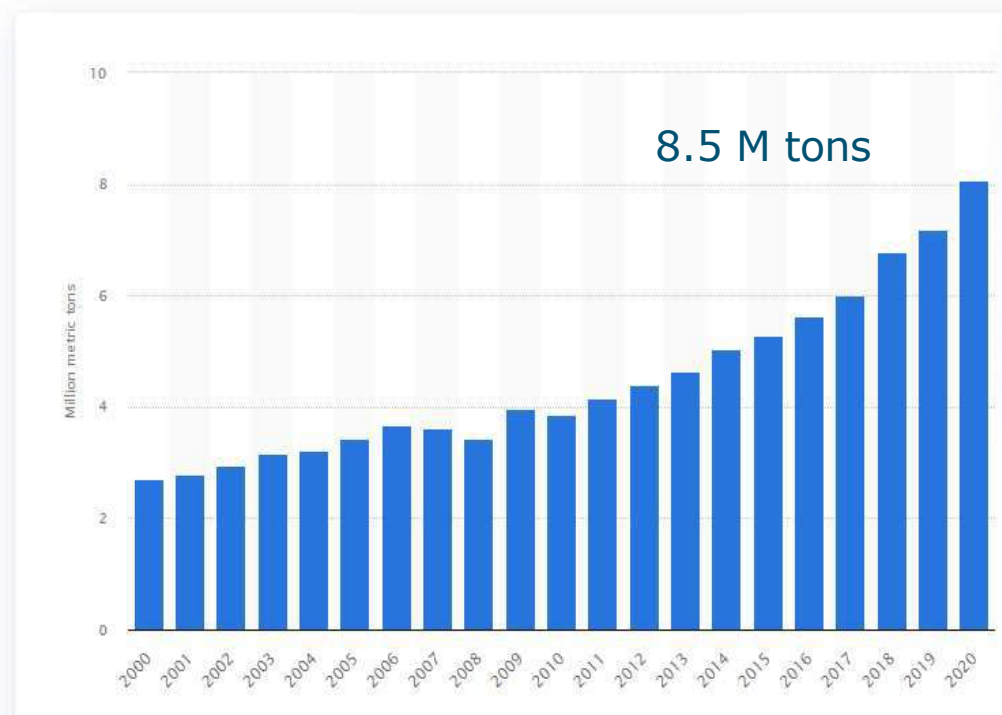
**WageningenFood & Biobased Research**

**The Netherlands**

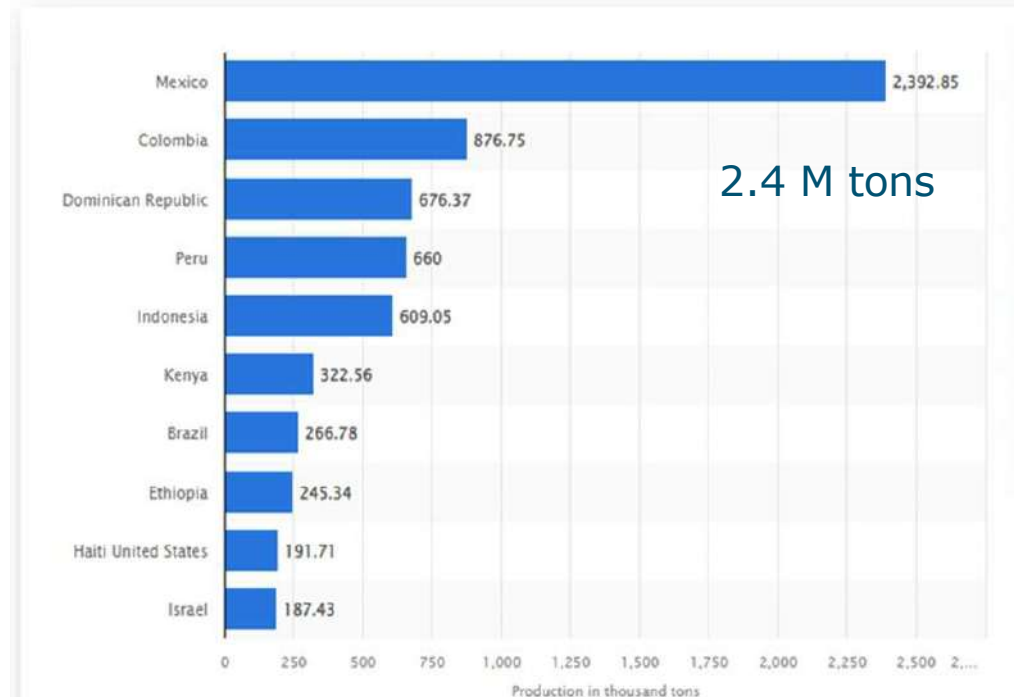
# Avocado production steadily increasing

- Producing countries in Mid and South America, Africa, Asia
- Main export market is in Europe and USA
- USA has avocado production in California; Europe mainly in Spain (55 000 tons), some in Italy (Sicily)

Avocado production worldwide from 2000 to 2020  
(in million metric tons) Source: Statista

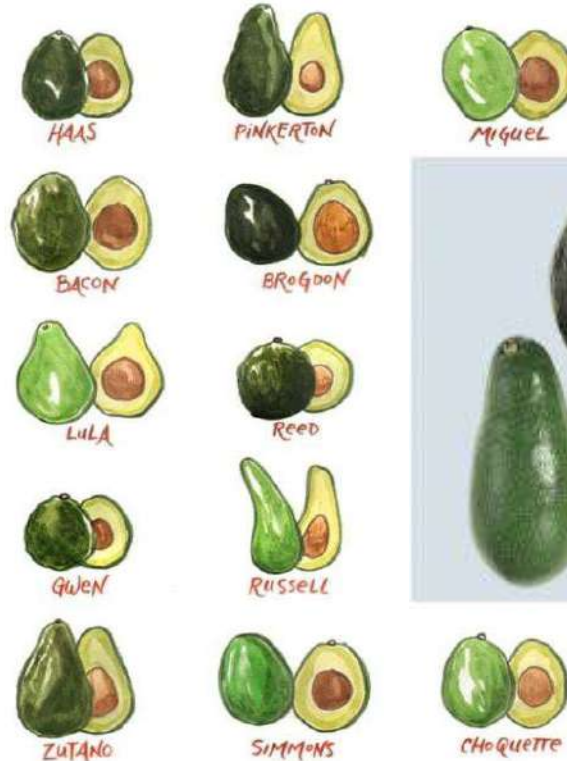
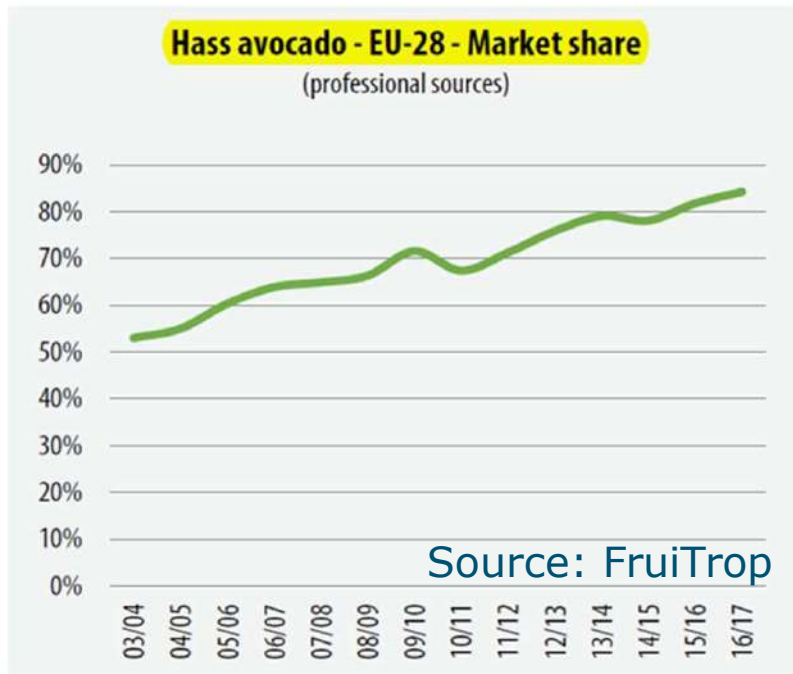


Global avocado production in 2020, by country  
(in 1,000 tons)



# Avocado product specifics

- Many different cvs (Fuerte and Hass most popular)
- Global trade is almost exclusively **Hass Avocado (90%)**
- Basically all the **same variety**, but with slight differences
  - Growing conditions, young, old, small, big trees
  - Different rootstocks are used to spread production
  - Mutants?



