# Feed grains research for ruminants: What's being done, some gaps and where to from here?

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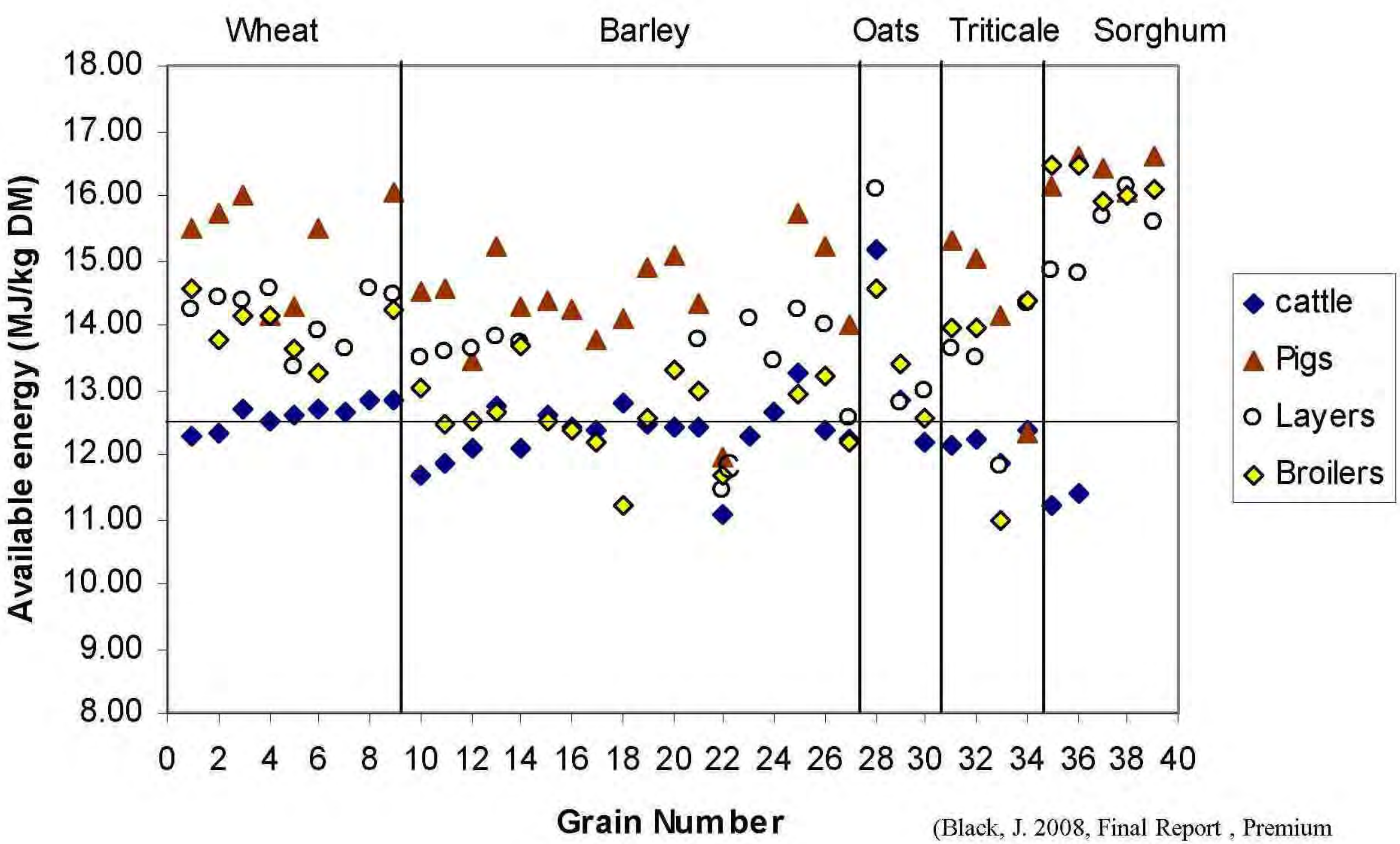
# Focus on 2 grains as models

Wheat – may ferment/digest too quickly

Sorghum – may ferment/digest too slowly




(Black, J. 2008, Final Report , Premium Grains for Livestock Program)

# The problem with wheat

High starch = risk of: ruminal acidosis
reduced appetite

Considerable variability in nutritive value

# The perceived problem with red wheat

Field reports that milk yield declines after a switch from white to red wheat

Consequently dairy farmer preference for Australian Standard White (ASW) wheats

However, red (winter) wheats have better yields and are better suited to Tasmanian growing conditions

# Objectives

Compare milk performance of cows fed red *vs* white wheat

Define the extent of variation in nutritive value of Tasmanian wheats

Evaluate red *vs* white wheats *in vitro* – especially from the starch perspective

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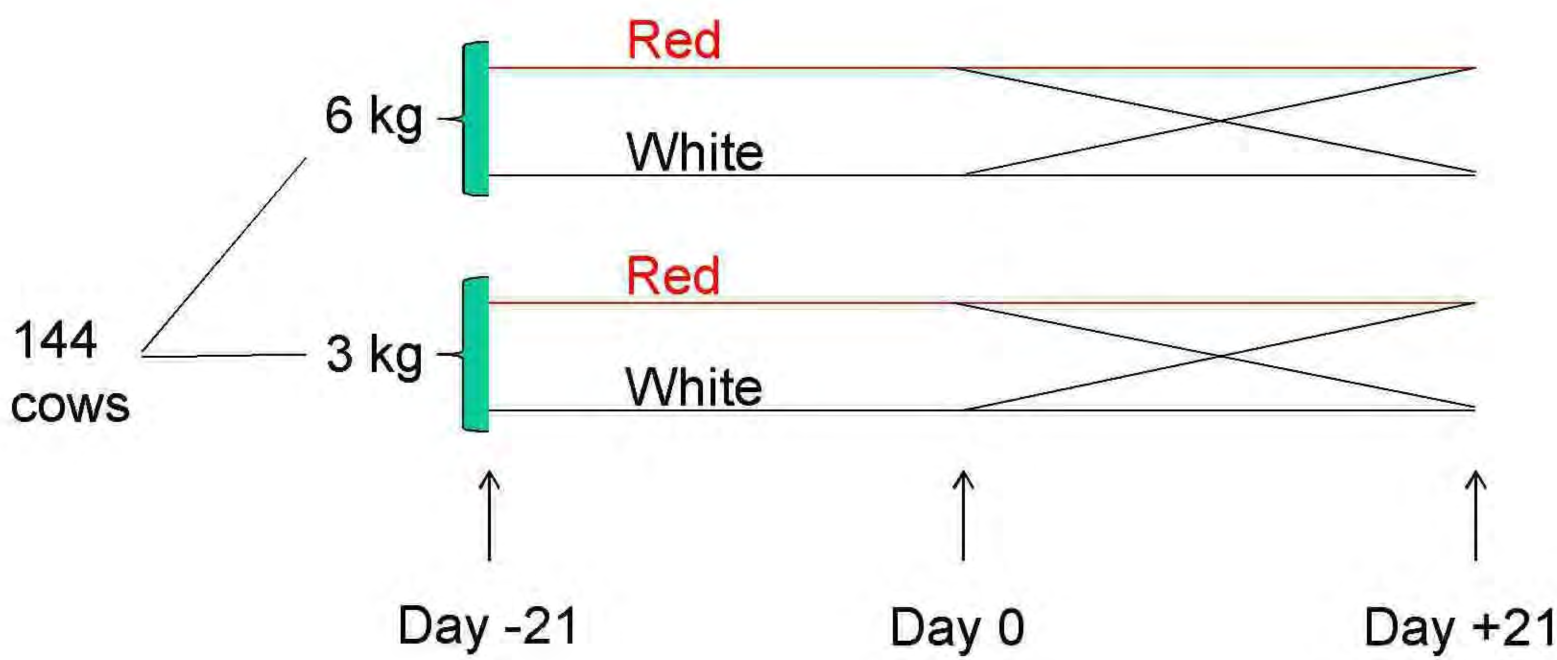
Red
6 kg
White
Red
144
cows
3 kg
White
Day -21
Day 0
Day +21

