

# Prediction of kernel density of single maize (*Zea mays* L.) kernels using a miniature near infrared (NIR) spectrophotometer

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# Outline



NIR spectroscopy:  
MicroNIR

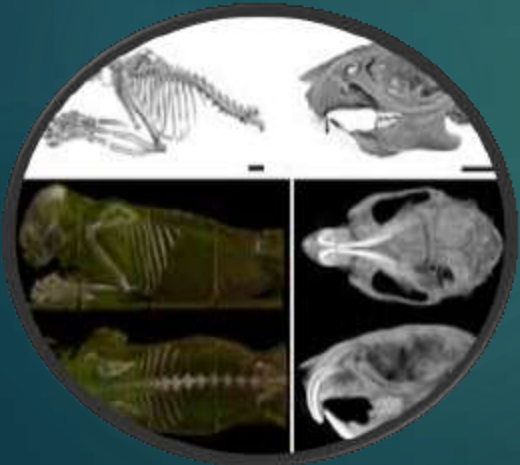
Maize breeding programmes



Single-kernel testing



X-ray  $\mu$ CT



Kernel density correlates with milling quality



# Samples



%Chop



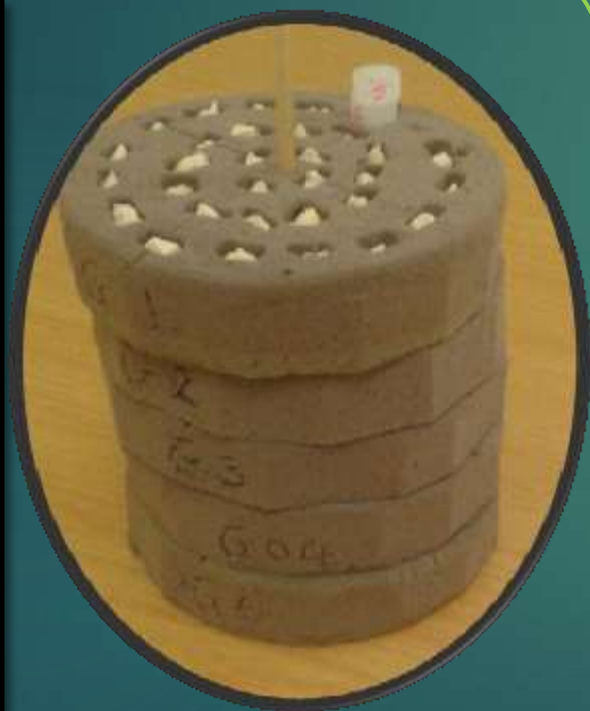
10 x good  
milling  
hybrids