Source: CBI



# Avocado Facts: presumed healthy

- High antioxidants
- High Vit E
- High Vit K/folate
- High fiber
- High potassium
- High Fat (14%: 2% sat; 10% mono unsat; 2% poly unsaturated)
- Medium energy
- Medium calcium
- Low Vit C
- Low sugar (0.6%)
- Low selenium



# Antioxidants (Trolox Equivalents/100g)



Avocado 2000



Mango 1000



Kiwi 1000



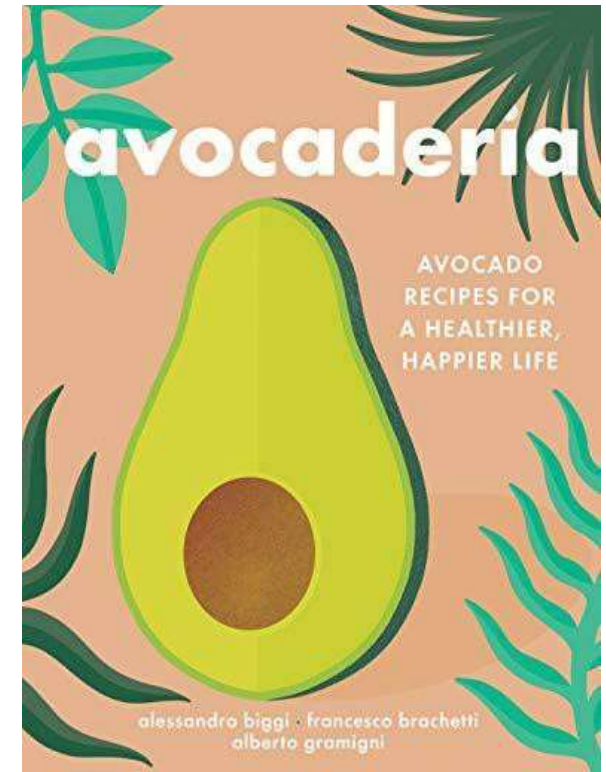
Banana 870



Pineapple 500

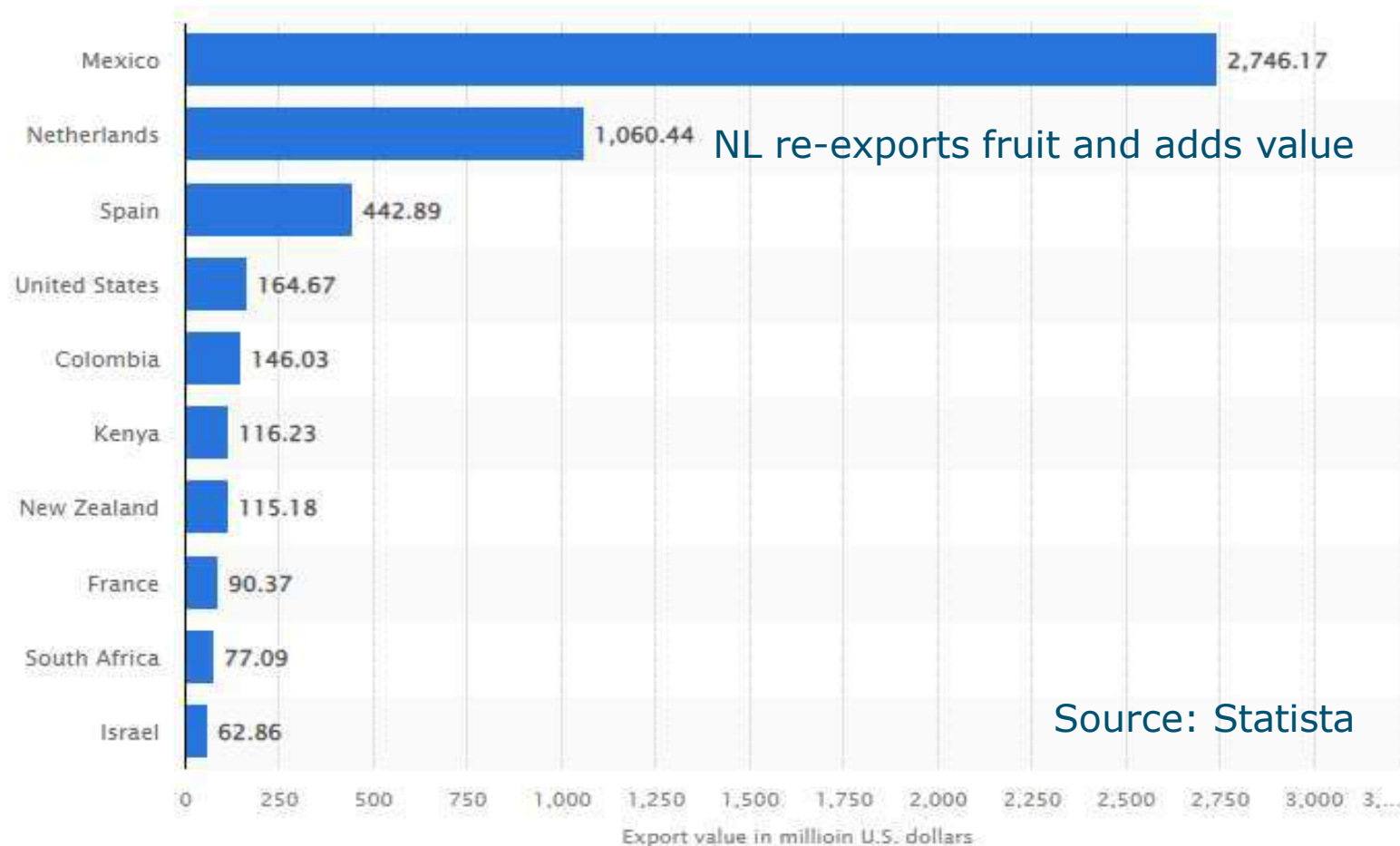
# Healthy fruit

- Presumed health effects are among the reasons for the popularity of Avocados the last 10 years
  - Special diets and recipes with avocado
  - Speciality restaurants
  - Avocado parties



# Exporting countries

Netherlands is second largest **Exporter** of Avocado (export value)



# Netherlands important trade hub

- The Netherlands (non-producer) is the **main trade hub** for avocados in Europe
- The Netherlands is responsible for half of Europe's avocado imports
- NL is **second-largest exporter of avocados** in the world. Large volumes are re-exported to Germany, France, the United Kingdom, Scandinavian countries and many others
- Several major avocado importers in the Netherlands, where **avocados are ripened** and from where they are distributed to many European destinations
  - Natures Pride, Bakker Barendrecht, Greenery, Total Exotics, HillFresh, LBP, Special Fruit (Be), ..