| | Red wheat (Mackellar) | White wheat (Sentinel) | |
|---|---|---|---|
| Milk yield, L | 18.0 | 18.0 | ns |
| Milk fat, % | 4.44 | 4.49 | ns |
| Milk protein, % | 3.50 | 3.52 | ns |
| Milk fat, kg | 0.79 | 0.80 | ns |
| Milk protein, kg | 0.63 | 0.63 | ns |
| Liveweight, kg | 534 | 535 | ns |

## Effect of wheat level

| | 3 kg wheat /cow/day | 6 kg wheat /cow/day | |
|---|---|---|---|
| Milk yield, L | 16.6 | 19.4 | *** |
| Milk fat, % | 4.52 | 4.41 | *** |
| Milk protein, % | 3.44 | 3.58 | *** |
| Milk fat, kg | 0.74 | 0.84 | *** |
| Milk protein, kg | 0.57 | 0.69 | *** |
| Liveweight, kg | 527 | 541 | *** |

Marginal response = 0.93 L milk/kg grain

# Results: *Nutritional comparison between Red and White wheat*

| Component | Red Wheat (Mackellar) | White Wheat (Sentinel) |
|---|---|---|
| Crude Protein %DM | 13.7 | 13.4 |
| Soluble protein, % of CP | 29.5 | 28 |
| NDF, %DM | 12.7 | 11.9 |
| ME, MJ/kgDM | 13.48 | 13.34 |
| Starch, %DM | 67.9 | 67.05 |
| Non-fibre carbohydrate, %DM | 73.2 | 75.55 |

# In vitro fermentation system

Fermentation in buffered rumen fluid measures gas production from all fermentable nutrients and is a direct measure of microbial activity and accessibility of feed to microbial enzymes.

Gas production is closely correlated with organic matter digestibility and can be used to predict the ME content of feed.

Gas production curves can be described mathematically allowing the kinetics of fermentation to be calculated and thus the rate and extent of fermentation of a feed can be evaluated.

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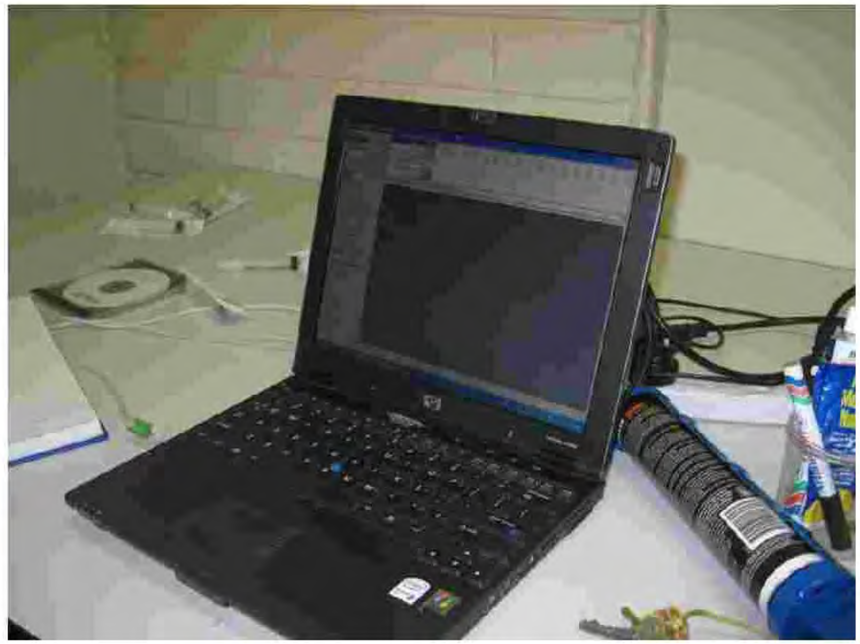
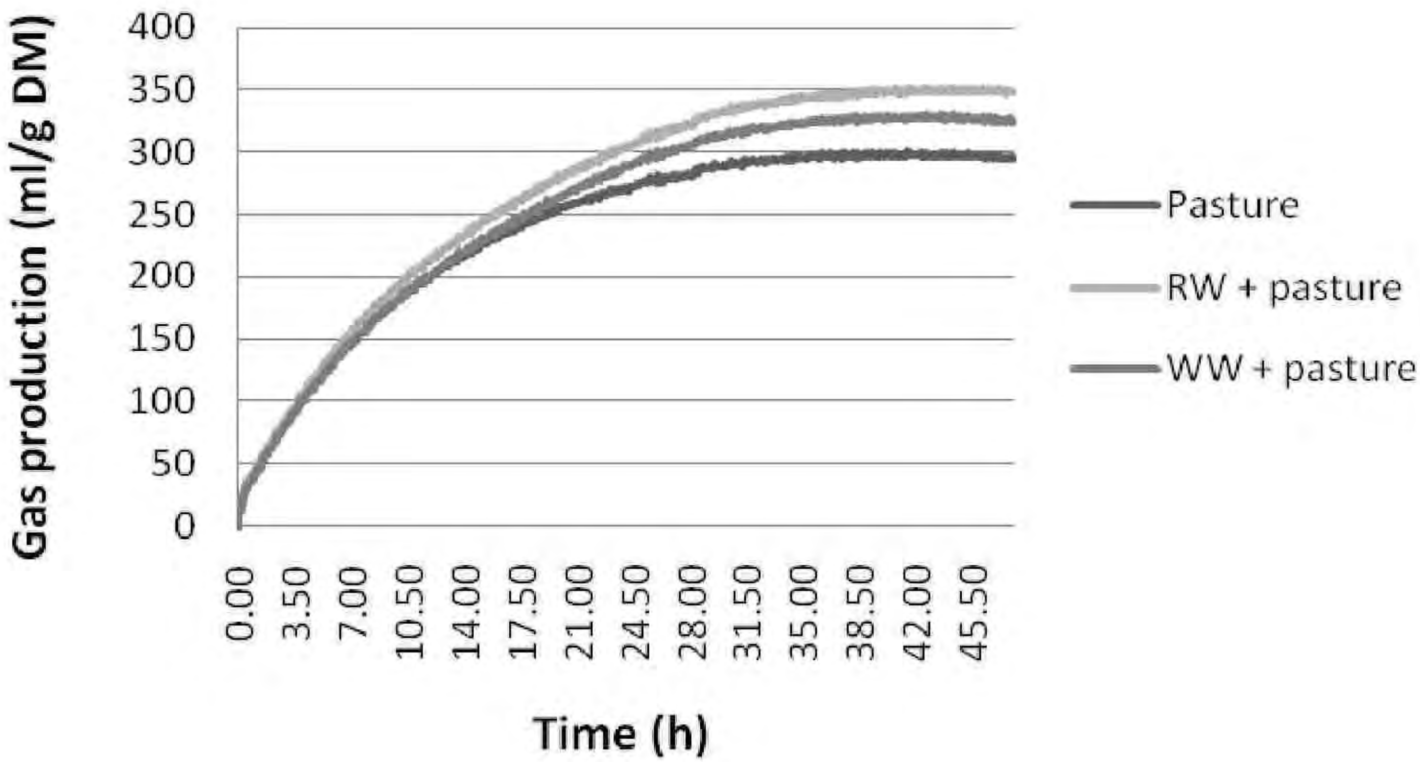
# *ANKOM* In Vitro Gas production System

