

International Macadamia Symposium 2023



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# Internal discolouration and hyperspectral imagery



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# Macadamia quality aspects

## Appearance

- Whole kernel
- Shoulder damage
- Brown centres **Issues:**  
**Hard to assess**  
**Subjective**

## Shelf life

**Issues:**  
**Not visually detected**  
**Destructive assessment needed**

- Peroxide value
- Free fatty acid levels
- Hexanal concentrations





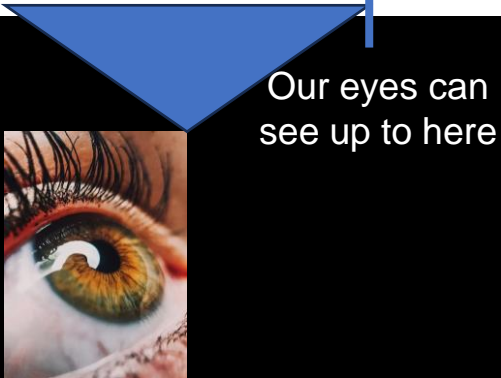
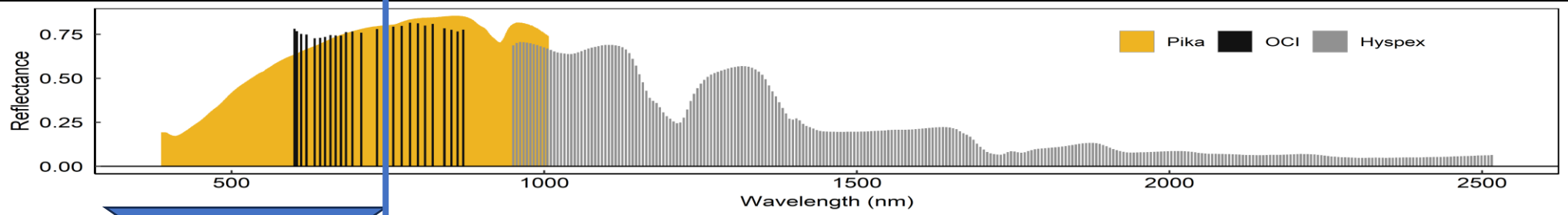
# New imaging tools

