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

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Outline

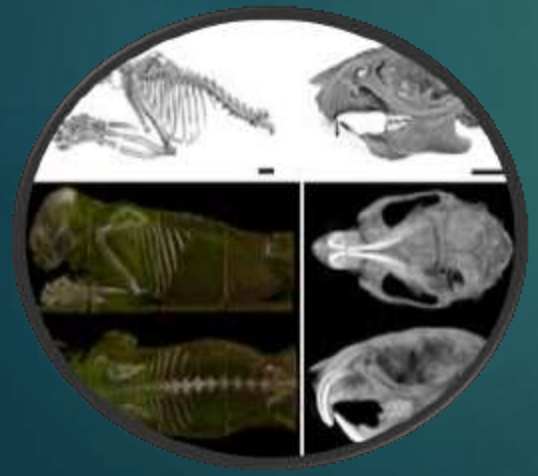
Maize breeding programmes

Single-kernel testing

Kernel density correlates with milling quality

X-ray µCT

NIR spectroscopy: MicroNIR



Samples

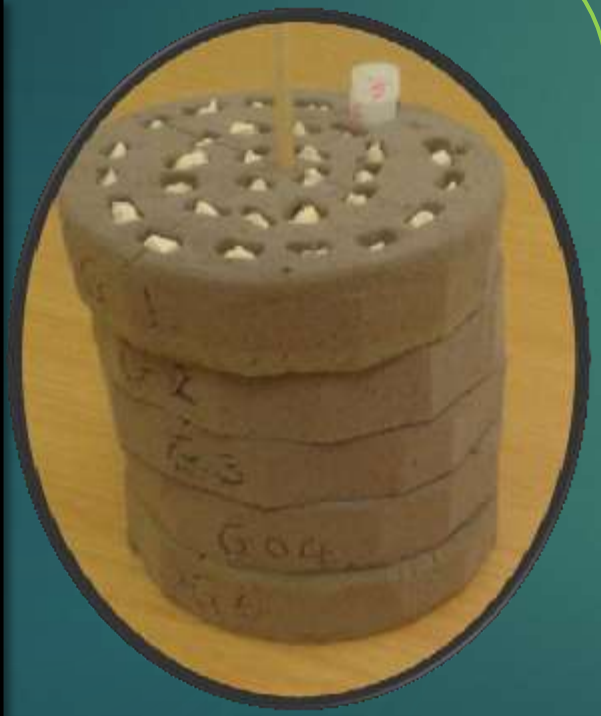
%Chop

10 x good milling hybrids

10 x poor milling hybrids

15 kernels from each hybrid = 300 kernels

X-ray micro-computed tomography (µCT): image acquisition