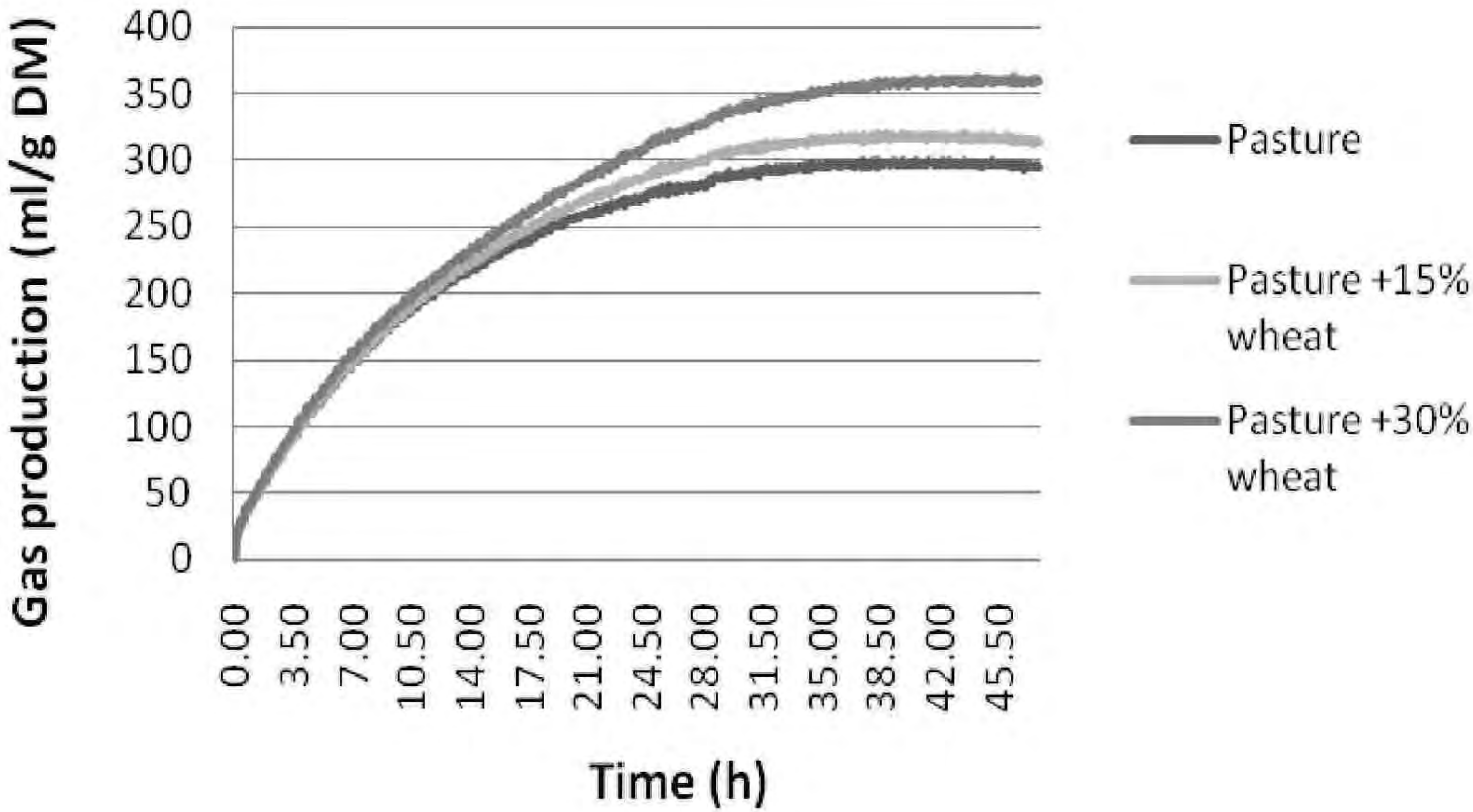
# *ANKOM* In Vitro Gas production System

# Gas production from Red and White wheats were the same



# Gas production increased with increasing wheat inclusion



Gas production kinetics for pasture only and pasture plus red or white wheat included at two levels obtained using the wireless in vitro gas measuring system. Data are the means of four replicate incubations per treatment.

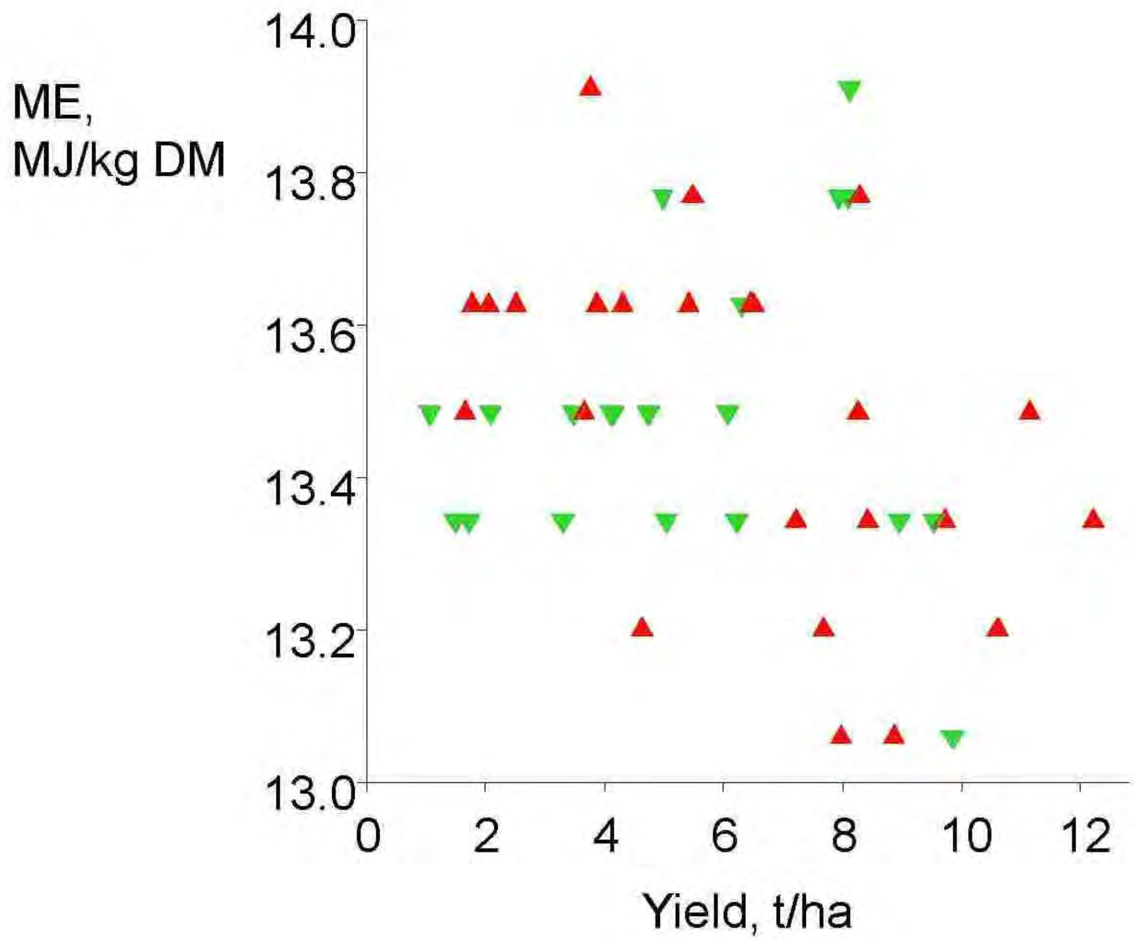
| Grain | None | Red | | White | | | P-value | |
|---|---|---|---|---|---|---|---|---|
| Level (%) | 0 | 15 | 30 | 15 | 30 | sed | Level | Level. Grain |
| $Max_{gas}$ (mL/g DM) | 300 | 351 | 390 | 324 | 398 | 16.4 | <0.001 | 0.25 |
| Rate constant ($h^{-1}$) | 0.918 | 0.938 | 0.941 | 0.925 | 0.942 | 0.006 | <0.001 | 0.11 |
| $ET_{50}$ (h)[a] | 7.54 | 8.55 | 10.46 | 8.64 | 10.61 | 0.403 | <0.001 | 0.91 |