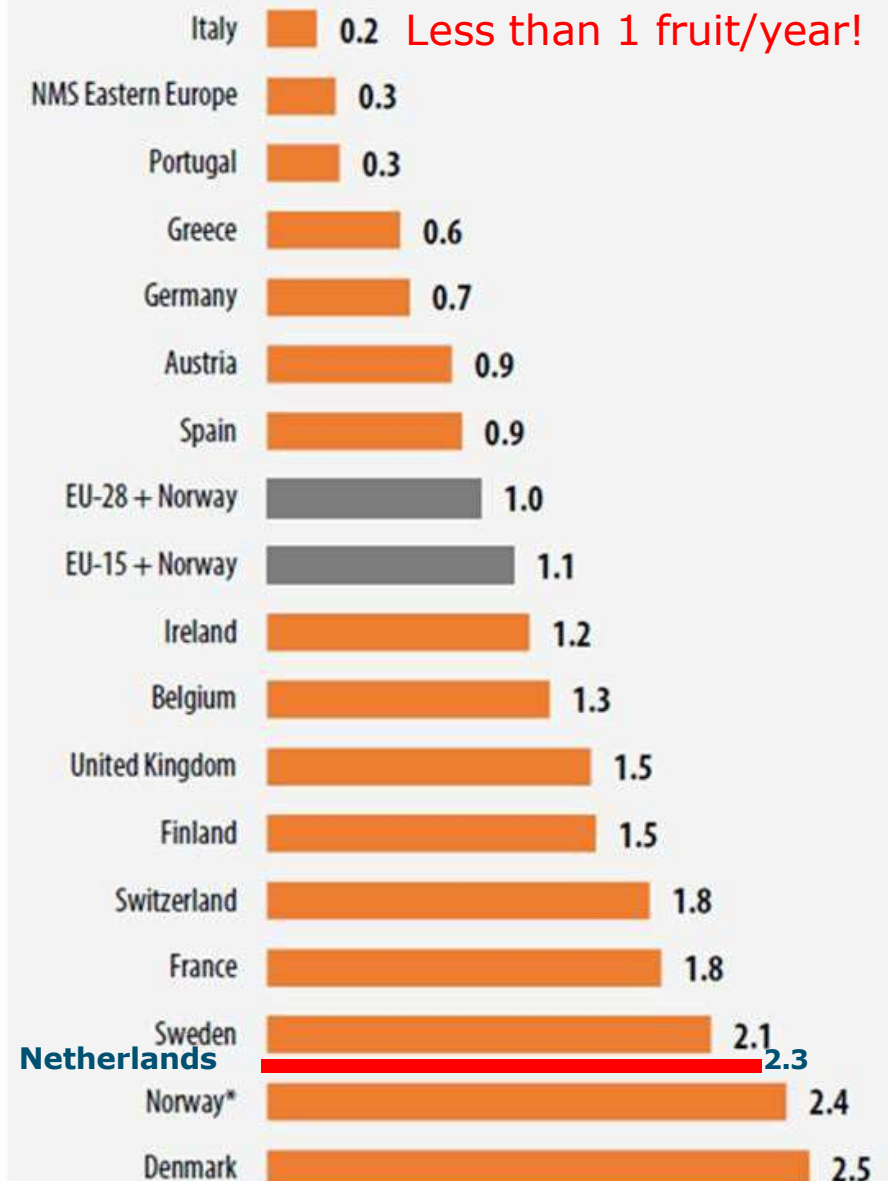


# Consumption

- Europe is ~1kg per capita per year.
- United States this is 3.5 kg and in Canada 2.5 kg
- **Huge growth potential!**
- Last 5 years consumption increased by ~200%
- Partly due to **Ready to Eat** fruit in the supermarkets

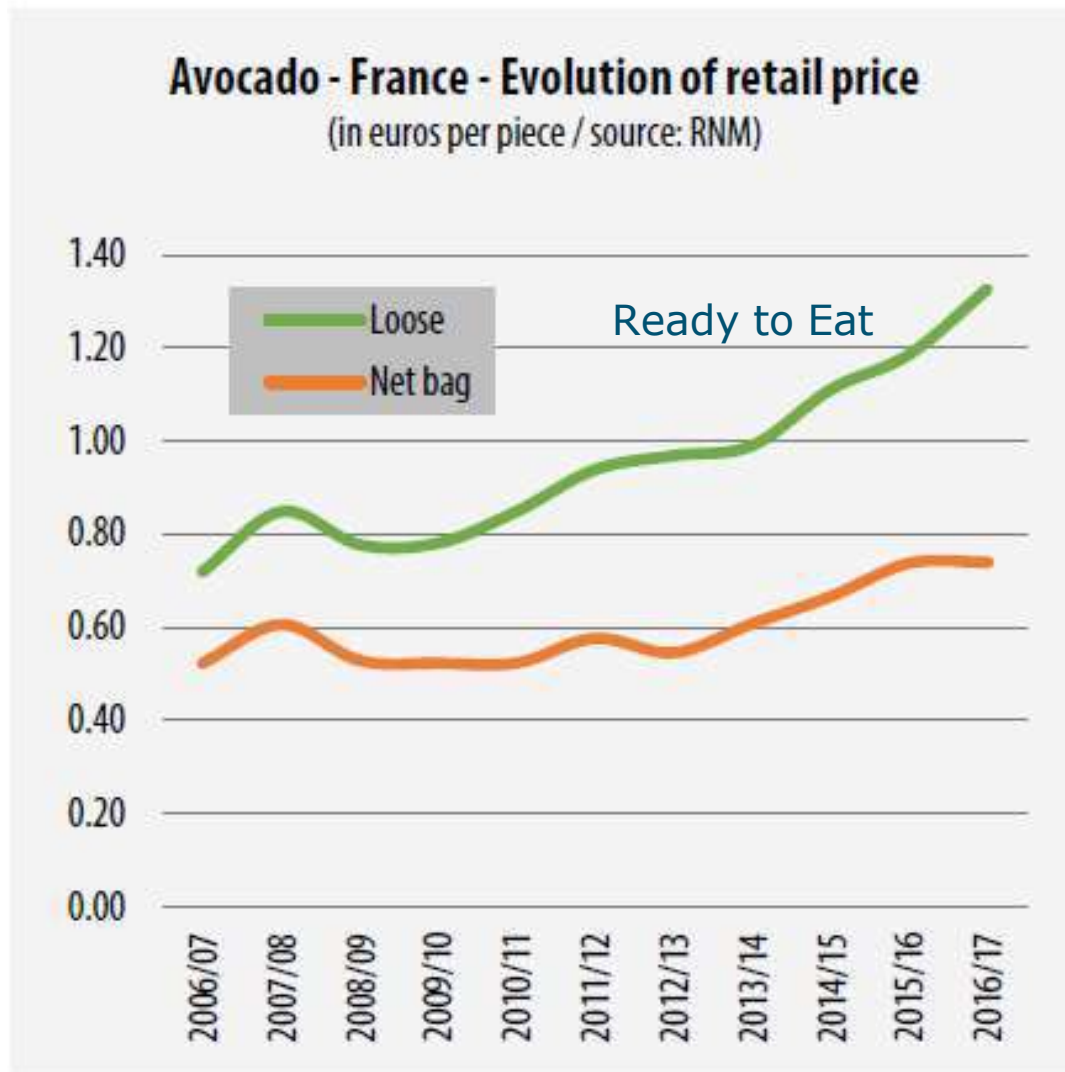
## Avocado - EU-28 - Consumption in 2016-17

(\*Norway: non EU / in kg/capita/year / source: Customs)



Source: FruiTrop

Ready to eat is growing most >> high price: 1 fruit typically 1.4 – 1.7 Euro



# Avocado chain

- Generally fruit are transported over sea in refrigerated containers at 5-7 °C; often under Controlled Atmospheres (3-5% O<sub>2</sub>; 5% CO<sub>2</sub>) and ethylene removal
- Transport times 3 – 5 weeks
- On arrival: Storage/ripening further transport in refrigerated trucks
- Ripening: ripening rooms 3-7 days
- Ripe (Ready2Eat) fruit in supermarkets



# Ripening economics

- The big fruit trading companies in NL ripen about 80-85% of imported avocados
- It is hard to estimate the **total % of fruit** that is ripened at destination to be sold as ready to eat: a guess would be **around 50-60%** and increasing
- The ripening process may take 3-7 days in special ripening chambers and it is generally known that about 5-20% of fruit is discarded during/after the ripening (waste)
- **Major problem: Each fruit ripens differently (related to maturity, natural variation), that means it is generally not possible to produce within one fixed ripening time a batch of ripe fruit**