10 x poor  
milling  
hybrids

15 kernels from each hybrid = 300 kernels

# X-ray micro-computed tomography ( $\mu$ CT): image acquisition



Sample preparation



X-ray computed tomography system

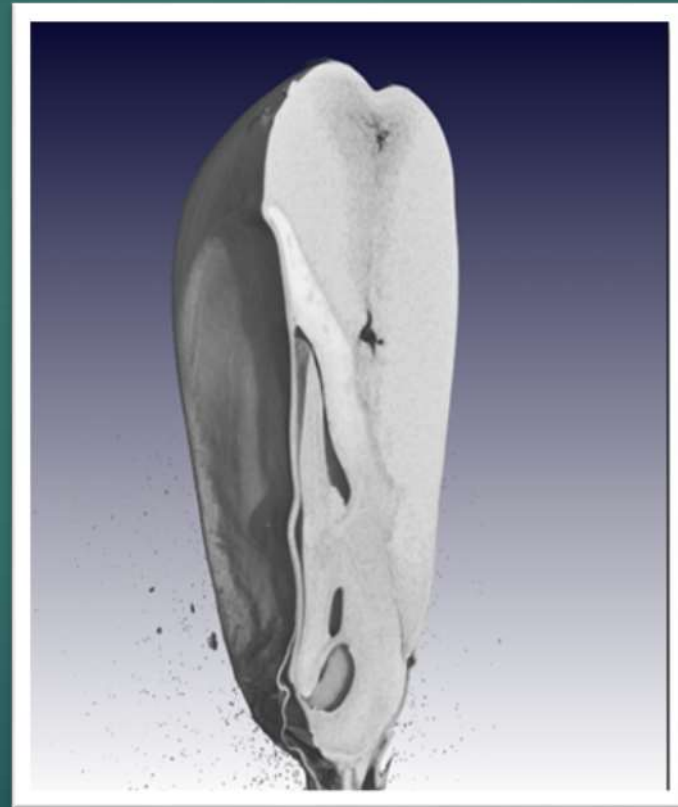


3-D rendering using Phoenix Datos acquisition and reconstruction software



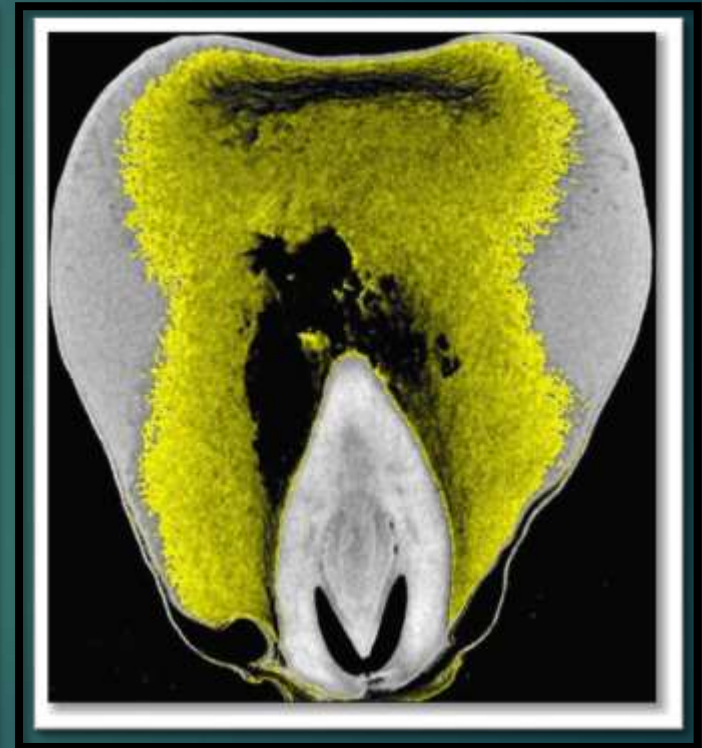
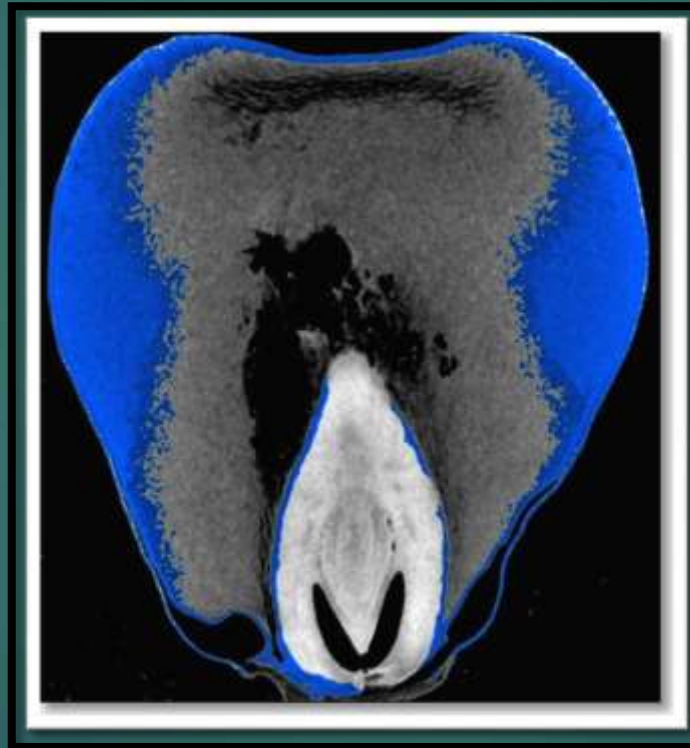
# X-ray micro-computed tomography ( $\mu$ CT): functionality of X-ray $\mu$ CT