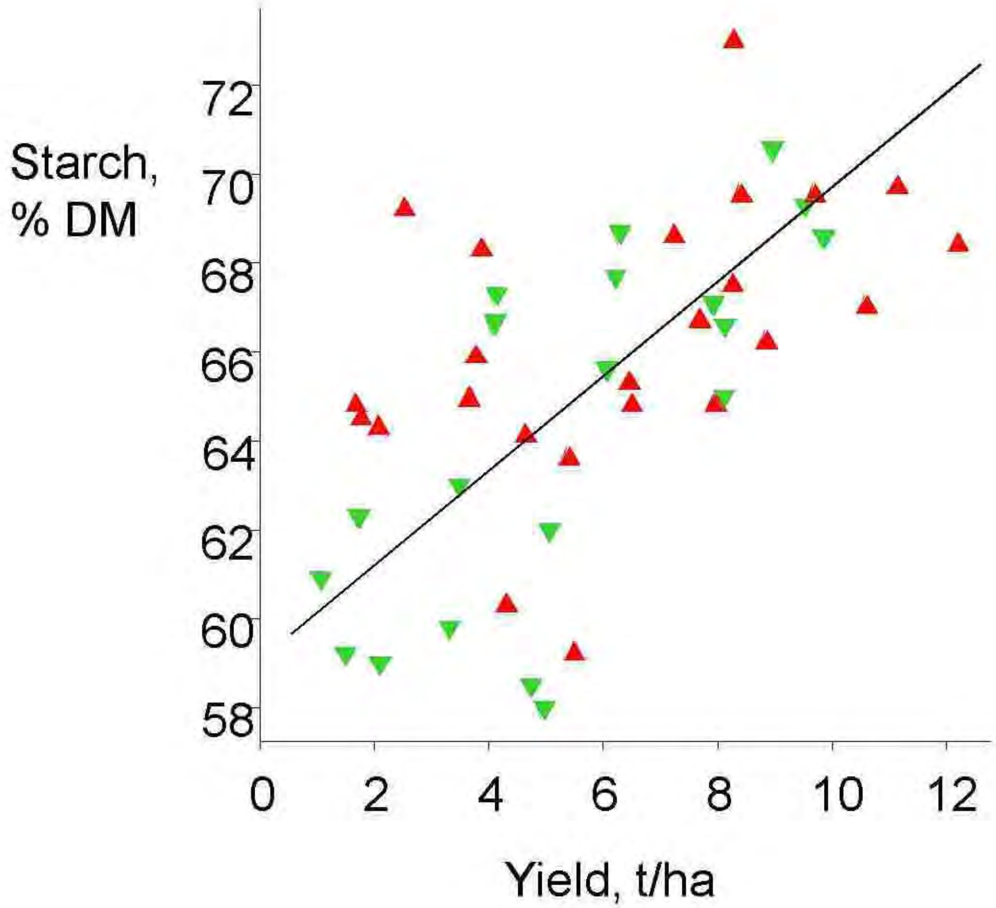
[a] Time taken to reach half maximal gas production in hours.

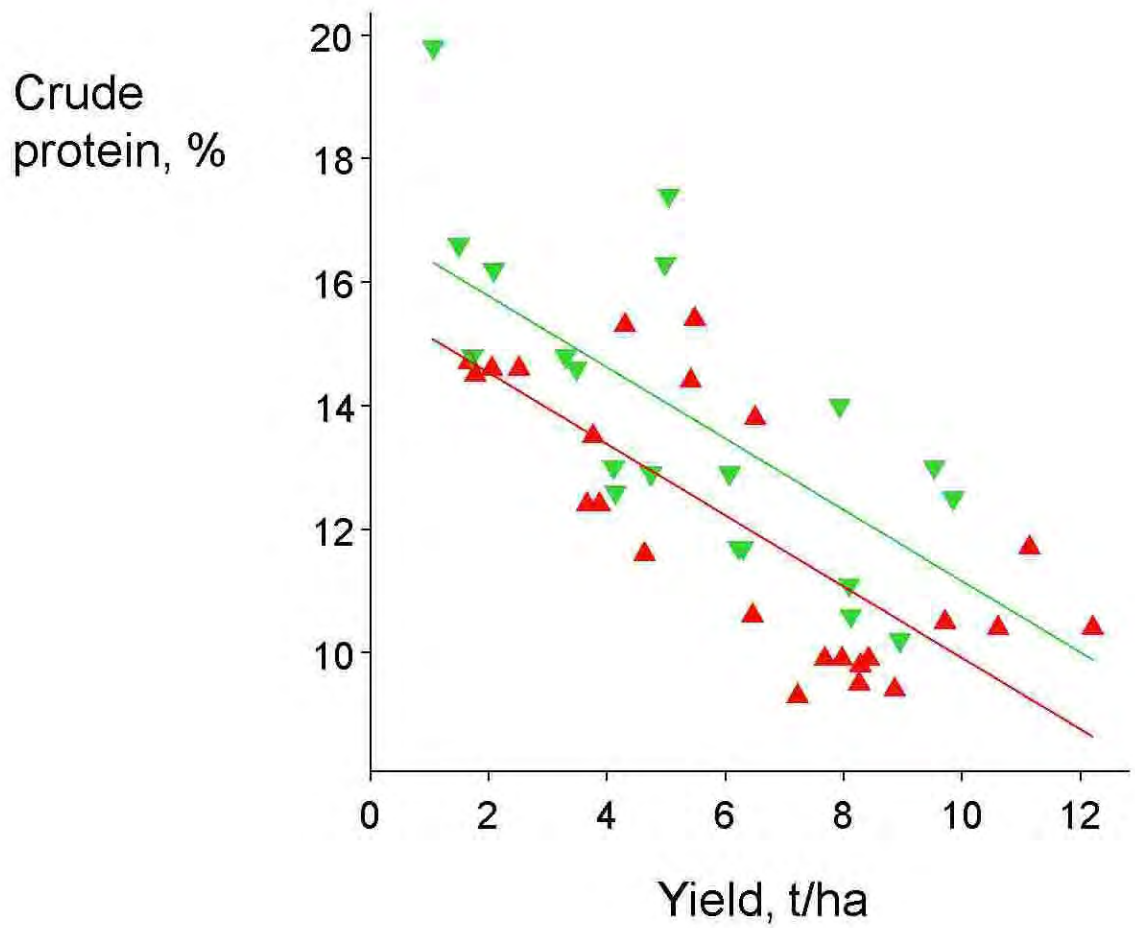
# Tasmanian Institute of Agricultural Research (TIAR)
# Wheat Library