The camera “sees”  
chemical bonds we can’t  
see

Hyperspectral imaging  
NIR on steroids



# Different sensors have different spectral ranges

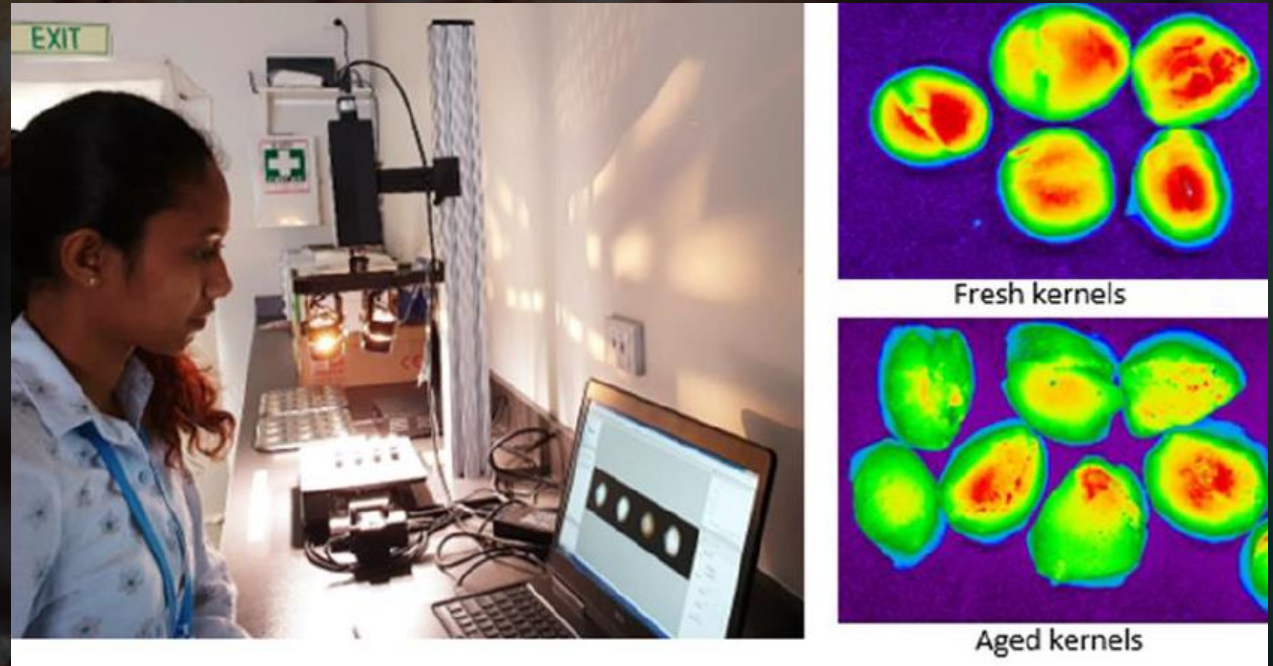




## Specific objectives

Use hyperspectral images to predict nut quality from kernels and/or nut-in-shells such as

- Brown centre
- Peroxide values and
- Moisture content





# What have we done?



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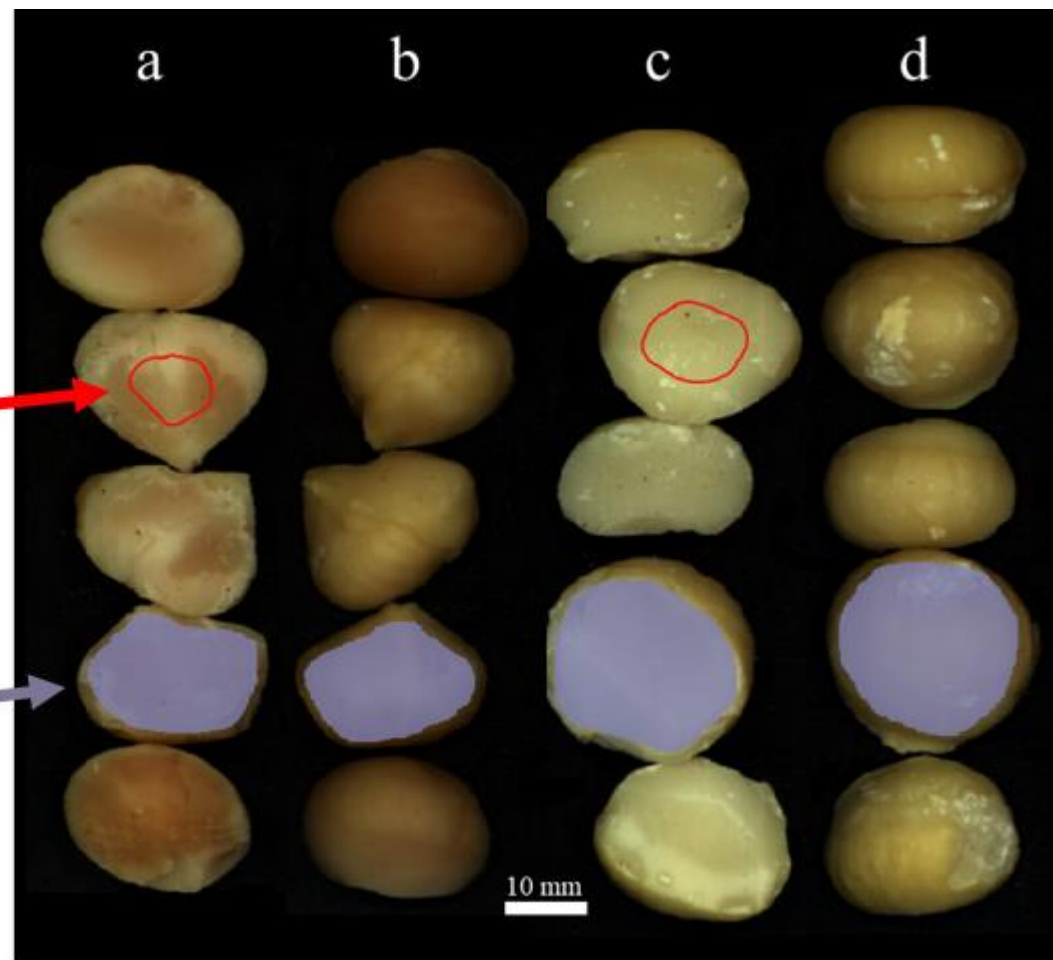