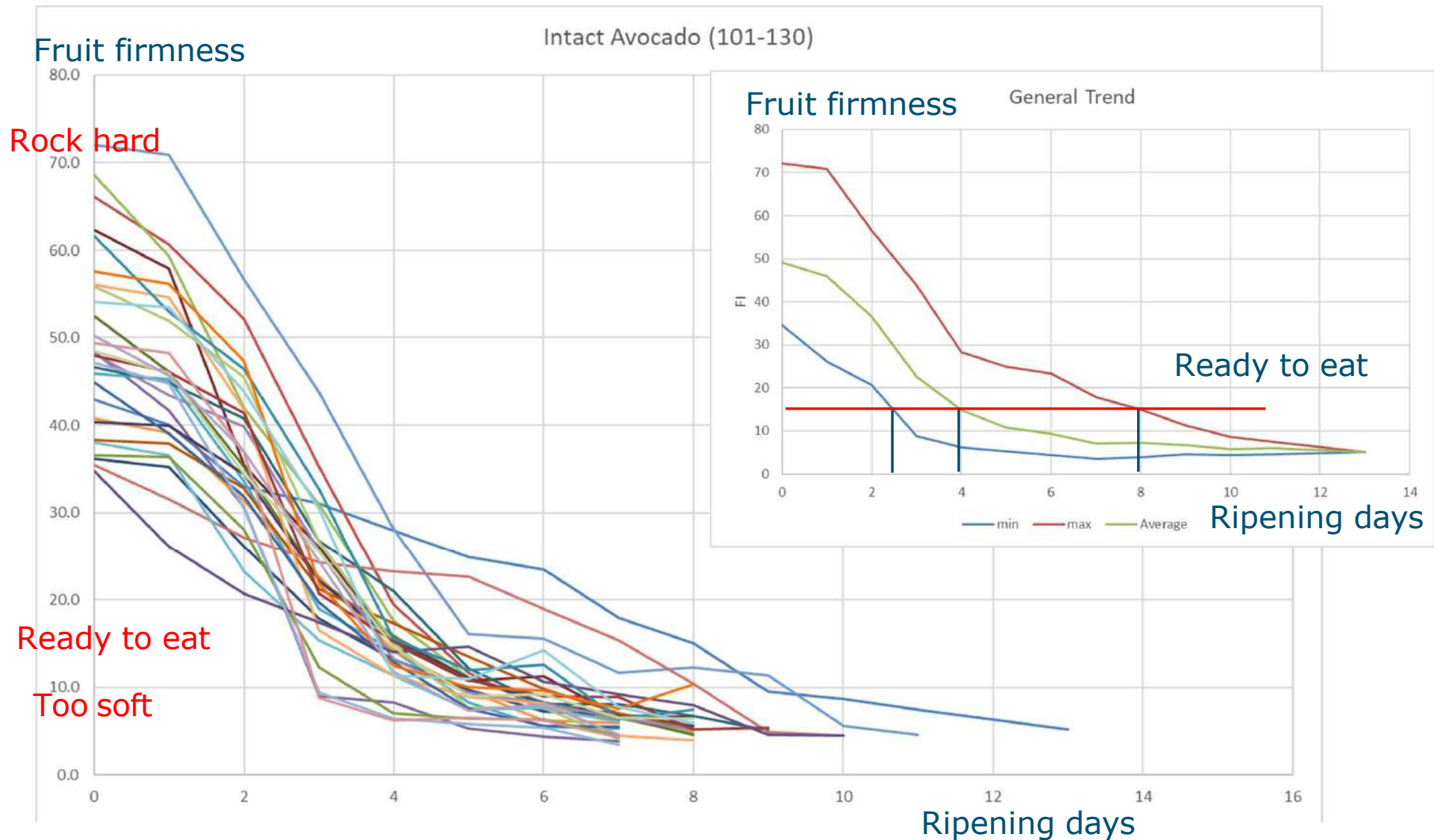


# When is the fruit Ready to Enjoy?

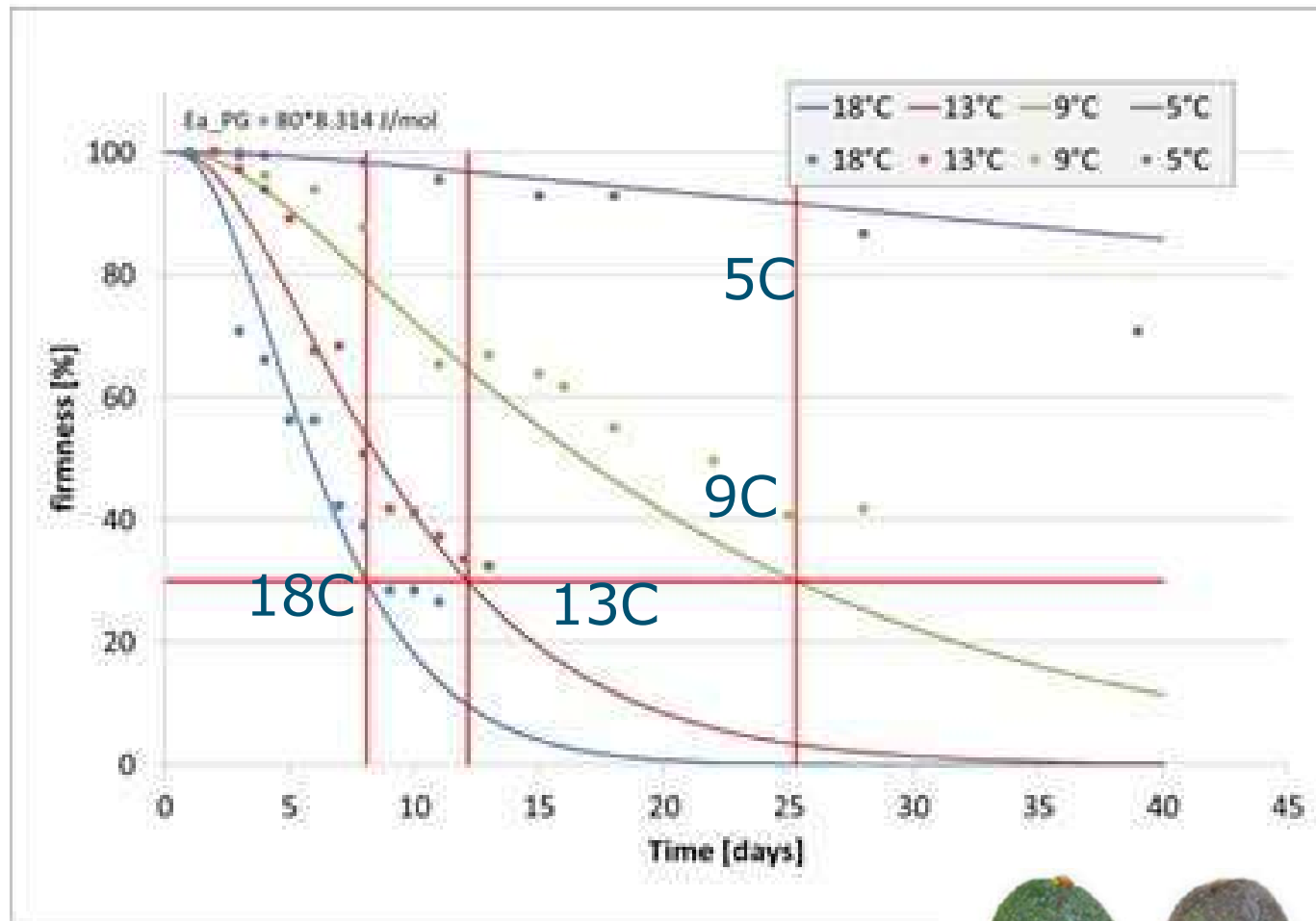
- Color is not always a good predictor for ripeness
- Firmness is more indicative of ripening stage
- Dry Matter % is important for taste
- We are developing improved protocols for efficient ripening and fruit that are Ready to Enjoy