# TIAR Wheat Library

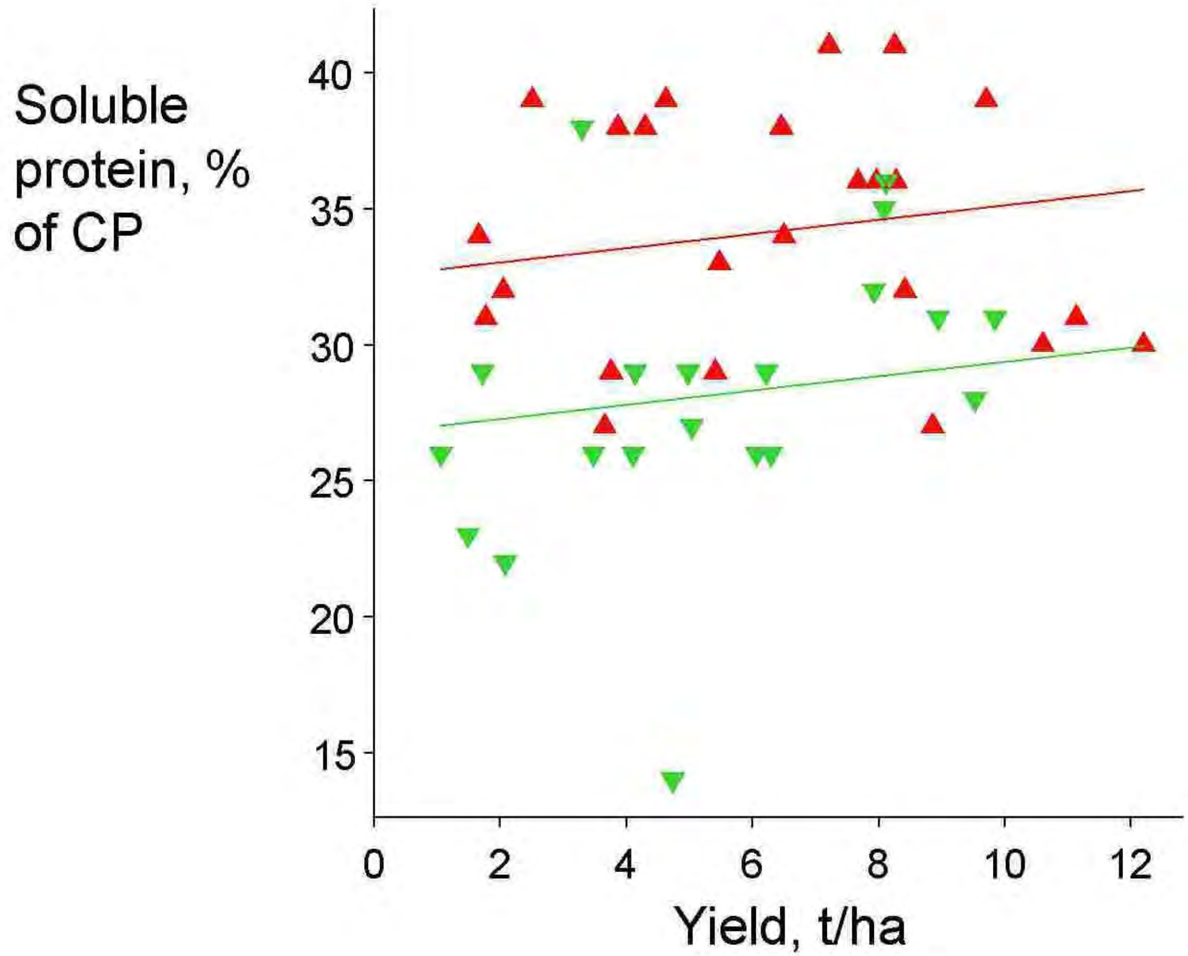
| Variety | Yield range | | | | | |
|---|---|---|---|---|---|---|
| | | | *Red* | | | |
| 95102.1 | 2.05 | 4.63 | 5.41 | 7.97 | 8.86 | 12.21 |
| Mackellar | 1.77 | 3.76 | 6.46 | 6.5 | 8.28 | 11.14 |
| Teesdale | 1.66 | 3.66 | 5.48 | 7.68 | 8.42 | 10.61 |
| Tennant | 2.51 | 3.87 | 4.3 | 7.22 | 8.26 | 9.71 |
| | | | *White* | | | |
| Brennan | 1.72 | 4.14 | 4.98 | 6.3 | 8.09 | 9.85 |
| H150.2 | 2.08 | 4.11 | 6.07 | 7.93 | 8.95 | |
| Kellalac | 1.49 | 3.48 | 4.74 | 6.22 | 8.12 | 9.53 |
| Sentinel | 1.06 | 3.3 | 5.04 | | | |