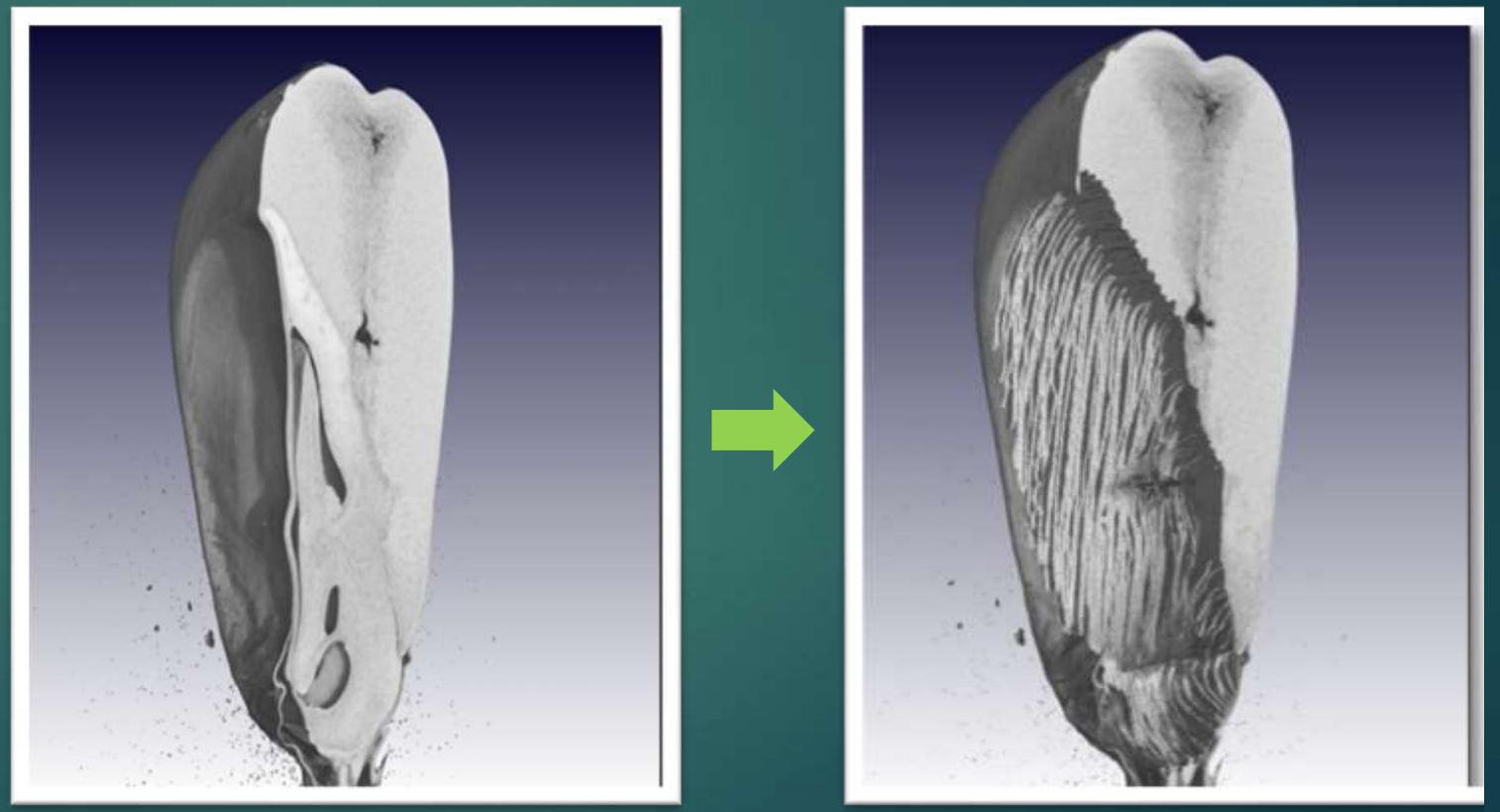
Sample preparation

X-ray computed tomography system

3-D rendering using Phoenix Datos acquisition and reconstruction software

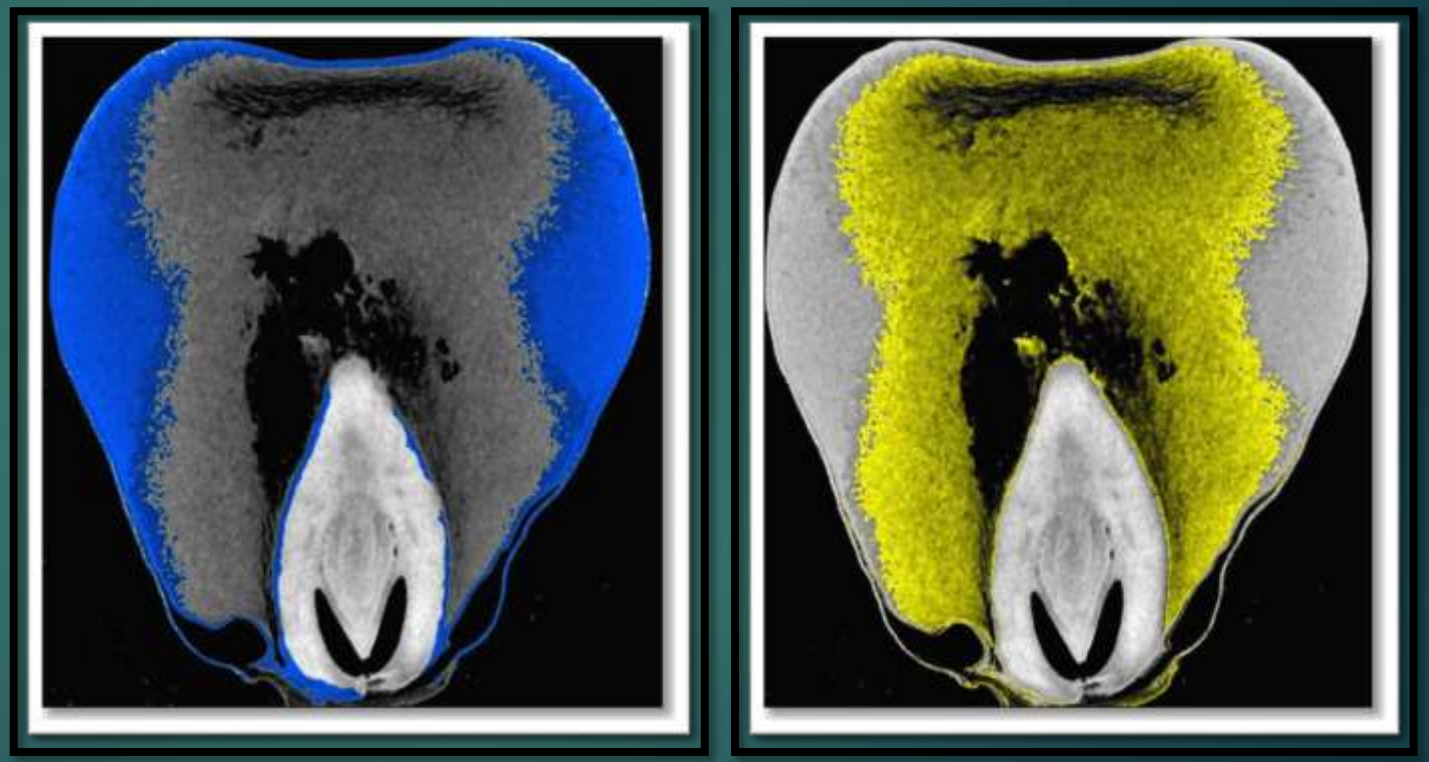
X-ray micro-computed tomography (µCT): functionality of X-ray µCT