- Exclusion of certain regions

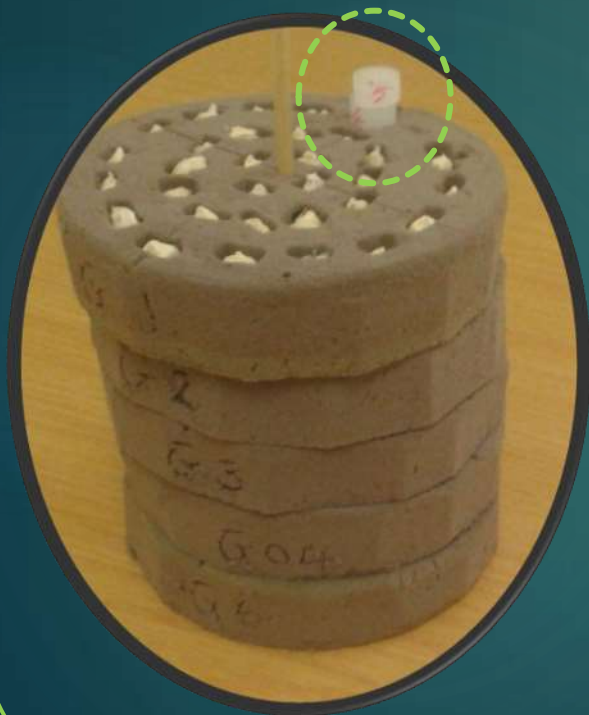


# X-ray micro-computed tomography ( $\mu$ CT): functionality of X-ray $\mu$ CT

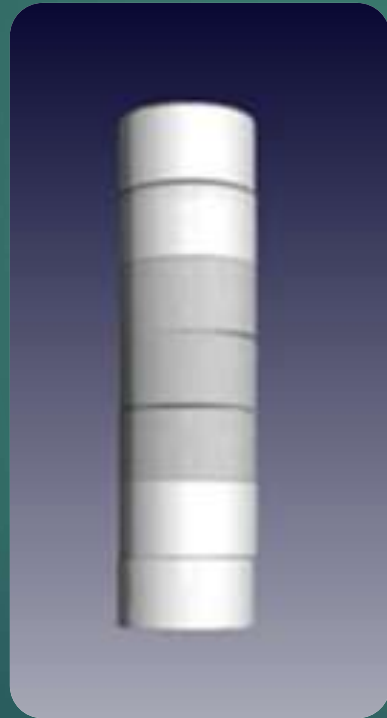
- Segmentation into specific regions
- Allows for quantification



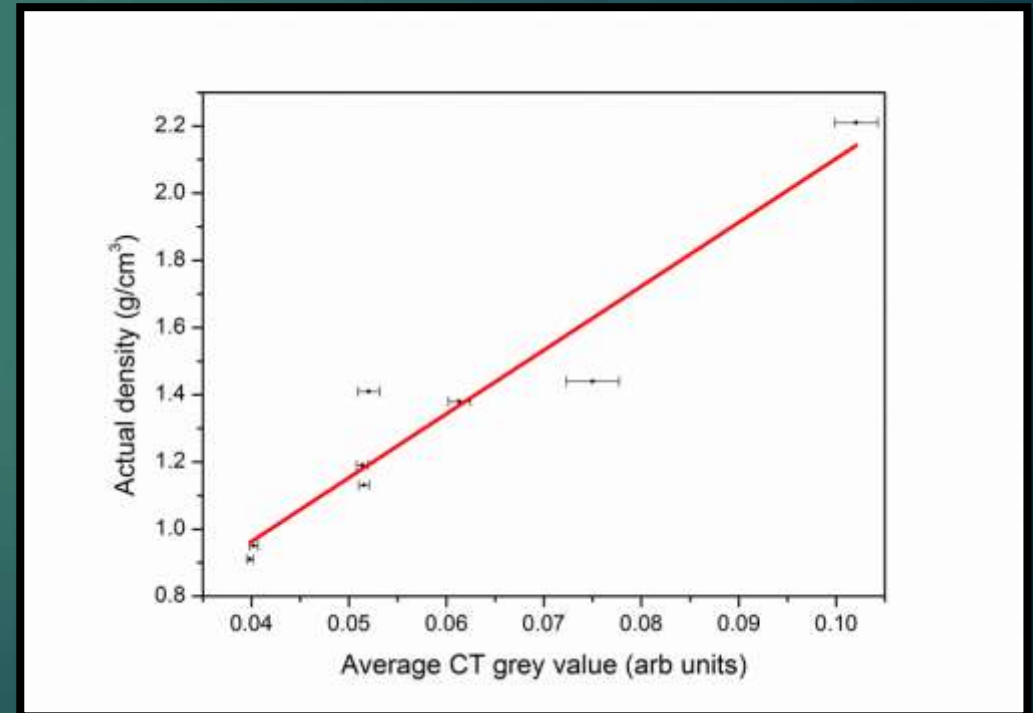
# X-ray micro-computed tomography ( $\mu$ CT): density calibration