# Example ripening patterns (firmness)

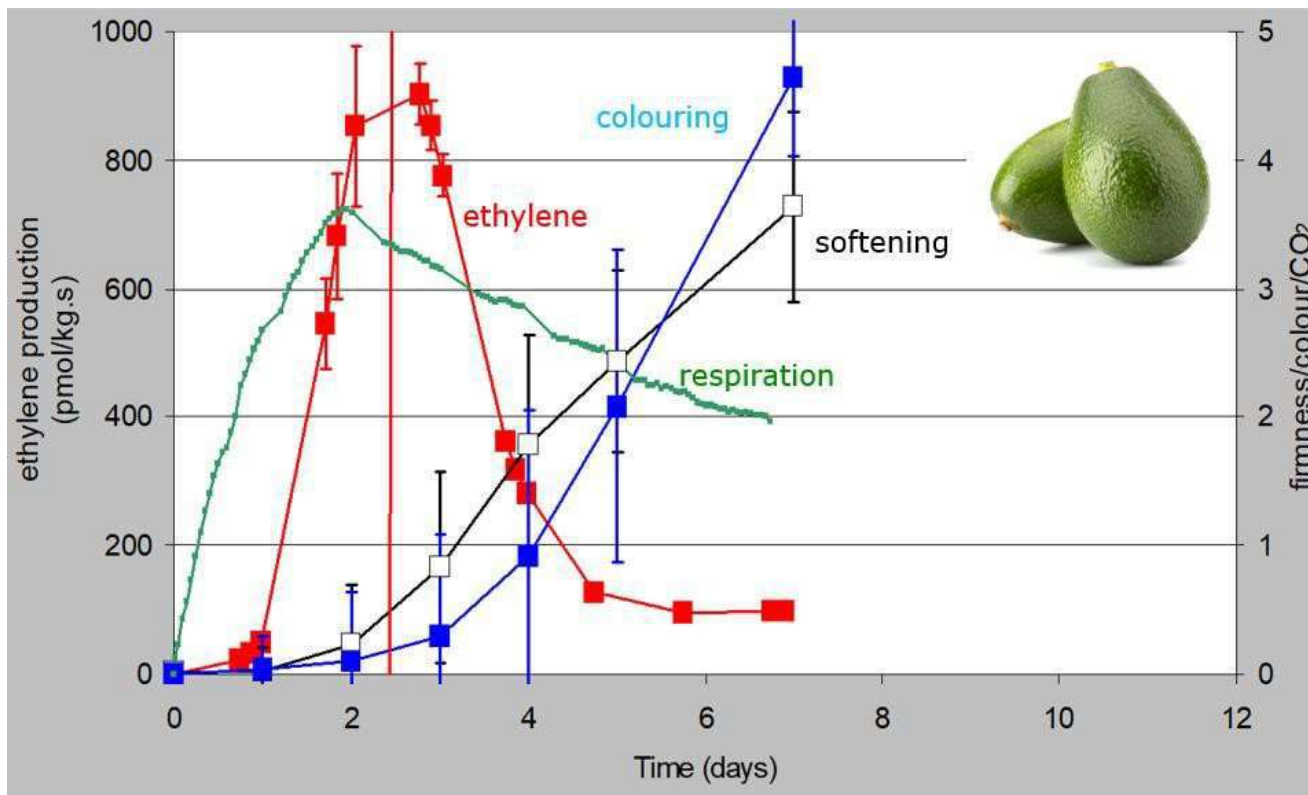


# Temperature affects ripening speed



# Effect Ethylene on ripening speed

- Ethylene coordinates the ripening in avocado fruit
  - **Big** effect in Early season fruit (low Dry Matter %)
  - **Small** effect on Late season fruit (high DM%)
  - **Big** effect on fruit immediately after harvest
  - **Small** effect on fruit after prior storage

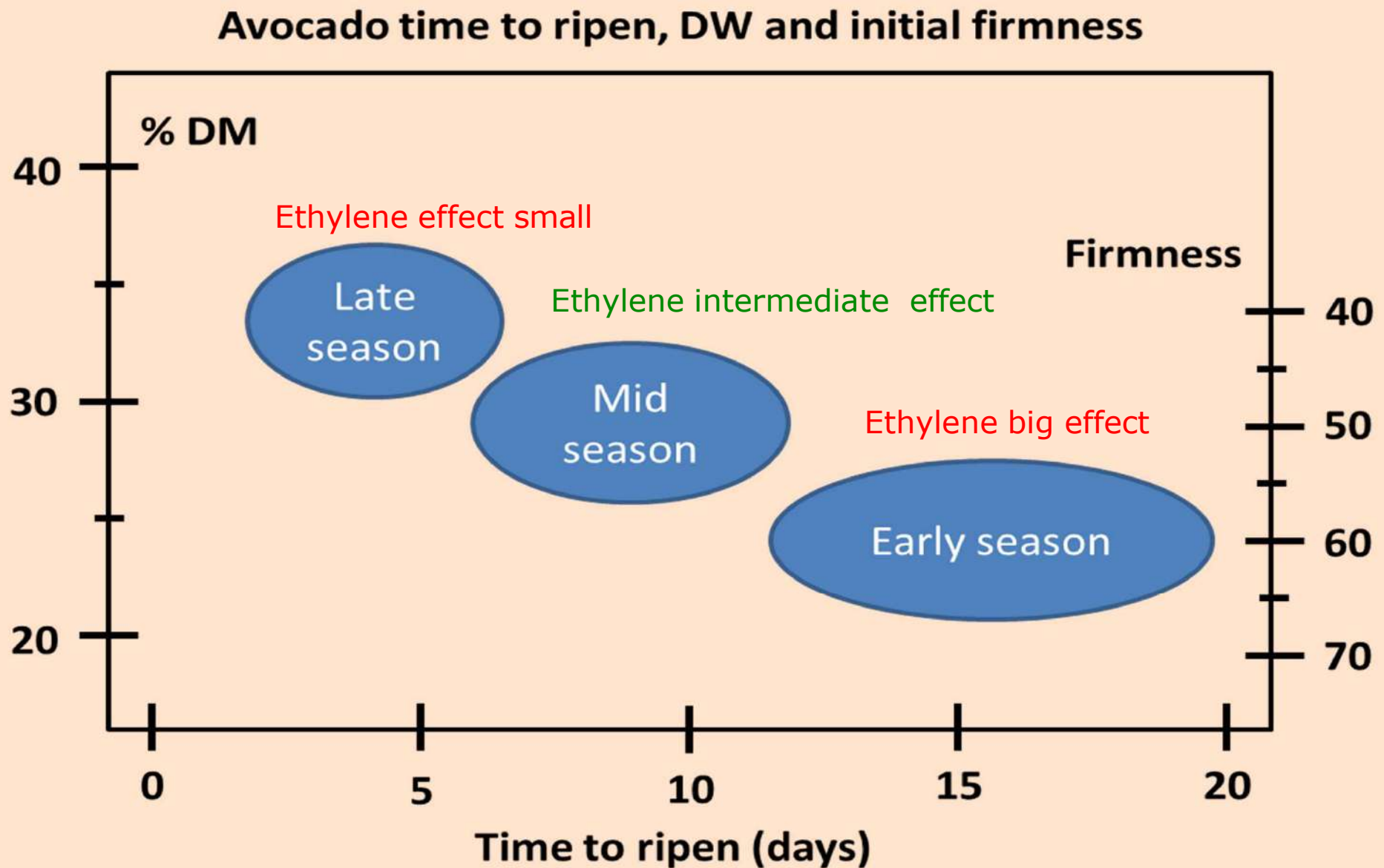




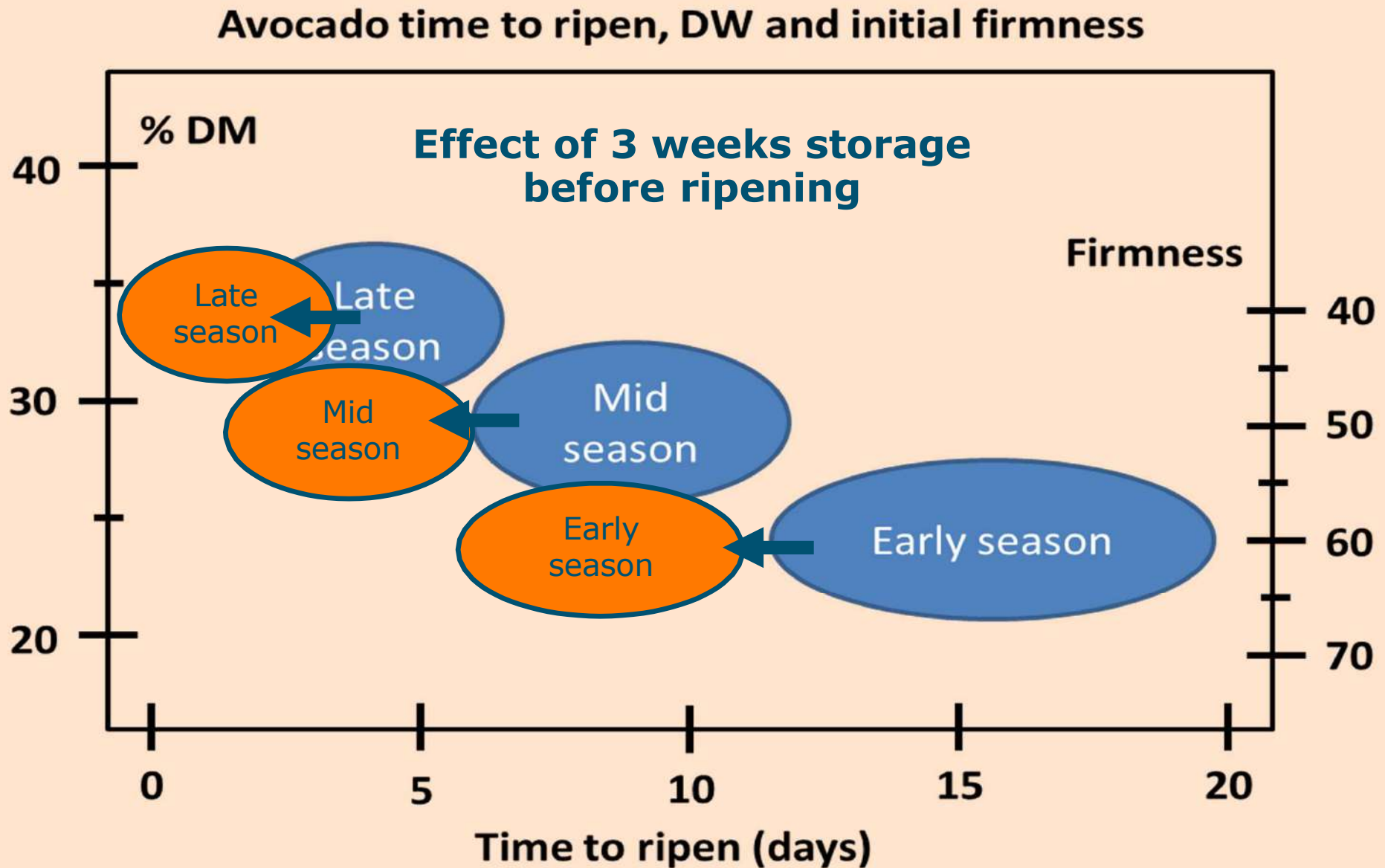
# Ripening of fruit: prediction modelling