- Exclusion of certain regions

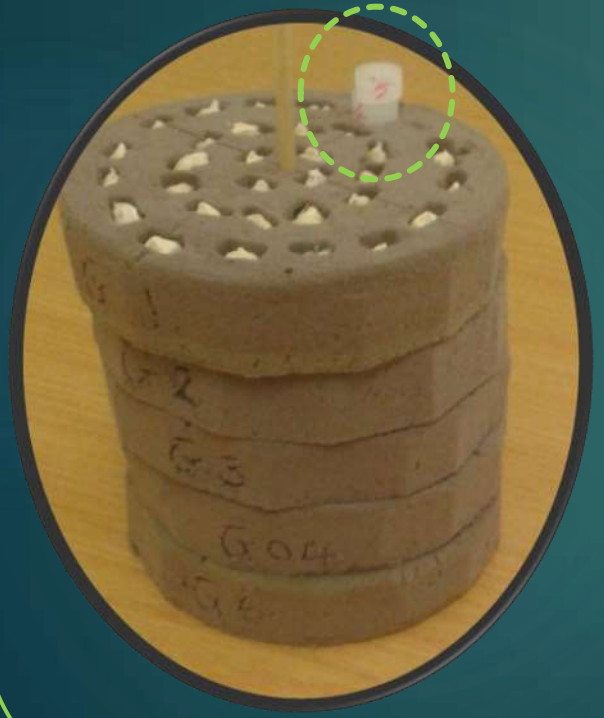


X-ray micro-computed tomography (µCT): functionality of X-ray µCT

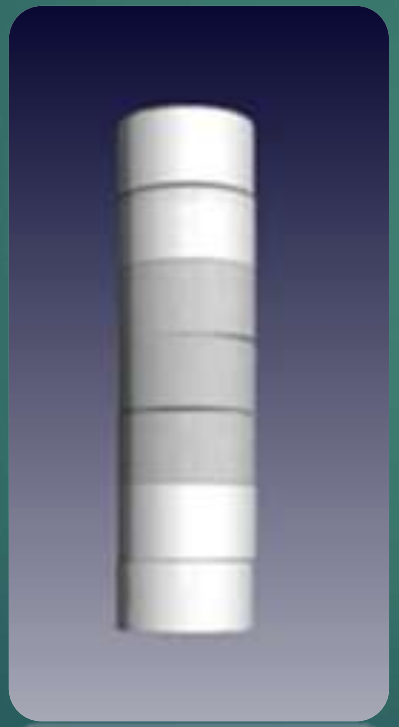
- Segmentation into specific regions
- Allows for quantification



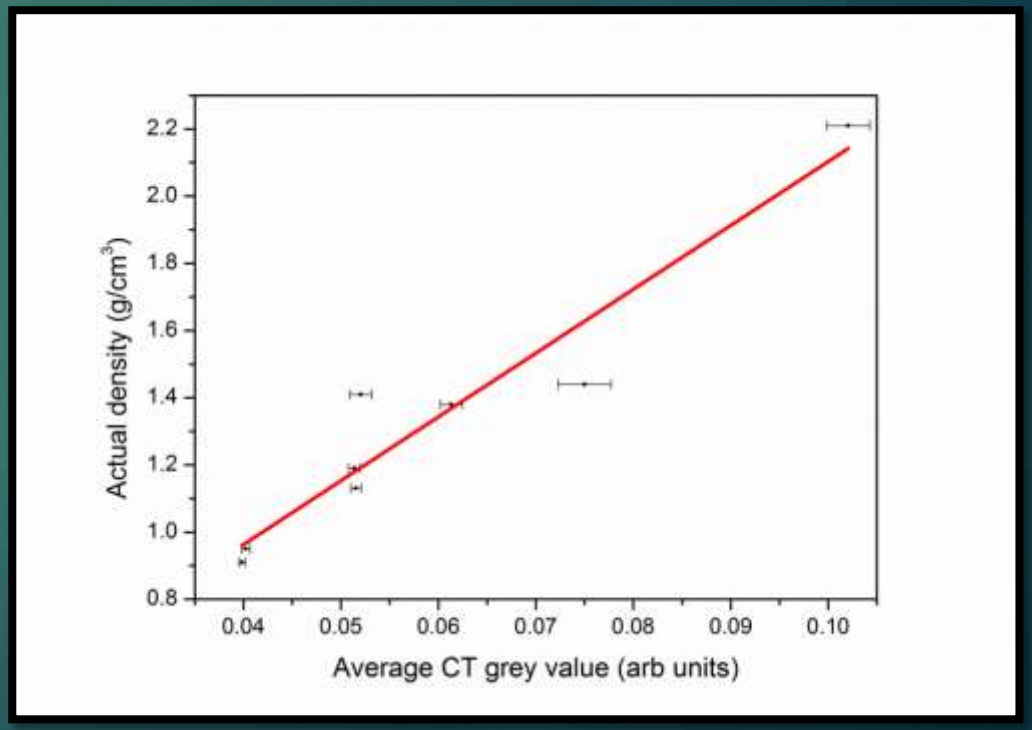
X-ray micro-computed tomography (µCT): **density calibration**



(g.cm^{-3})
2.15
1.2
0.92
0.91
0.92
1.37
1.15



Actual density (g.cm^{-3}) = m x grey value + c
where, m = the slope and c = intercept



X-ray micro-computed tomography (µCT): **usefulness of X-ray µCT**

- Floating test vs. X-ray µCT
- r = 0.78
- Large bias indicates difference in measurements
- Influence of cavities

