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# Advancing table grape quality assessment with non-destructive technologies: what we know and what we still need to discover.

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## 10<sup>th</sup> INTERNATIONAL TABLE GRAPE SYMPOSIUM

26 November - 1 December 2023

Lord Charles Hotel, Somerset West, South Africa



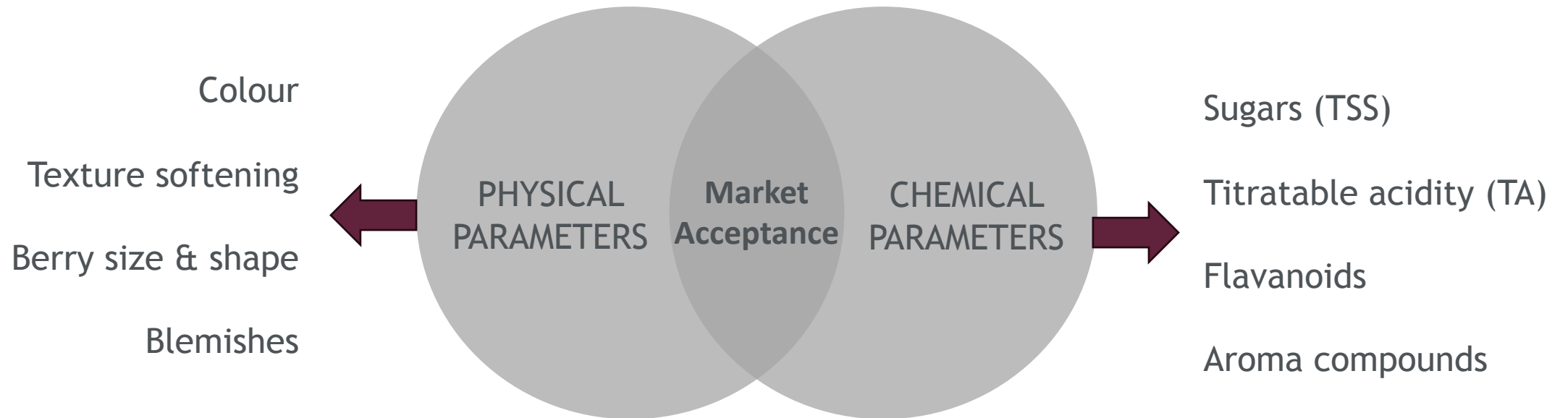
# THE IMPORTANCE OF ACCURATE QUALITY ASSESSMENT

- Table grapes are an economically important commodity crop
  - One of four major fruits
  - 36% of grape production is table grapes for consumption



# THE IMPORTANCE OF ACCURATE QUALITY ASSESSMENT

- Premature or delayed harvesting can lead to:
  - Difficulties in accessing markets for premium price
  - Rejection by market



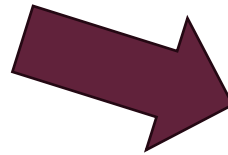
# THE CURRENT SCENARIO

## Methods currently used for determining table grape quality

- Mostly chemical/analytical analysis (simple and complex)
- Visual assessment and scoring of colour, compaction etc.

- PROBLEMS??

- Destructive
- Time-consuming
- Not necessarily representative
- Subjective
- Not cost effective