(g.cm<sup>-3</sup>)  
2.15  
1.2  
0.92  
0.91  
0.92  
1.37  
1.15



Actual density (g.cm<sup>-3</sup>) =  $m \times \text{grey value} + c$   
where,  $m$  = the slope and  $c$  = intercept



# X-ray micro-computed tomography ( $\mu$ CT): usefulness of X-ray $\mu$ CT

- Floating test vs. X-ray  $\mu$ CT
- $r = 0.78$
- Large bias indicates difference in measurements
- Influence of cavities





# Near infrared (NIR) spectroscopy: multiple kernels

- Non-destructive
- Fast
- Easy to operate
- Low-cost

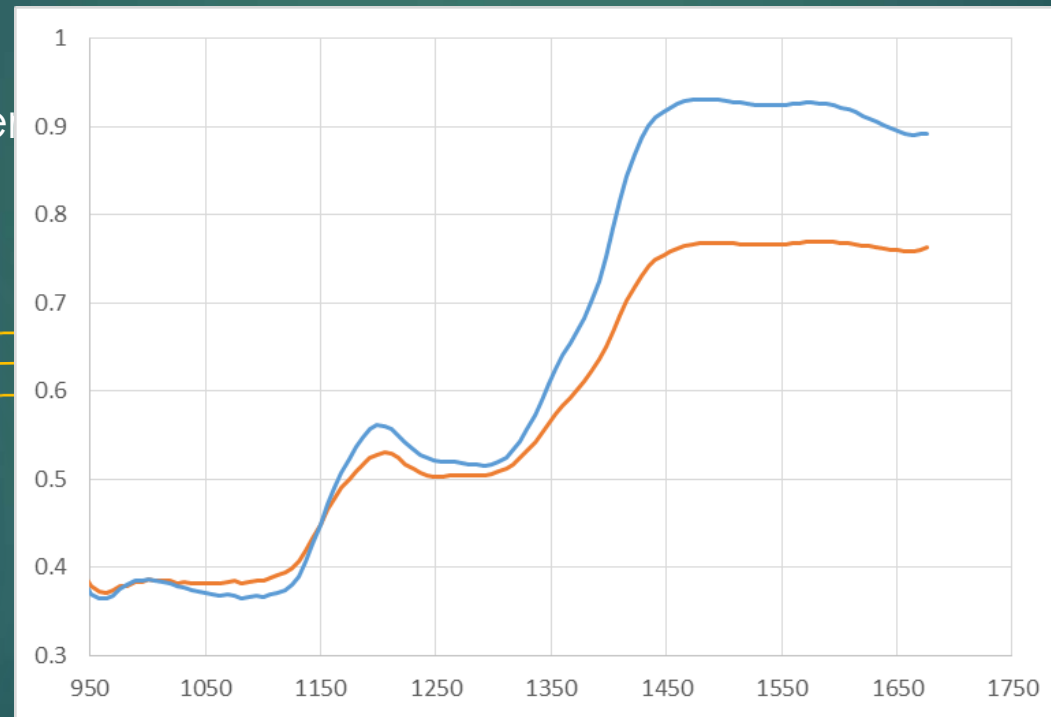
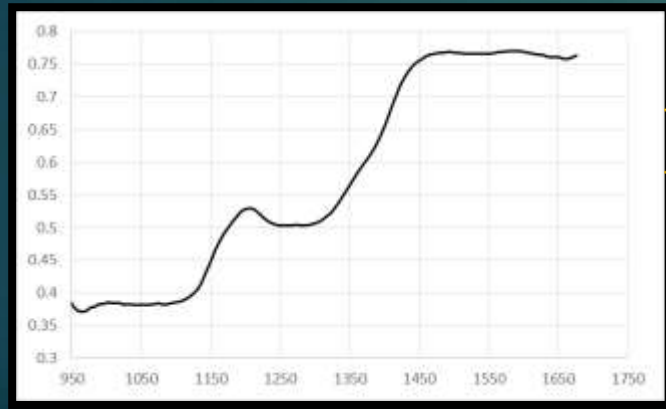