Near infrared (NIR) spectroscopy: multiple kernels

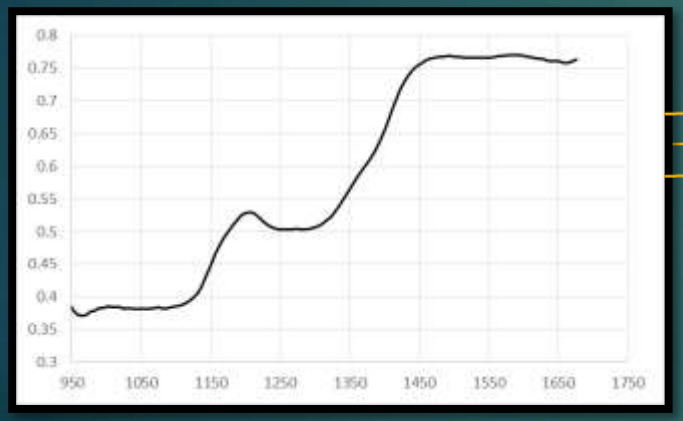
- Non-destructive
- Fast
- Easy to operate
- Low-cost

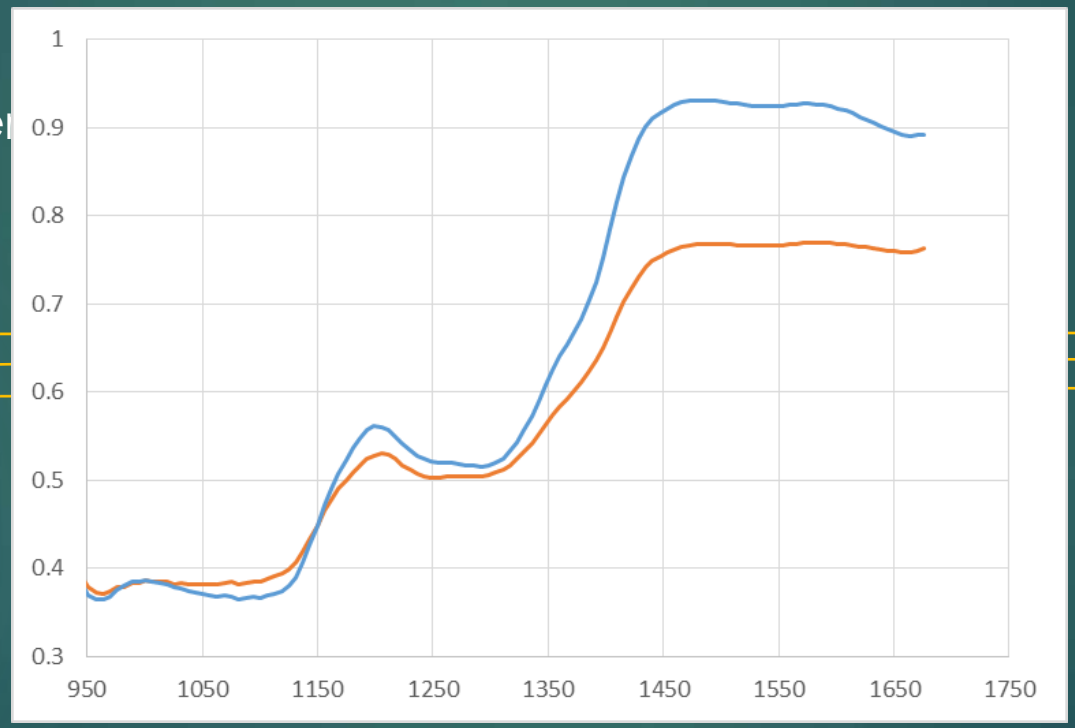
Bulk maize characterisation of:

- Oil
- Protein
- Starch
- Moisture
- And more…

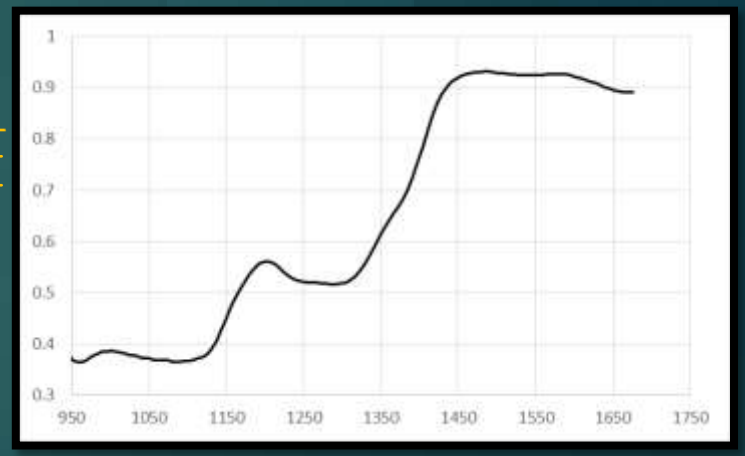
Near infrared (NIR) spectroscopy: single kernels

Germ-down side = endosper





Germ-up side = germ

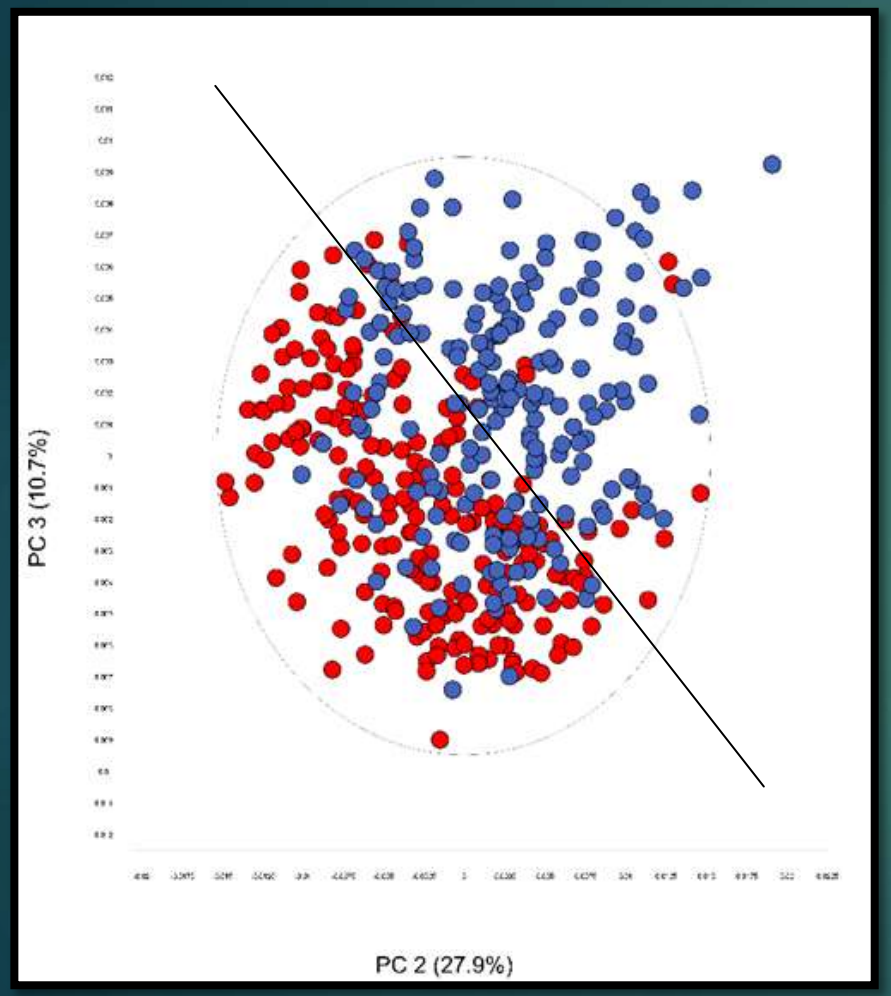


MicroNIR spectrophotometer

MicroNIR1700 (908 – 1680 nm)