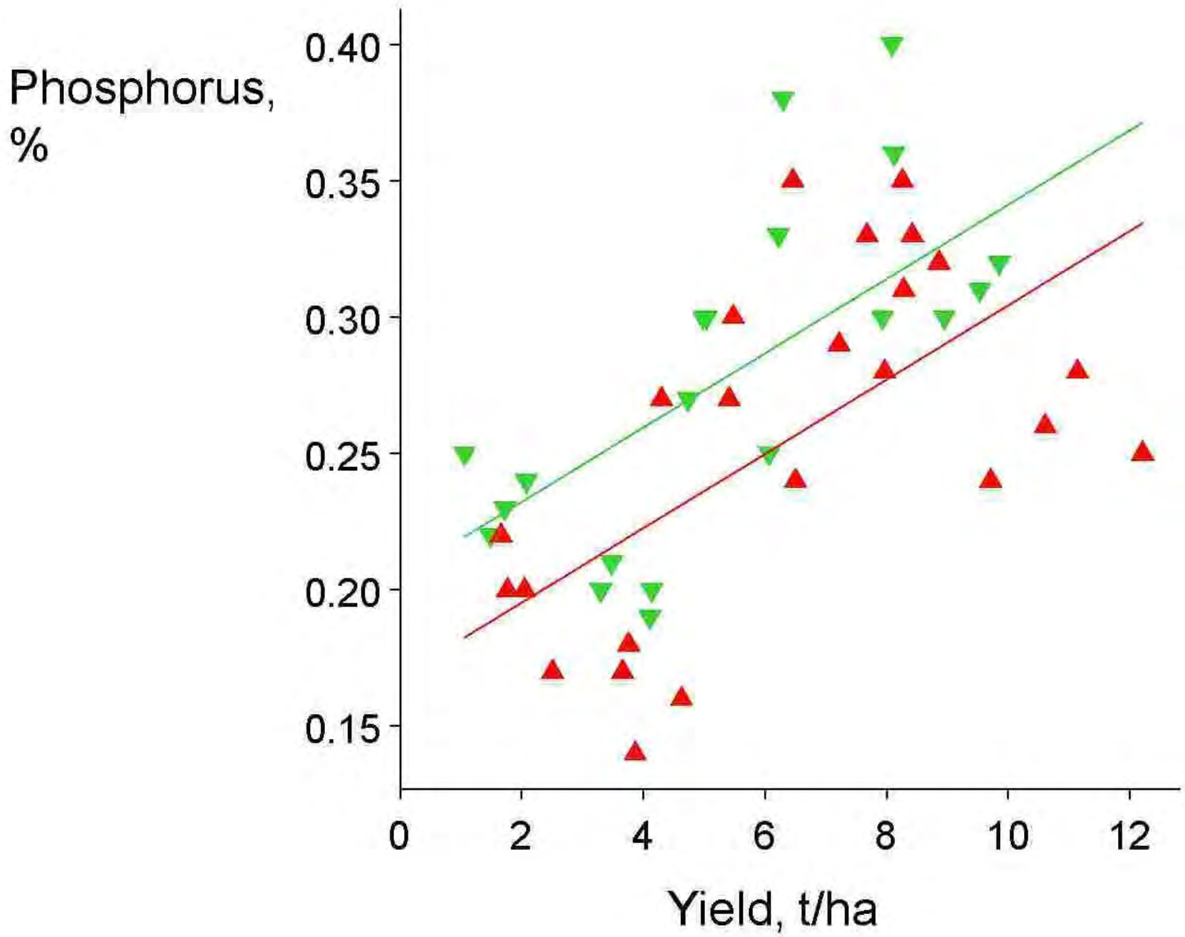

ME,
MJ/kg DM
14.0
13.8
13.6
13.4
13.2
13.0
0
2
4
6
8
10
12
Yield, t/ha

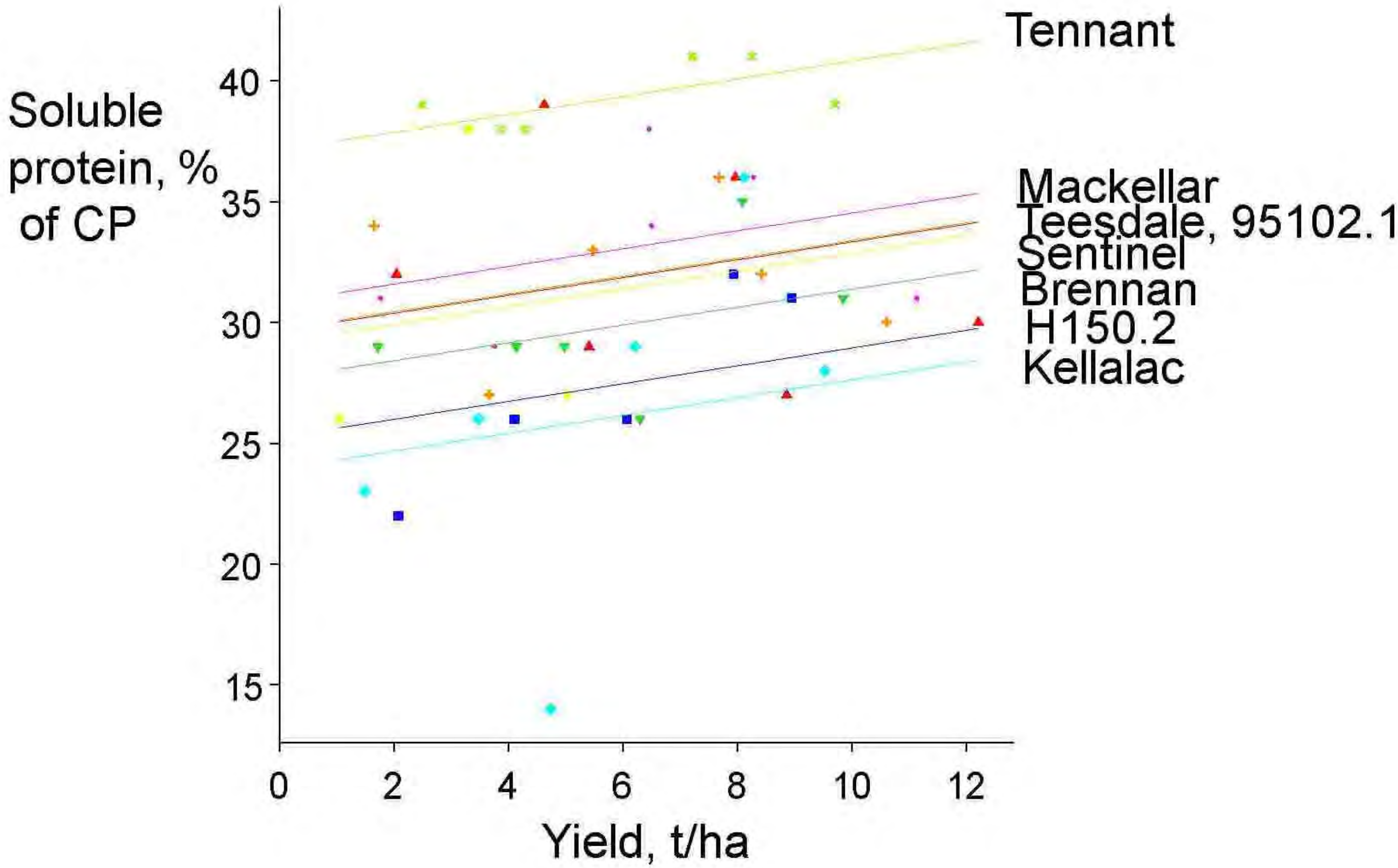

Starch,
% DM
72
70
68
66
64
62
60
58
0
2
4
6
8
10
12
Yield, t/ha

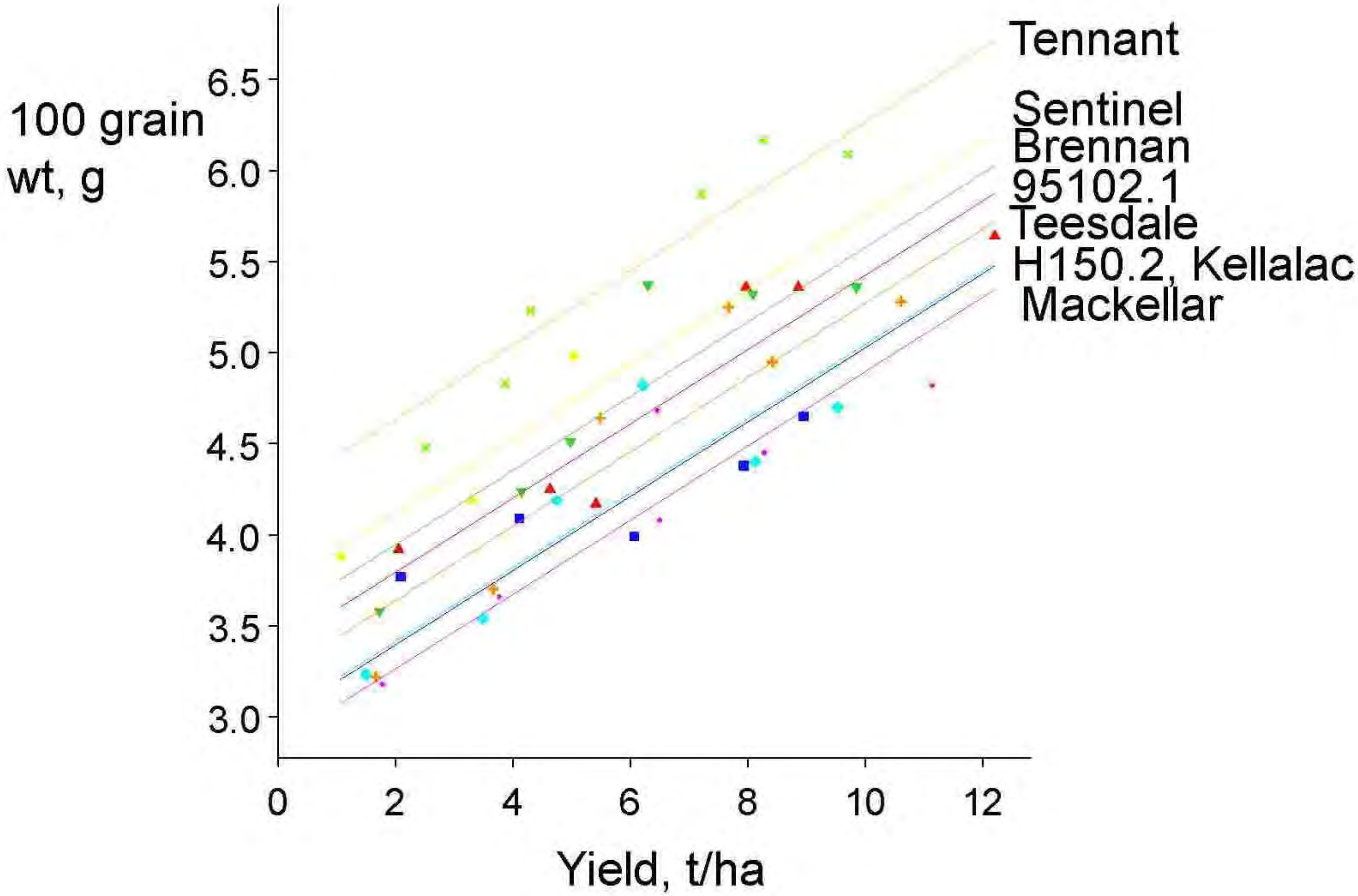


Crude
protein, %
20
18
16
14
12
10
0
2
4
6
8
10
12
Yield, t/ha


Soluble
protein, %
of CP
40
35
30
25
20
15
0
2
4
6
8
10
12
Yield, t/ha


Phosphorus,