Bulk maize  
characterisation of:

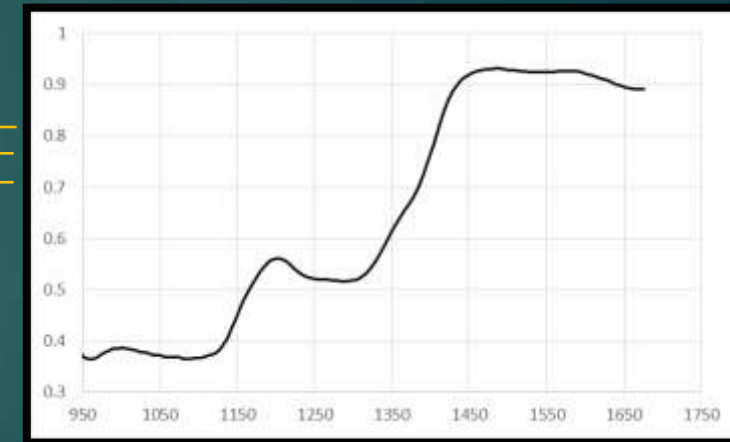
- Oil
- Protein
- Starch
- Moisture
- And more...

# Near infrared (NIR) spectroscopy: single kernels

Germ-down side = endosperm



Germ-up side = germ



# MicroNIR spectrophotometer

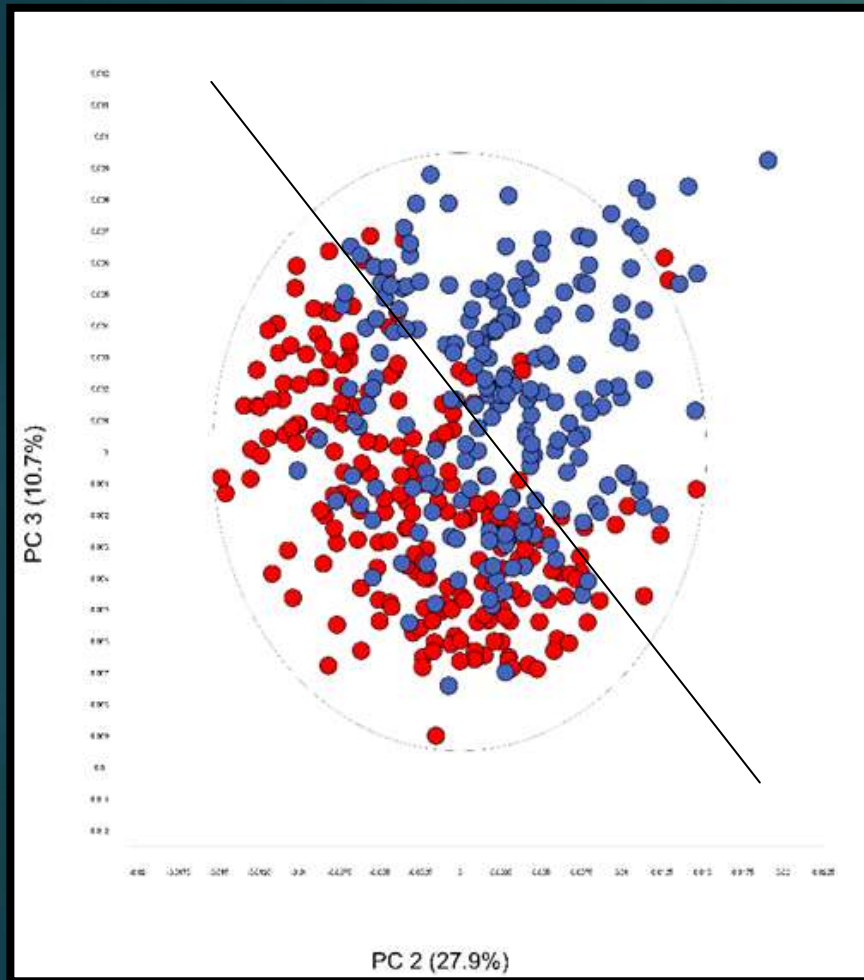


MicroNIR1700 (908 – 1680 nm)