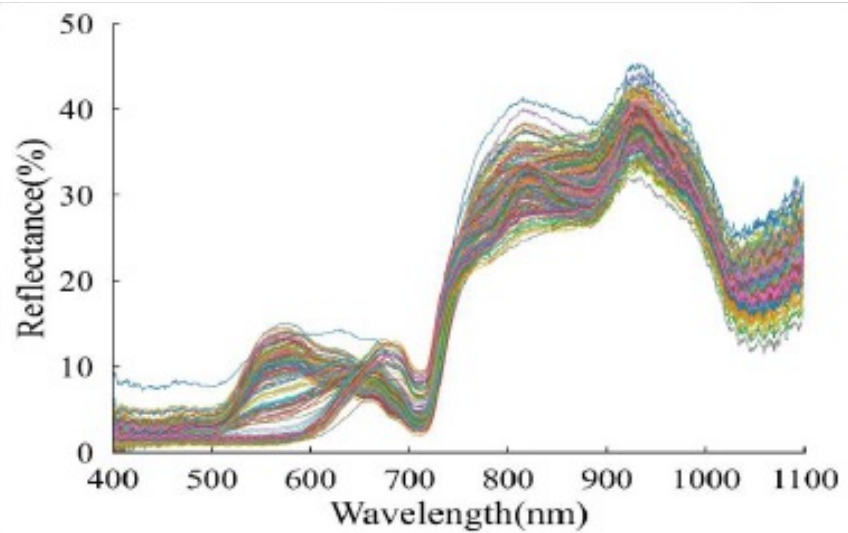


## THE NEED FOR NON-DESTRUCTIVE METHODS:

1. Fast, accurate and objective
2. Multiparametric
3. High throughput
4. Provide real-time information
5. Field and packhouse applications?