%
0.40
0.35
0.30
0.25
0.20
0.15
0
2
4
6
8
10
12
Yield, t/ha


Tennant
Mackellar
Teesdale, 95102.1
Sentinel
Brennan
H150.2
Kellalac
Soluble protein, % of CP
40
35
30
25
20
15
0
2
4
6
8
10
12
Yield, t/ha



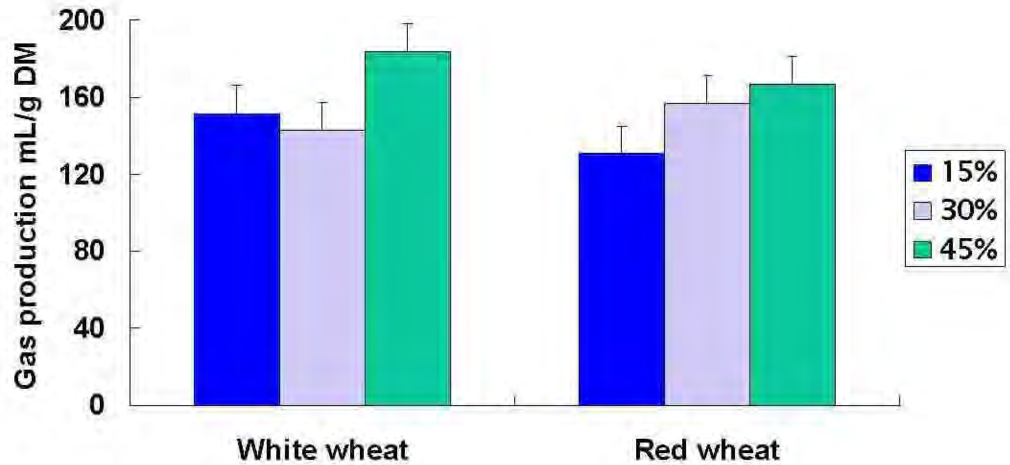
100 grain wt, g
Yield, t/ha
Tennant
Sentinel
Brennan
95102.1
Teesdale
H150.2, Kellalac
Mackellar
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
0
2
4
6
8
10
12