- Firm fruit take longer to reach R2E than softer fruit
- Ripening depends on temperature
- Effect of Ethylene (ripening hormone) depends on fruit maturity (**early, mid, late season fruit**) and prior transportation time
- **We use all this information to predict for each individual fruit the ripening behaviour**
- A measurement of **firmness and Dry Matter%** of each fruit at arrival is required, and information about prior storage time
- Then, different batches can be sorted out and given specific ripening conditions

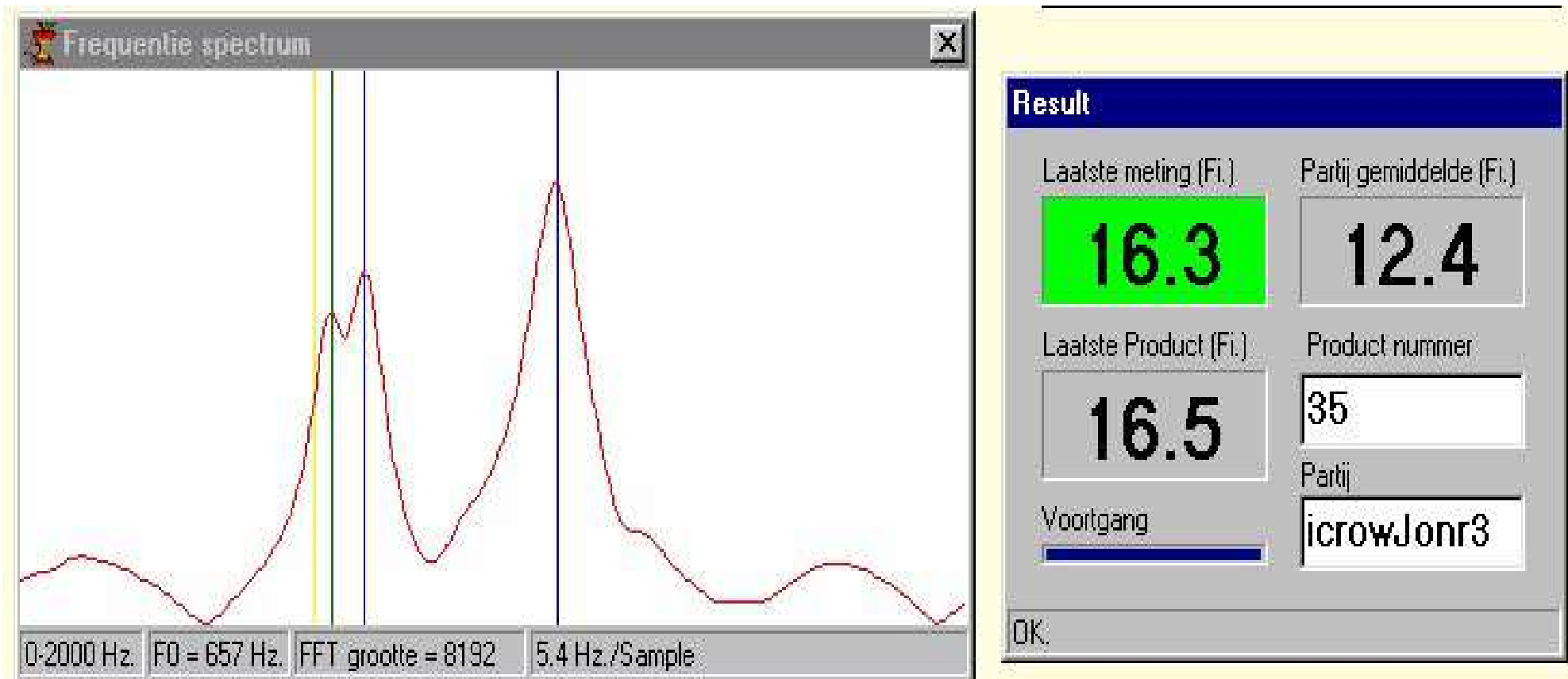
# Avocado ripening (no prior storage)



# Avocado ripening (3 weeks prior storage)



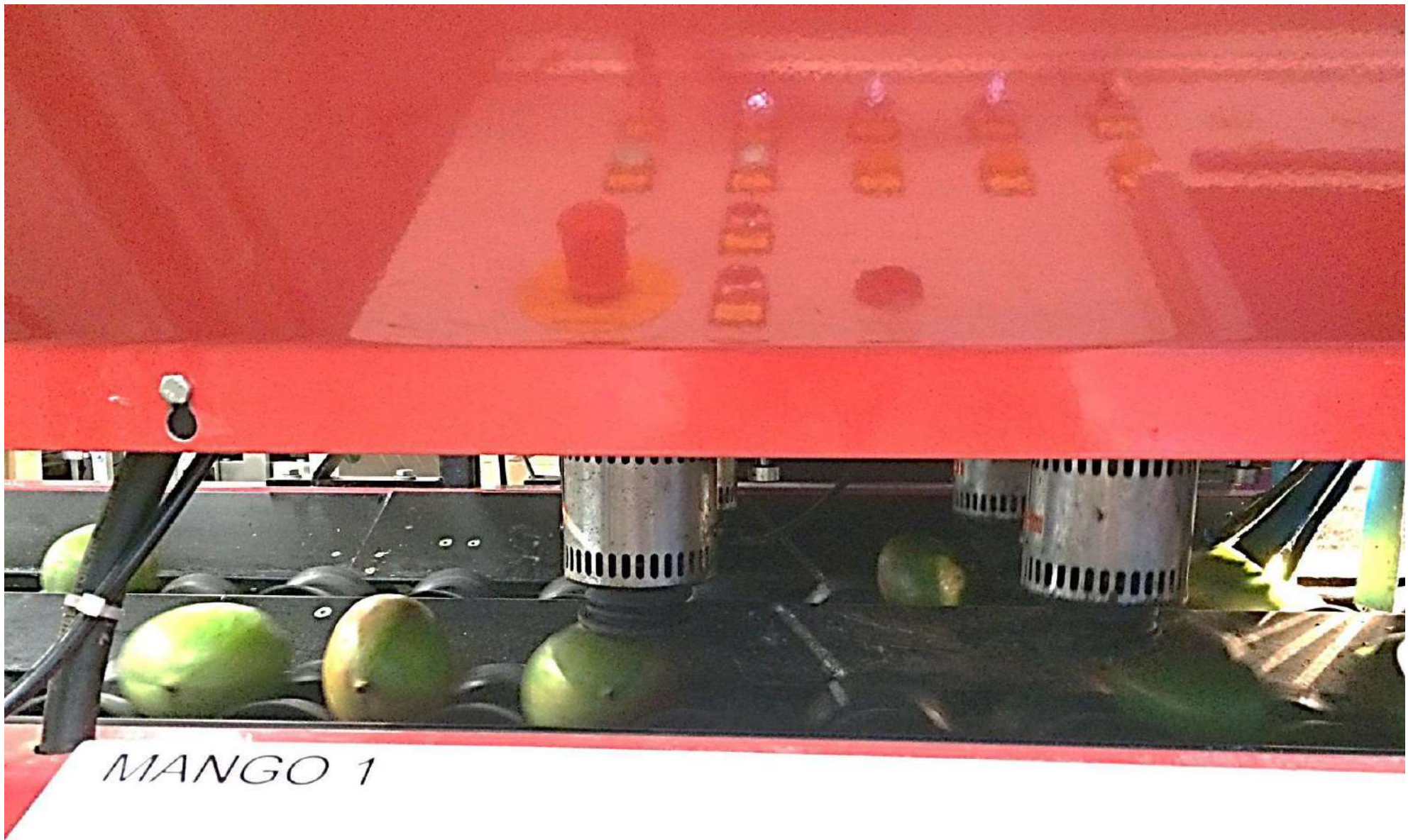
# Sorting based on Acoustic spectrum non-destructive