# Step 1 Imaged samples

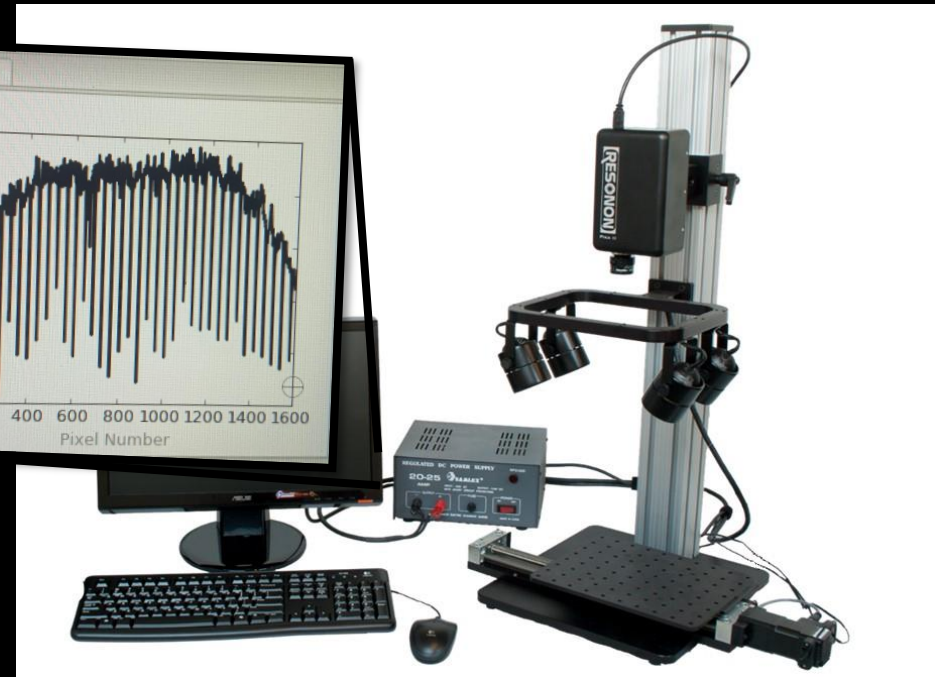
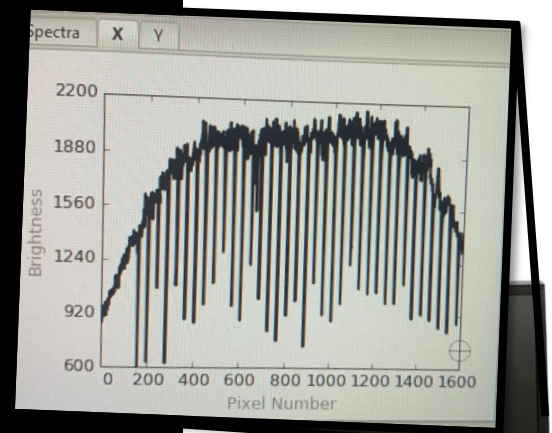
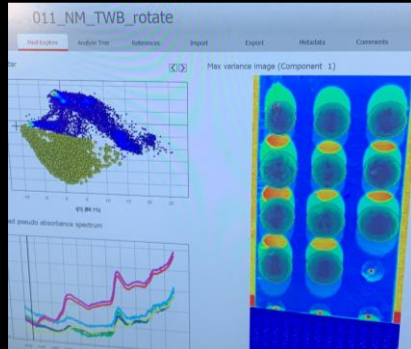


Step 3  
Chemical  
data

Step 2  
Spectral  
data



```
21 #import files
22 dark_ref = envi.open('hyspex\BC004\darkref_BC004.hdr', 'hy
23 white_ref = envi.open('hyspex\BC004\whiteref_BC004.hdr', '
24 data_ref = envi.open('hyspex\BC004\BC004.hdr', 'hyspex\BC0
25
26 #make nparray of images
27 dark_nparr = np.array(dark_ref.load())
28 white_nparr = np.array(white_ref.load())
29 data_nparr = np.array(data_ref.load())
30
31 #resize arrays
32 dark_nparr_resize = st.resize(dark_nparr, (768,384,288))
33 white_nparr_resize = st.resize(white_nparr, (768,384,288))
34
```