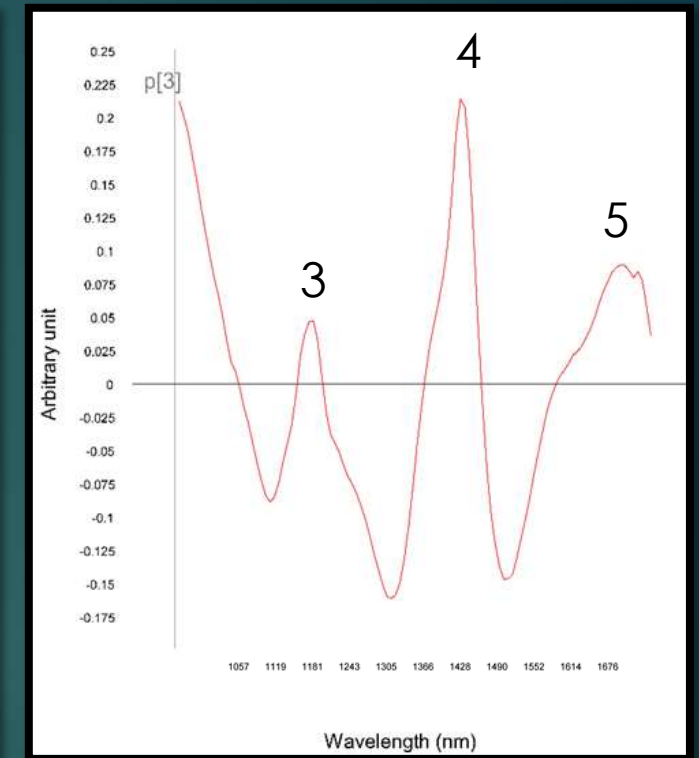
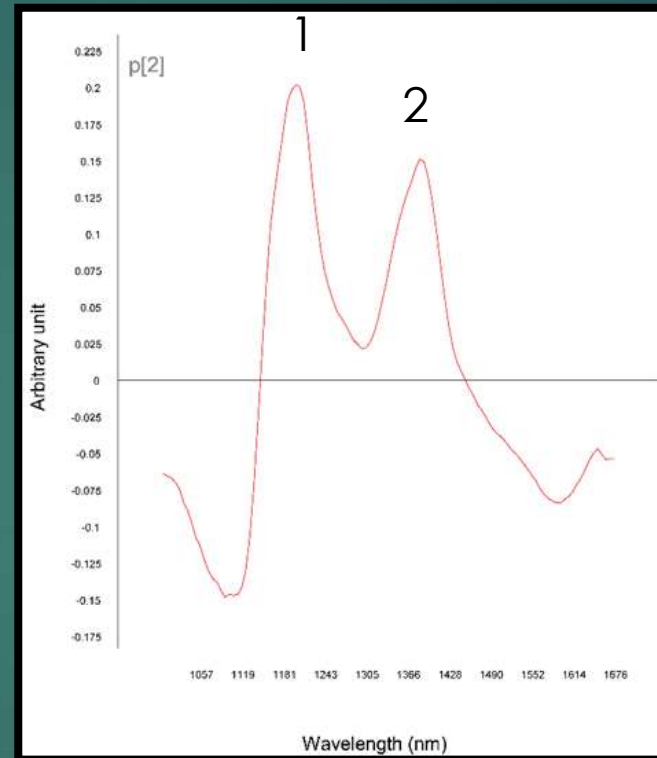
Hollowed out Teflon disk with maize kernel