Hollowed out Teflon disk with maize kernel

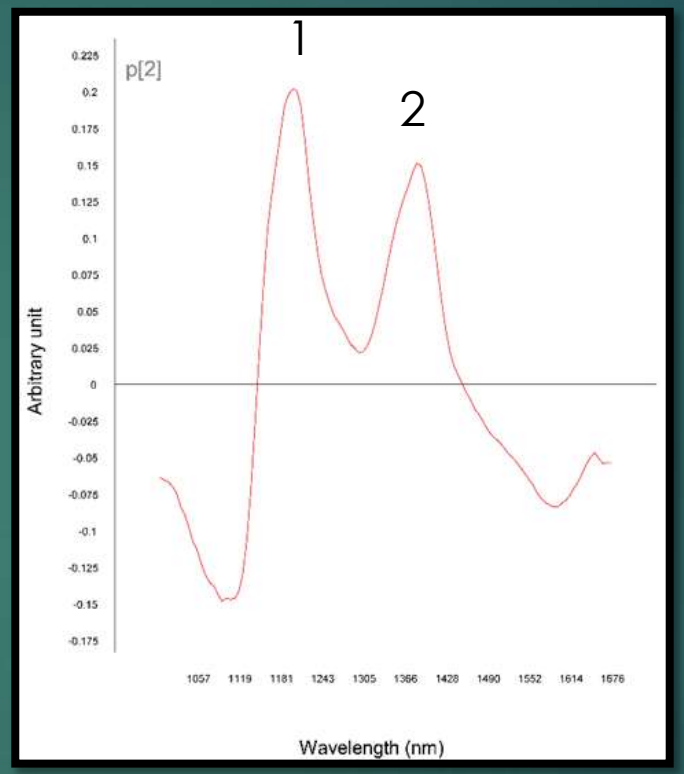
Principal component analysis (PCA)