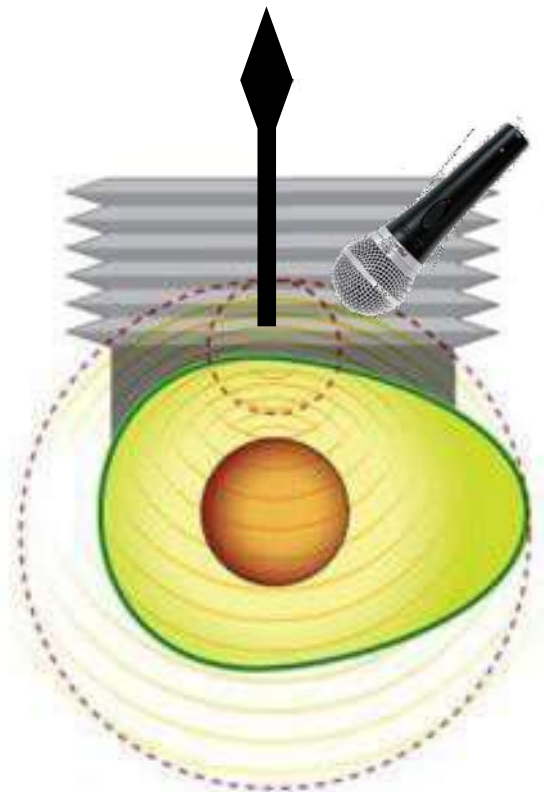




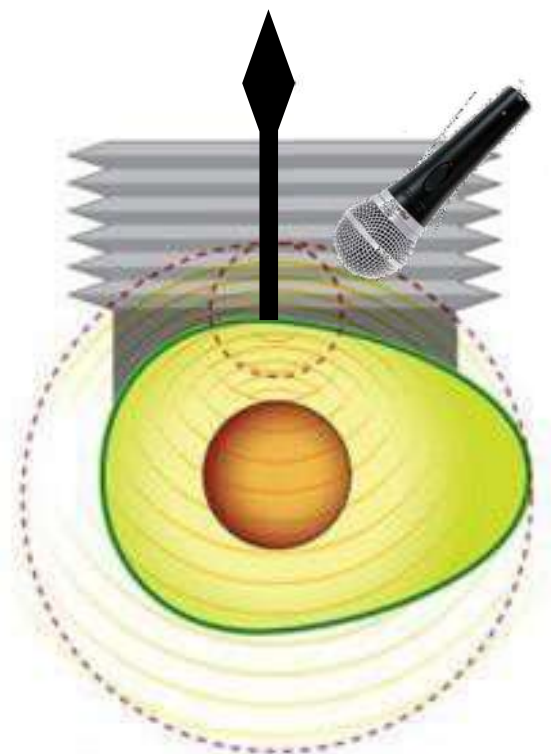




# Acoustics to measure firmness

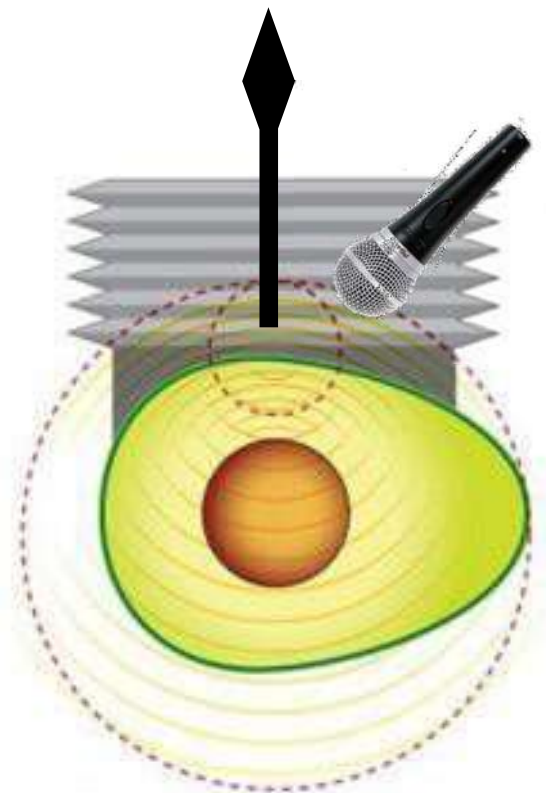


Acoustic Firmness Sorting  
High Technology

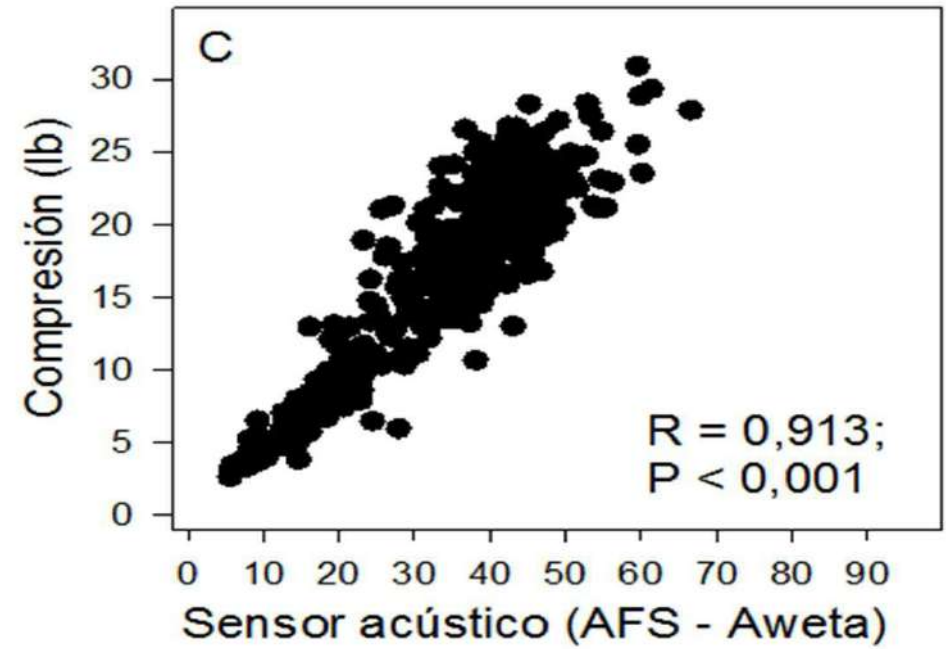
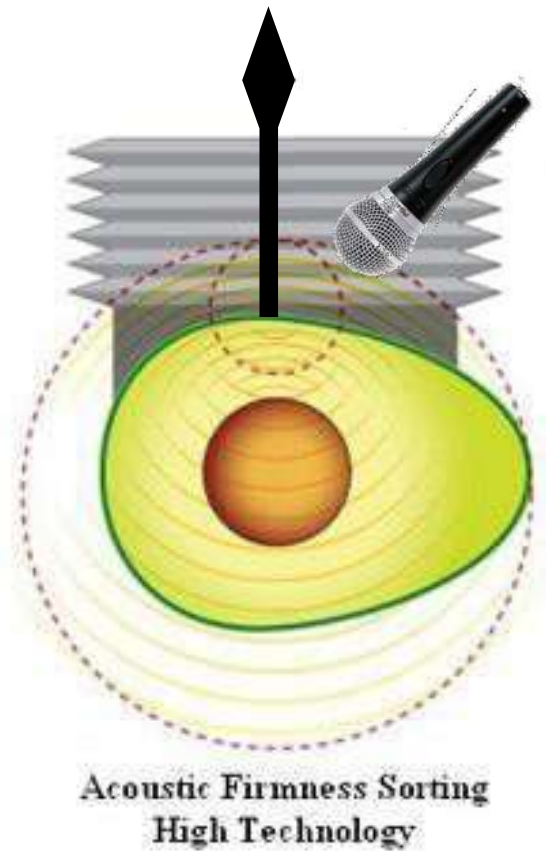