# Principal component analysis (PCA)



A PCA score plot

- Good milling
- Poor milling

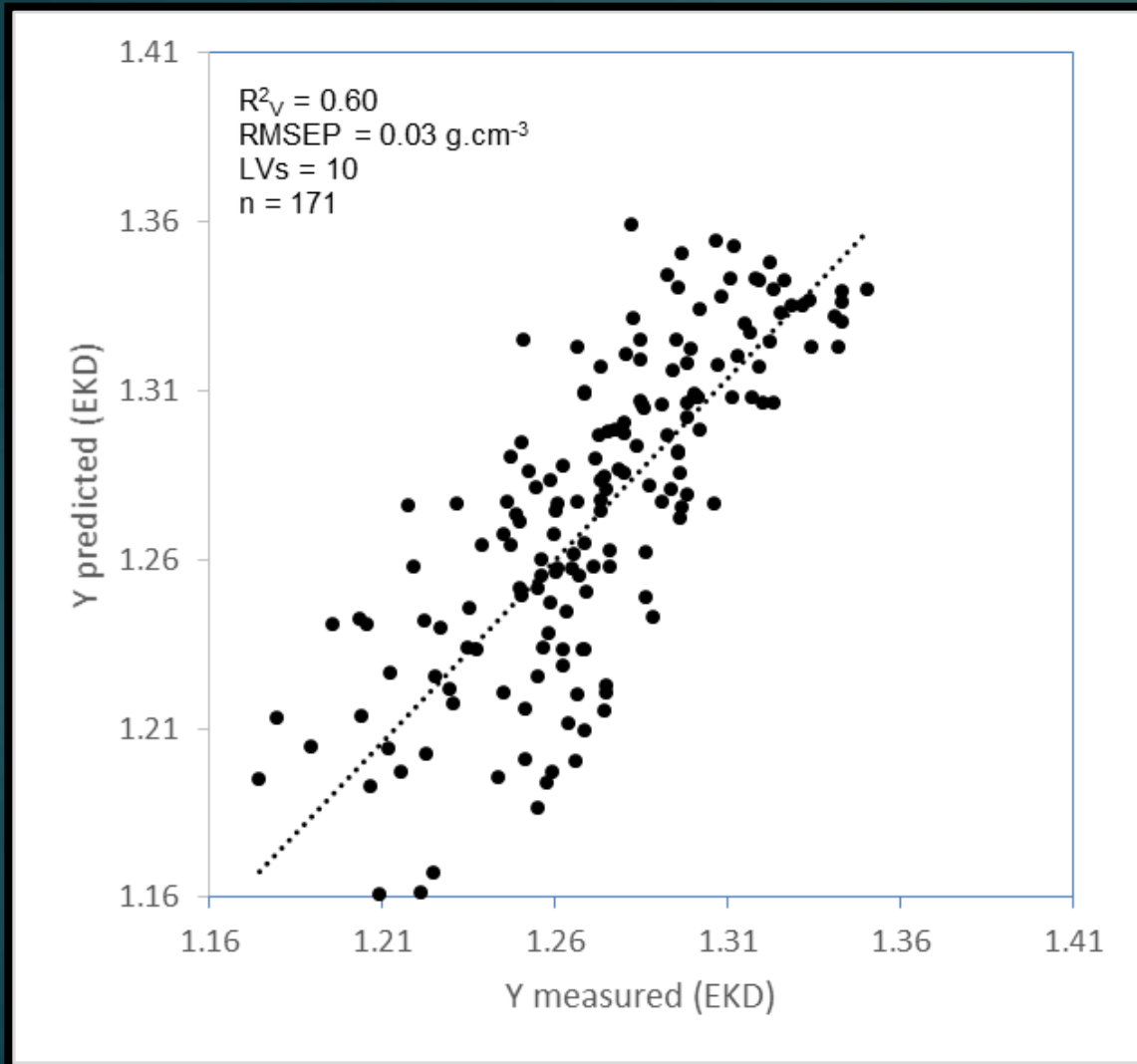


Loading line plots for PC 2 and PC 3, respectively

(1) 1225 nm and (2) 1430 nm, associated with starch and protein; (3) 1170 nm, (4) 1395 nm and (5) 1660 nm, all associated with starch



# Partial least squares (PLS) regression: testing predictability



Calibration statistics:

**$R^2 = 0.60$**

**$RMSEP = 0.03 \text{ g.cm}^{-3}$**

**$SEL = 0.01 \text{ g.cm}^{-3}$**

Calibration improvements:

- **Including more variability**
- **Using more wavelengths**

Validation set: n = 171

# Conclusion

- ▶ X-ray  $\mu$ CT derived density measurements are an indication of maize milling quality
- ▶ These measurement, when used in combination with NIR spectroscopy, can predict milling quality of individual maize kernels, to an fair extent
- ▶ Breeding programmes can benefit from such a method to discriminate between good milling and poor milling kernels, non-destructively, fast and relatively cheap
- ▶ The MicroNIR has shown to be very useful for single kernel applications

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