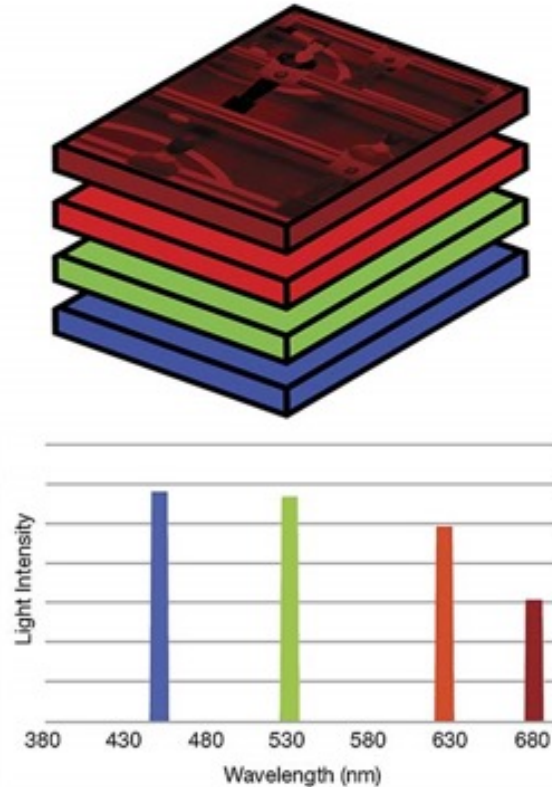
# THE TECHNOLOGIES UNDER INVESTIGATION

## Spectrometry



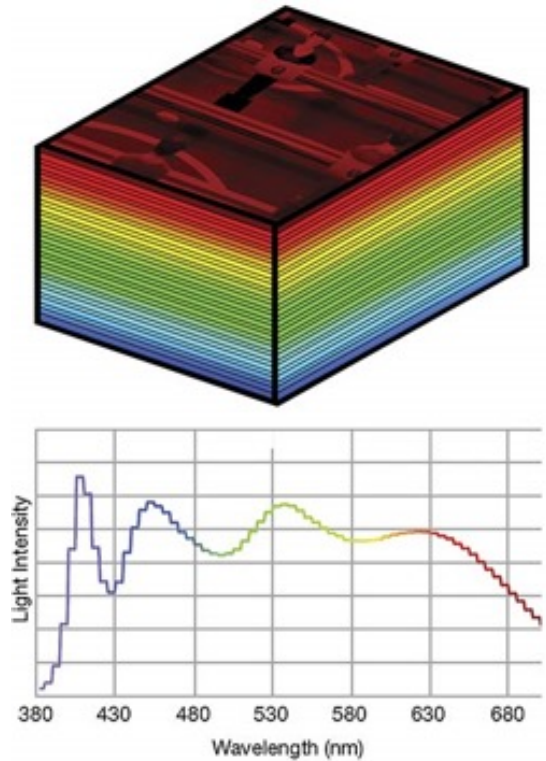
- Continuous data

## Multispectral



- 4-10 bands per pixel

## Hyperspectral



- 100+ bands per pixel

↑ 1D spectral data + 2D spatial data ↑

# PRELIMINARY SCOPING REVIEW

## What do we want to find out?

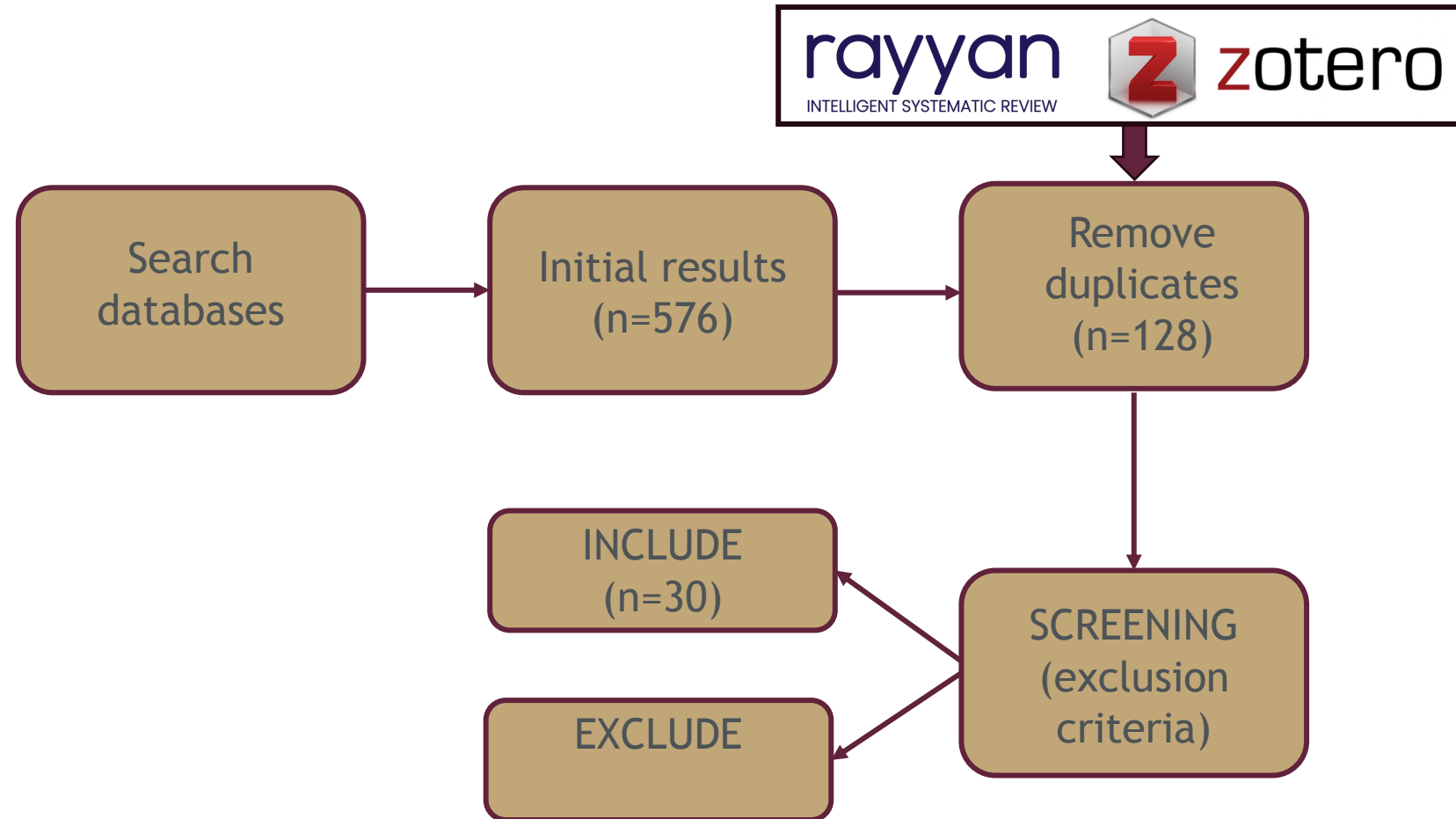
Research question / objective	Sub-questions / sub-objectives
What <b>literature exists</b> on use of multispectral imaging, hyperspectral imaging and spectroscopy for <b>grape</b> quality evaluation	How much is in <u>table grapes</u> ? How much is <u>lab vs field</u> ? Which <b>quality parameters</b> have been investigated for table grapes using non-destructive technologies?
What <b>protocols</b> were used for <b>table grape quality parameters</b> ?	In the <u>field</u> ? In the <u>lab</u> ? Which protocols were <u>most appropriate</u> for the respective parameter(s) measured?
What <b>data analysis techniques</b> were used in the studies conducted on table grapes?	For <u>data extraction</u> ? For <u>feature selection</u> ? <u>Pre-processing</u> steps used? Which <b>modling techniques</b> were <u>most suitable</u> ?