Acoustic Firmness Sorting  
High Technology





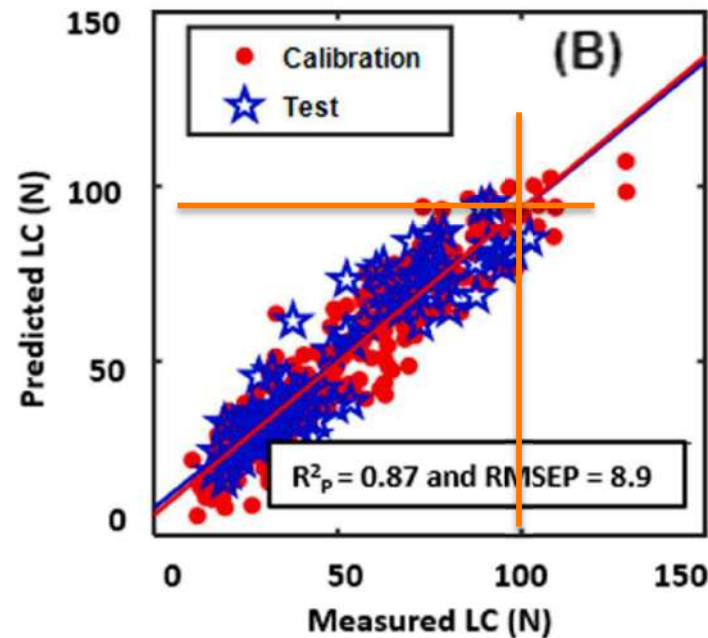
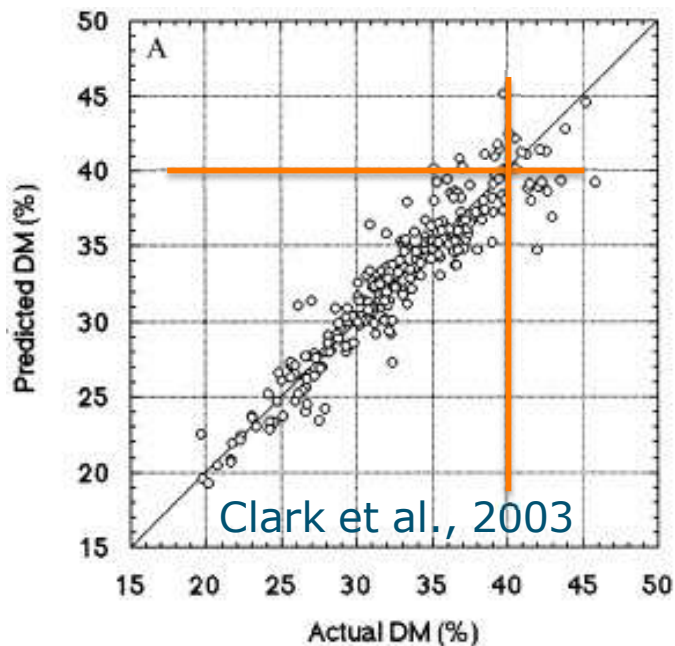
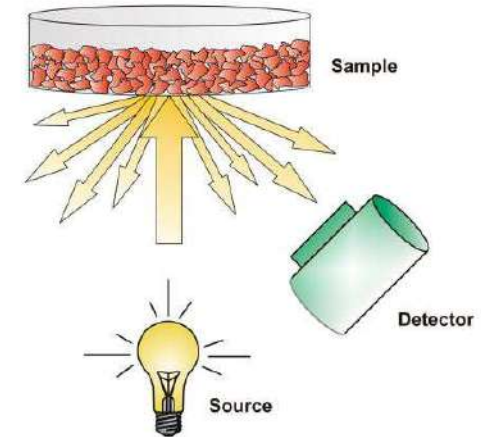
Acoustic Firmness Sorting  
High Technology



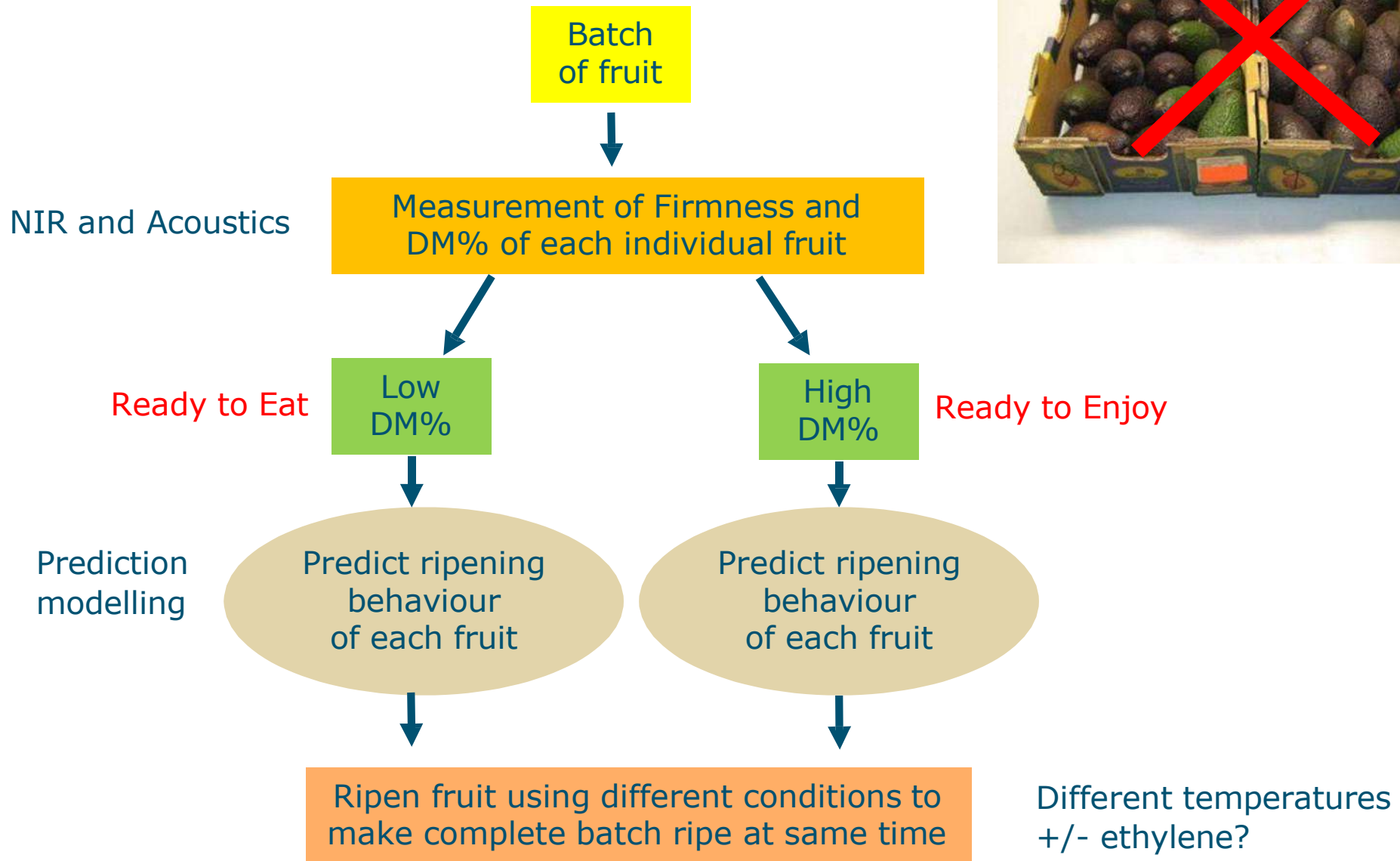
Good correlation between non-destructive and destructive measurements of firmness

# Measuring dry matter% and firmness

- Same sorting machines often also contain a NIR measurement
  - Near infrared spectroscopy
  - The spectrum contains info about the fruit properties
- Good correlation with fruit DM% and also Firmness



# Pre-ripening sorting



# Developments

- Avocado consumption is boosted by its reputation as a **healthy fruit** and innovation in **ready-to-eat** avocados
- The 'ready to eat' trend is particularly strong in the United Kingdom and the Netherlands, but many countries in Europe are following. It will continue to develop further and help **boost the consumption**
- **Ripening models** take into account initial ripeness (firmness) and dry matter content (both measured non-destructively) and storage history
- Applying this ripening knowledge leads to **less variability** in end product quality (more consumer satisfaction) and **restricts waste**.



**Thank you for  
your attention!**



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