# Step 4: Machine learning of hyperspectral imaging





# What did we find?

Face-Up



Test dataset			Model
BC	PK	Accuracy	
24	0	100.0%	SVC
0	19		
24	0	100.0%	ANN
0	19		
16	0	100.0%	ANN
0	16		
20	1	96.9%	ANN
0	11		

Face-Down



Test dataset			Model
BC	PK	Accuracy	
22	1	42.1%	SVC
10	11		
22	1	97.7%	ANN
0	21		
18	2	93.9%	ANN
0	13		
15	0	100.0%	ANN
0	18		

- High brown centre prediction accurately

- Face up had higher prediction accuracy than face down



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# How was prediction accuracy with pooled data?



Pooled dataset also promising

**Why a pooled method?**

**Nothing is perfect**

Many halves and misshaped kernels exist in processing lines



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# Why was face down prediction still possible?

**Table:** Chemical properties and nutrient analysis of brown centre and premium kernels

Chemical / Nutrient	Units	Brown centre (n = 43)	Premium kernel (n = 41)	p-value
Fructose	%	0.44(0.33)	0.00(0.00)	<0.001
Glucose	%	0.32(0.31)	0.01(0.06)	<0.001
Sucrose	%	3.08(2.05)	2.95(0.81)	0.5
Fat	%	51.0(7.8)	55.0(2.9)	0.009
PV	MEQ kg <sup>-1</sup>	1.38(2.37)	1.18(1.41)	0.6
Total carbon	%	66.2(4.9)	68.4(4.2)	0.003
Total nitrogen	%	1.86(0.41)	1.70(0.21)	0.053
Calcium	mg kg <sup>-1</sup>	513(185)	403(89)	0.001
Iron	mg kg <sup>-1</sup>	15.2(5.6)	12.2(2.8)	0.044
Potassium	%	0.63(0.14)	0.48(0.05)	<0.001
Magnesium	%	0.155(0.028)	0.136(0.021)	<0.001
Phosphorus	%	0.26(0.05)	0.22(0.03)	<0.001
Total sulphur	%	0.17(0.03)	0.14(0.02)	<0.001
Zinc	mg kg <sup>-1</sup>	25(16)	16(4)	<0.001

MEQ: milli equivalent units

Chemical differences between brown centre and premium

We do not see it but camera sees it



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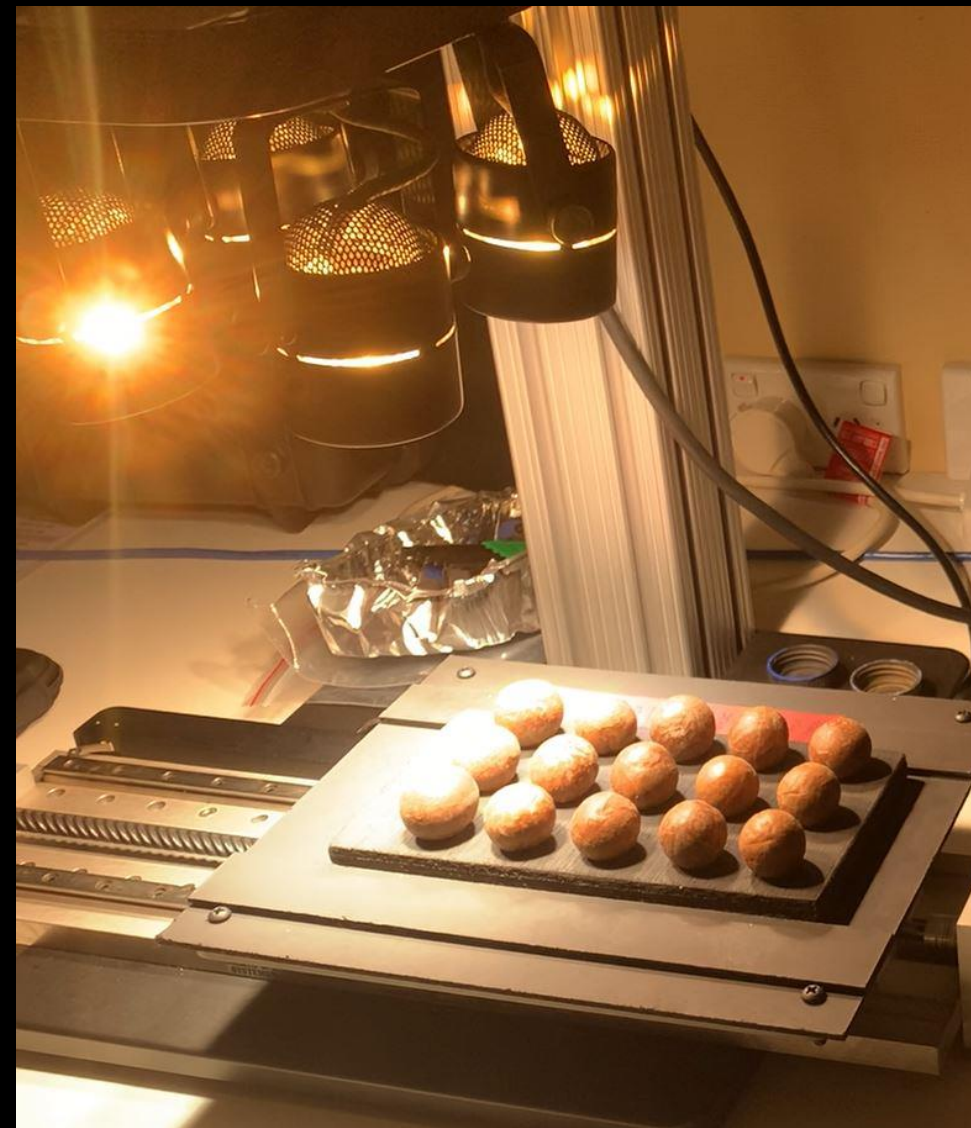
# What else?