# PRELIMINARY SCOPING REVIEW

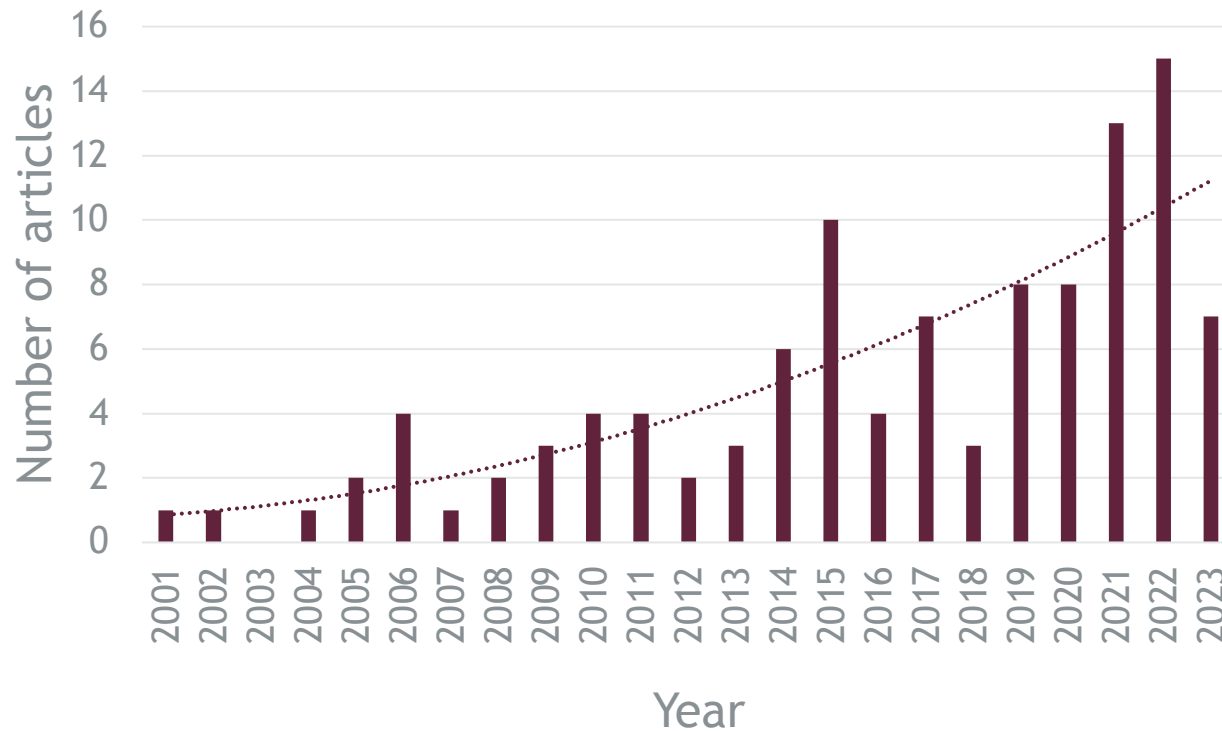
## The process

- Search strategy
  - Define search strings
  - Define databases



# INITIAL SEARCH RESULTS

## Distribution of articles 2001 - 2023



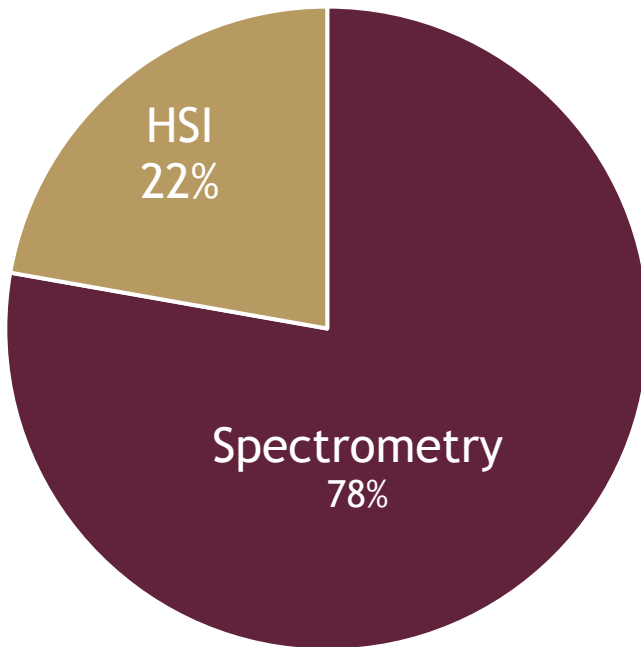
- After duplicate removal
- n=128



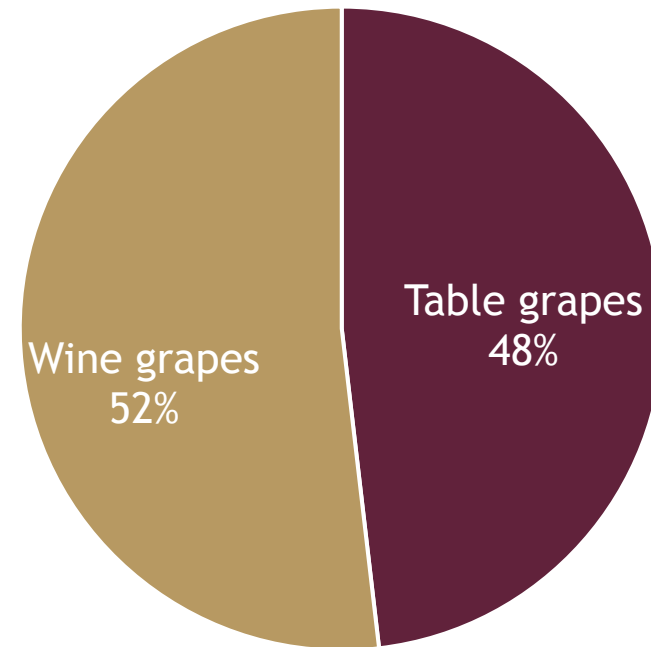
# TECHNOLOGIES AND GRAPE TYPES

TIME PERIOD OF INCLUDED STUDIES	
SPECTROMETRY	2008 - 2023
HYPERSPPECTRAL IMAGING	2012 - 2023

Percentage of articles per **technology**

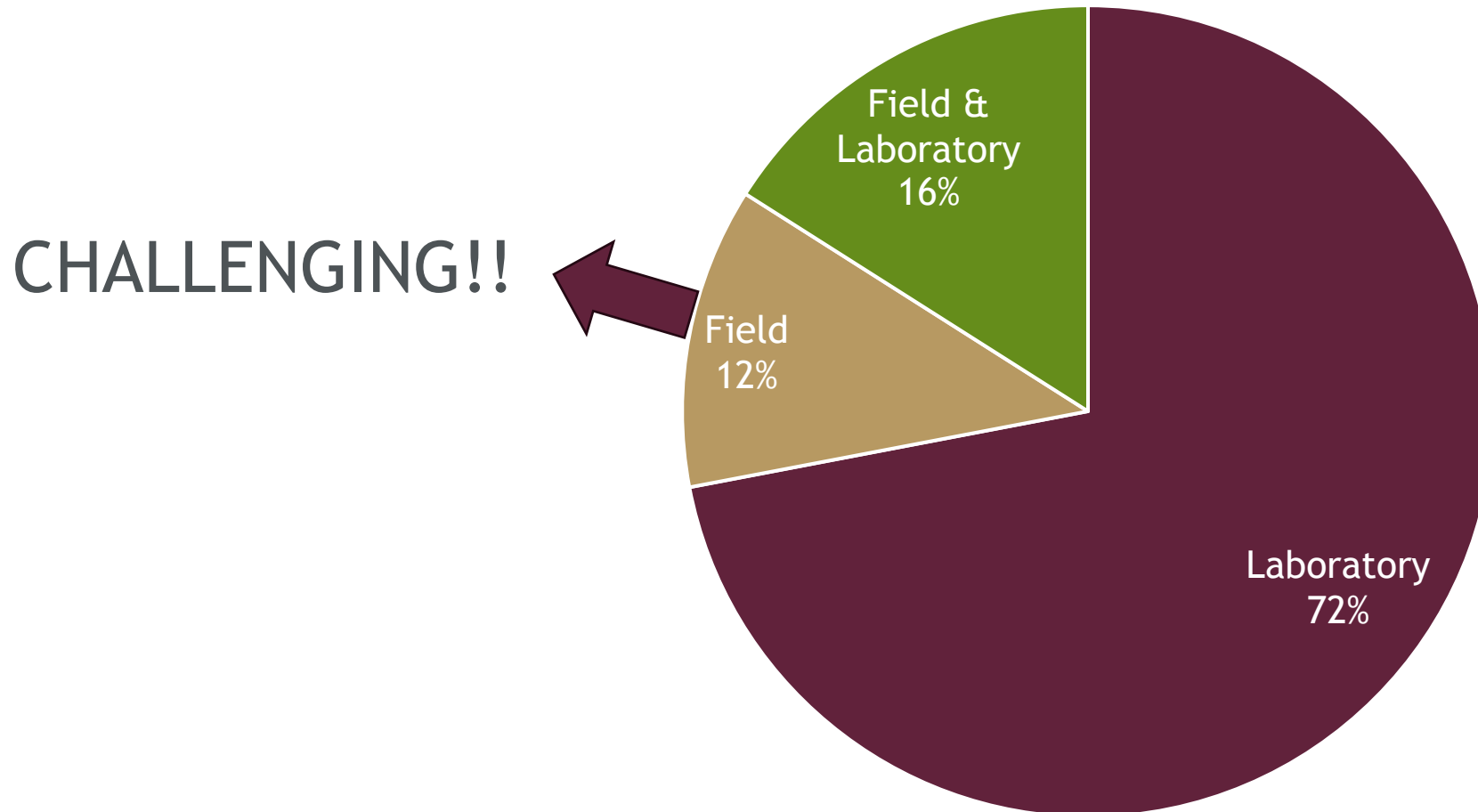


Percentage of articles per **grape type**



# STUDY CONDITIONS

## Percentage of articles per study condition



# DATA PROCESSING AND MODELLING

## Data preprocessing

- Normalization
- 1d Savitzky-Golay
- 2d Savitzky-Golay
- Standard normal variate (SNV)
- Multiplicative scatter correction (MSC)

## Wavelength selection

- Variable importance in projection (VIP)
- Competitive adaptive reweighted sampling (CARS)
- Regression coefficient (RC)
- Successive projections algorithm (SPA)

## Modelling

- Partial least squares (PLS)
- Support vector machine (SVM)
- Least squares support vector machine (LSSVM)
- Principle component analysis (PCA)
- Partial least squared discriminant analysis (PLS-DA)