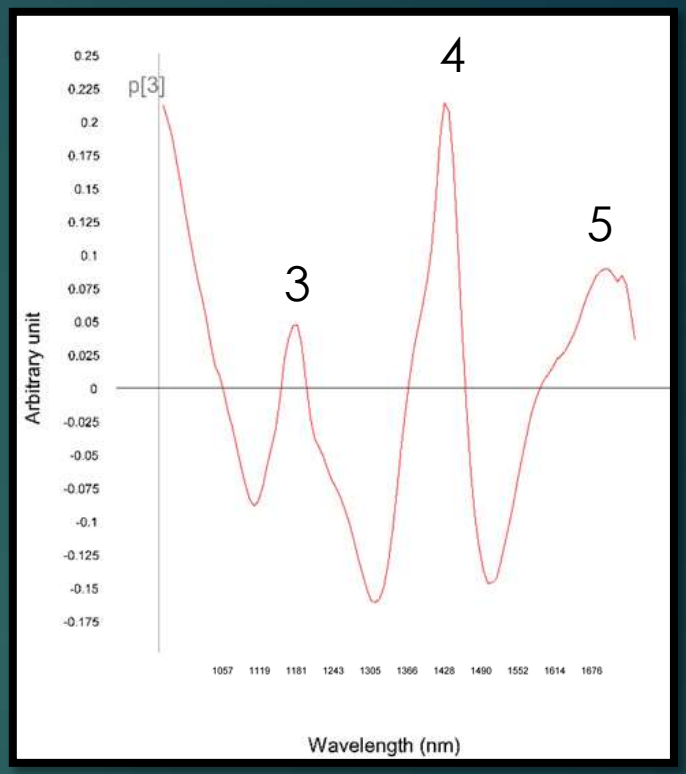


A PCA score plot

Good milling

Poor milling

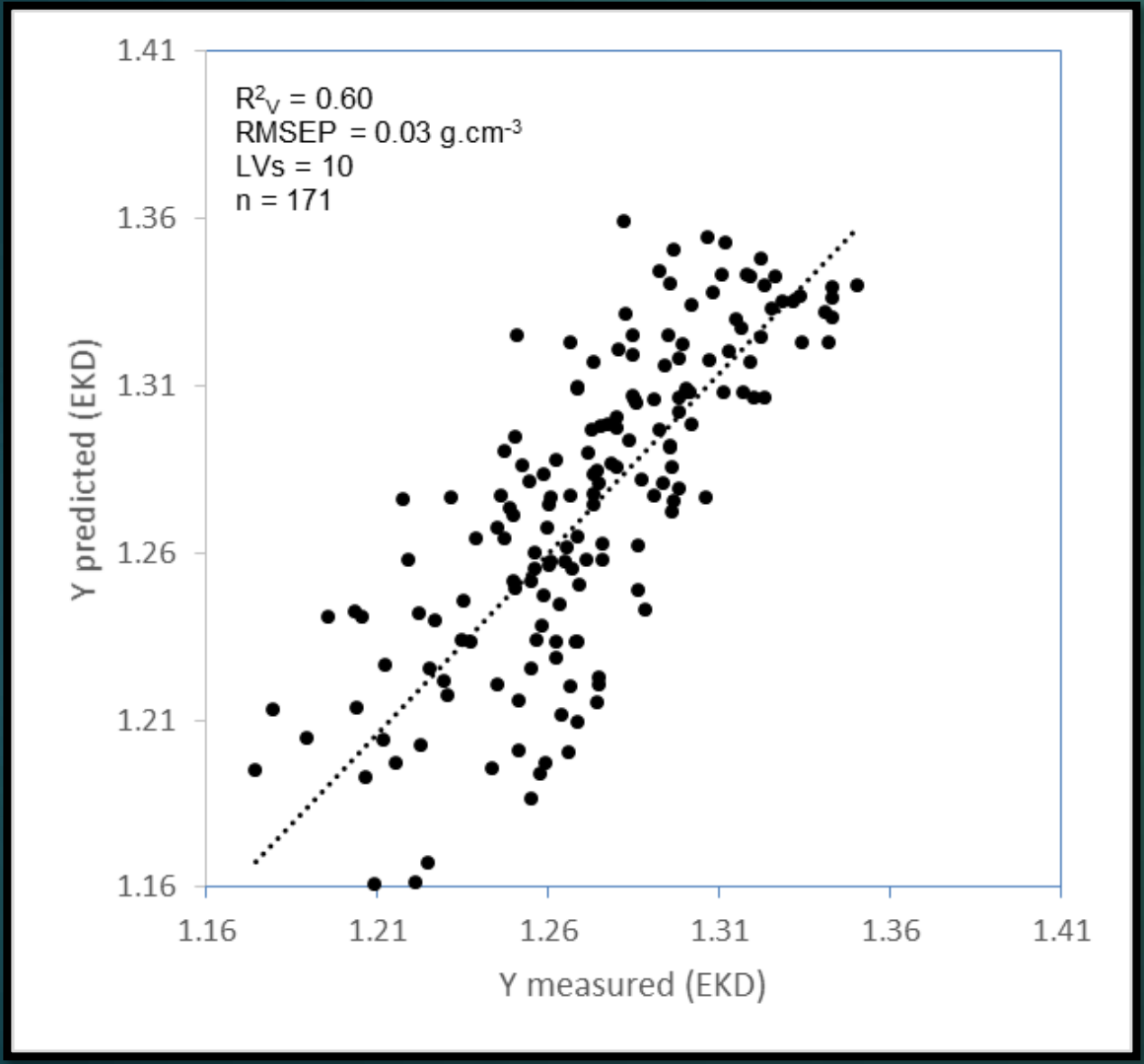




Loading line plots for PC 2 and PC 3, respectively

(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



Validation set: n = 171

Calibration statistics:

R^2 = 0.60

RMSEP = 0.03 g.cm^{-3}

SEL = 0.01 g.cm^{-3}

Calibration improvements:

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

Conclusion

- X-ray µCT 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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