Nut in shell moisture prediction

Kernel moisture prediction

Peroxide value prediction

Free fatty acid prediction



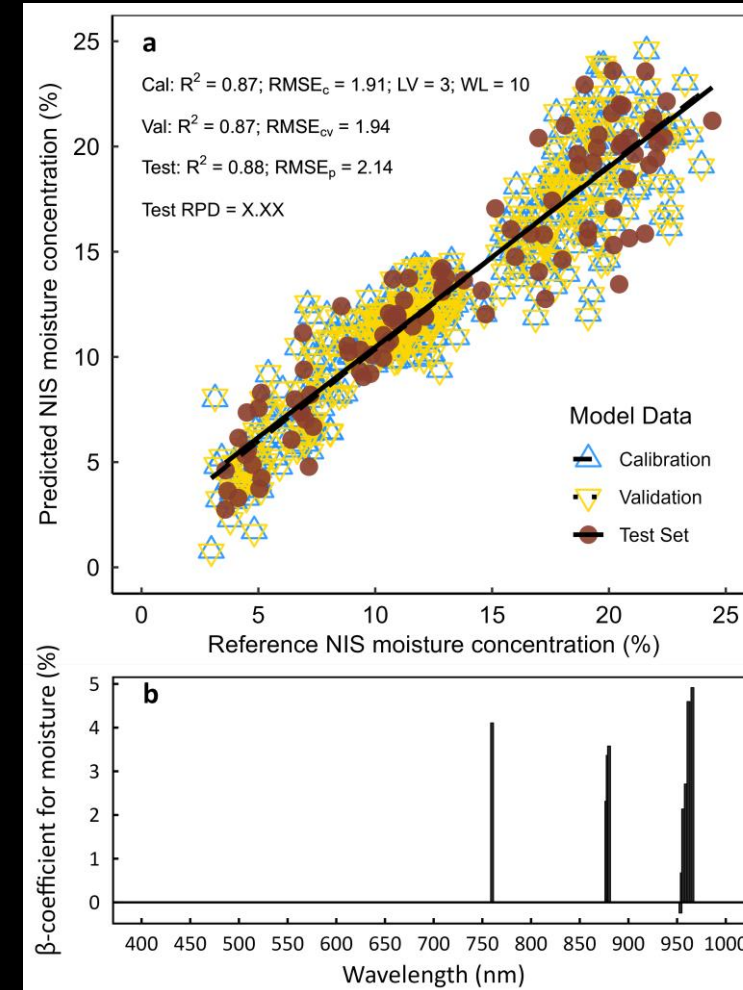
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# Nut-in-shell moisture prediction

Moisture was predicted with high accuracy



Jointly funded by



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# Thank You! Questions?