# DATA PROCESSING AND MODELLING

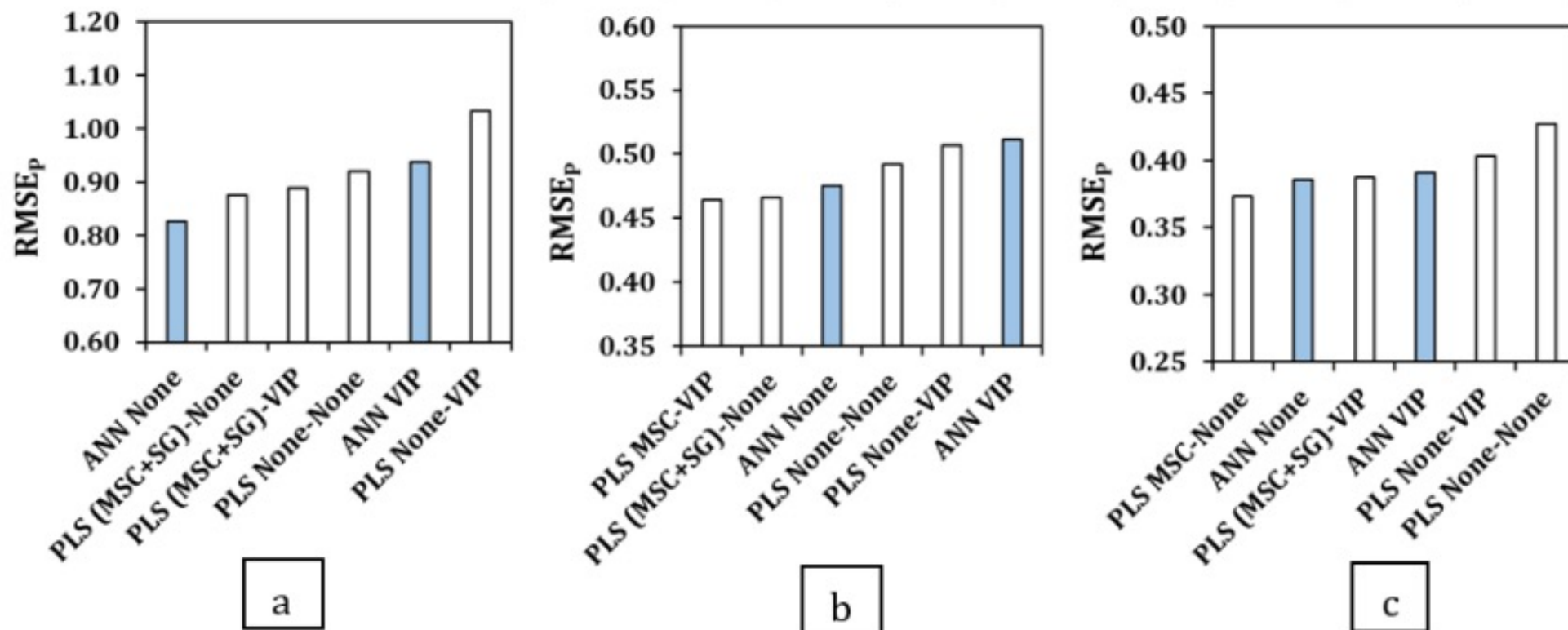


Figure 2. The prediction errors ( $RMSE_p$ ) that were achieved for TSS (a), TA (b) and the TSS/TA ratio (c) for ANN and PLS regression using the different spectral pre-processing methods. Light blue bars indicated the ANN models.

# PARAMETERS OF INTEREST

## Chemical

- Primary metabolites
  - Sugars (TSS)
  - Acids (Tartaric, Malic)
- Titratable acidity (TA)
- pH

## Physical

- Seedlessness (classification)
- Colour
- Firmness
- Size?
- Berry number?

# RESULTS FROM LITERATURE

## ACCURACY IS KEY

- The accuracy of prediction of models is measured
- $R^2$  is a prominent indicator - variation in interpretation

PARAMETER	$R^2$ (prediction)
Total soluble solids (TSS)	0.76 - 0.95
Titratable acidity (TA)	0.47 - 0.94
Firmness	0.57 - 0.78

## IT LOOKS PROMISING

- Many studies have promising results for non-destructive quality assessment techniques
- Complexity due to the number of models, processing methods and possible combinations
- Different protocols have been used - what will work best?
  - Distance from the object (especially MSI and HSI)
  - Light source
- Difficulties/Limitations
  - Conditions (°C, %RH, light)
  - Adaptability to field conditions not always possible



# CLOSING REMARKS

## WHERE DO WE GO FROM HERE?

- The final goal is global models for quality parameters.
- This will still require much research
  
- Include various cultivars
- Accounting for ambient conditions?
- Develop standardize protocols?
  
- Developing smaller hand-held sensors/sensors incorporated into mobile phones



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Thank you  
Enkosi  
Dankie



Photo by Stefan Els