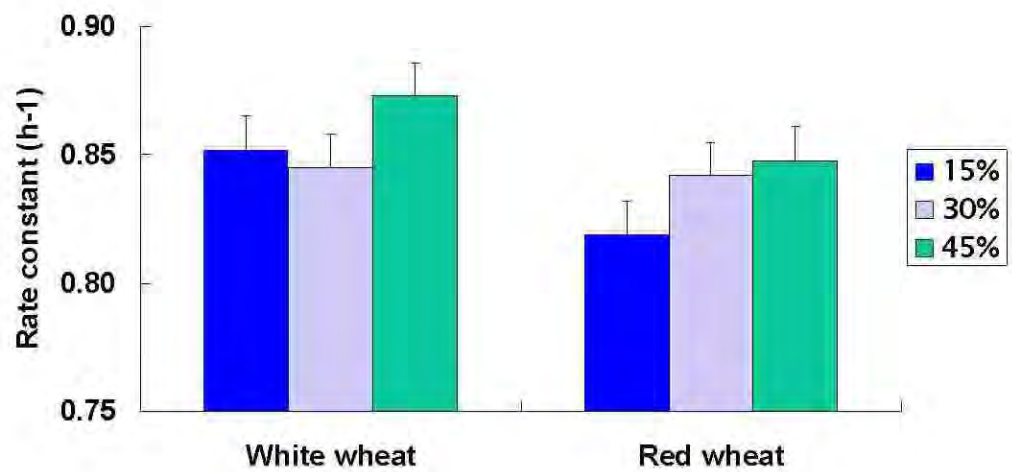
# Screening study of wheats

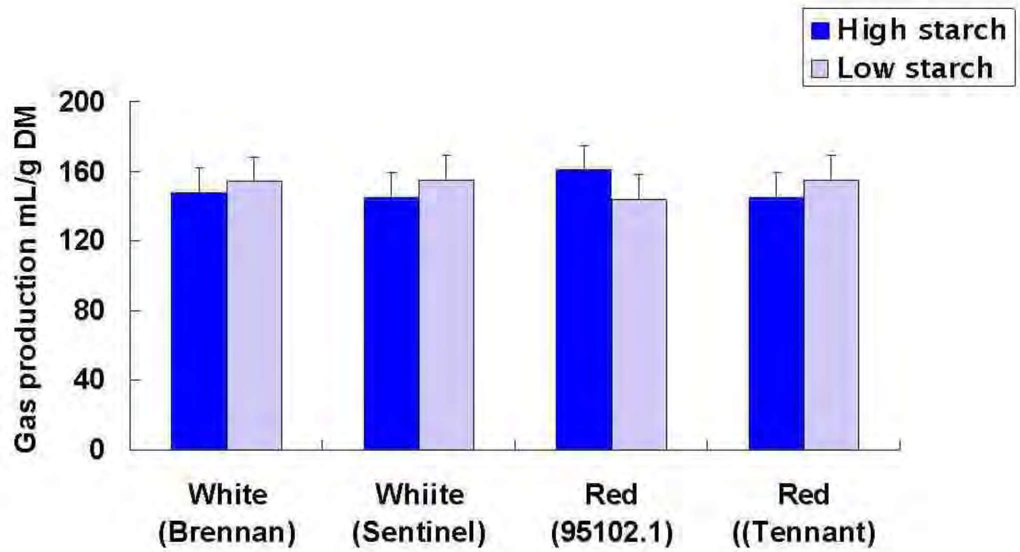
From the TIAR wheat library chose high (ca. 69%) and low (62%) starch samples of 2 red and 2 white wheats

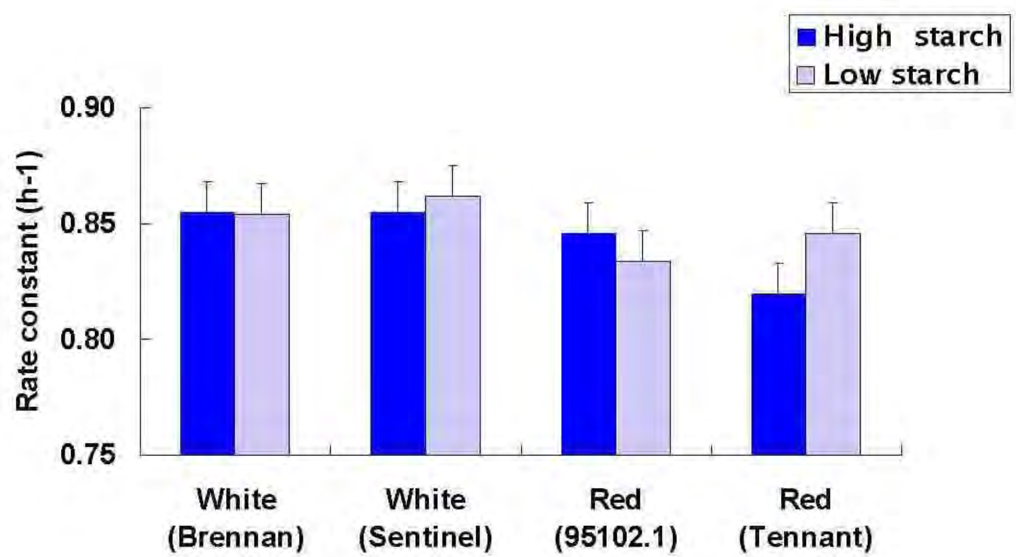
Investigated in vitro fermentation at 3 levels of inclusion (15, 30 and 45%)

Correlated in vitro fermentation characteristics with chemical composition

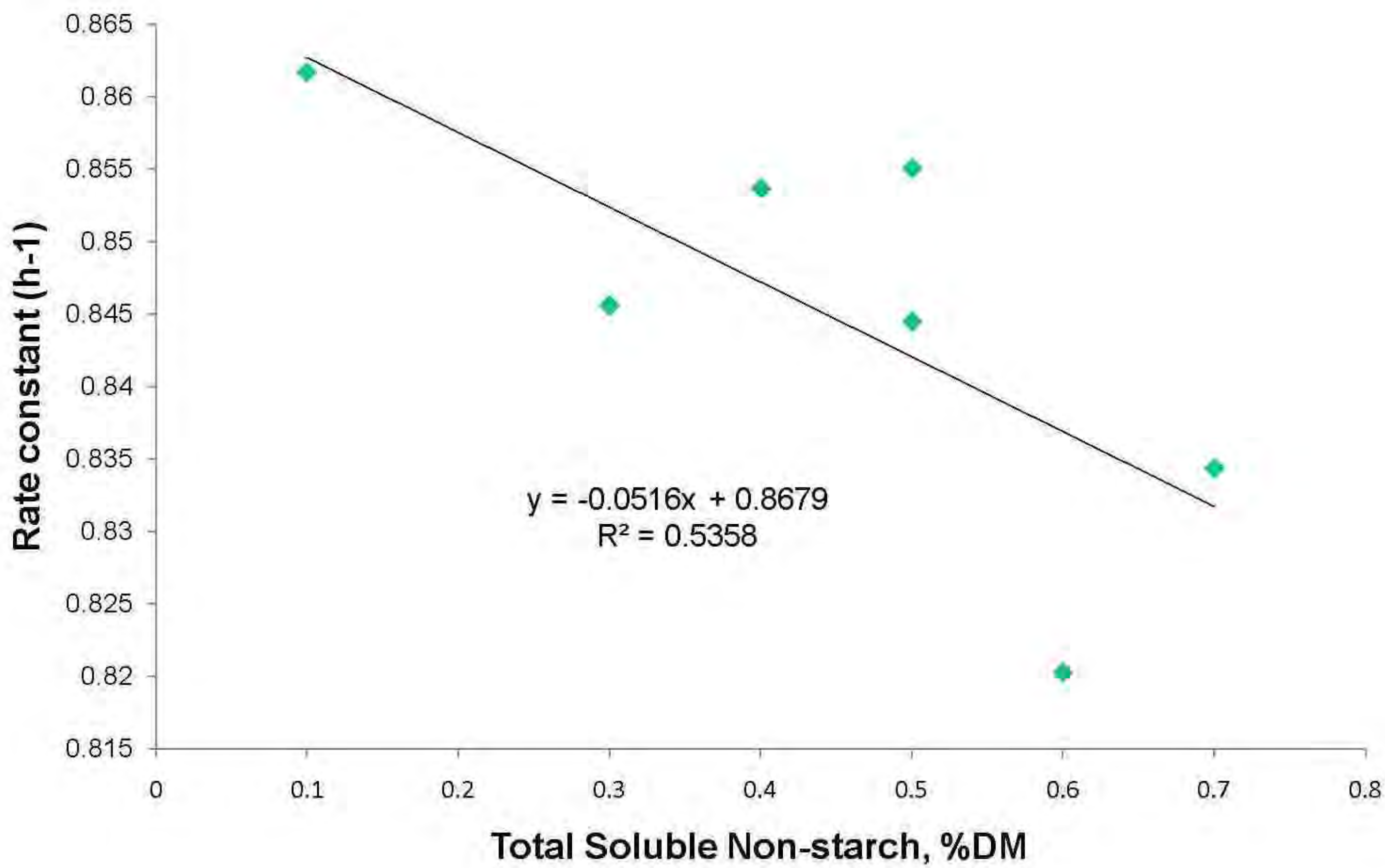

200
160
120
80
40
0
Gas production mL/g DM
White wheat
Red wheat
15%
30%
45%


0.90
0.85
0.80
0.75
Rate constant (h-1)
White wheat
Red wheat
15%
30%
45%

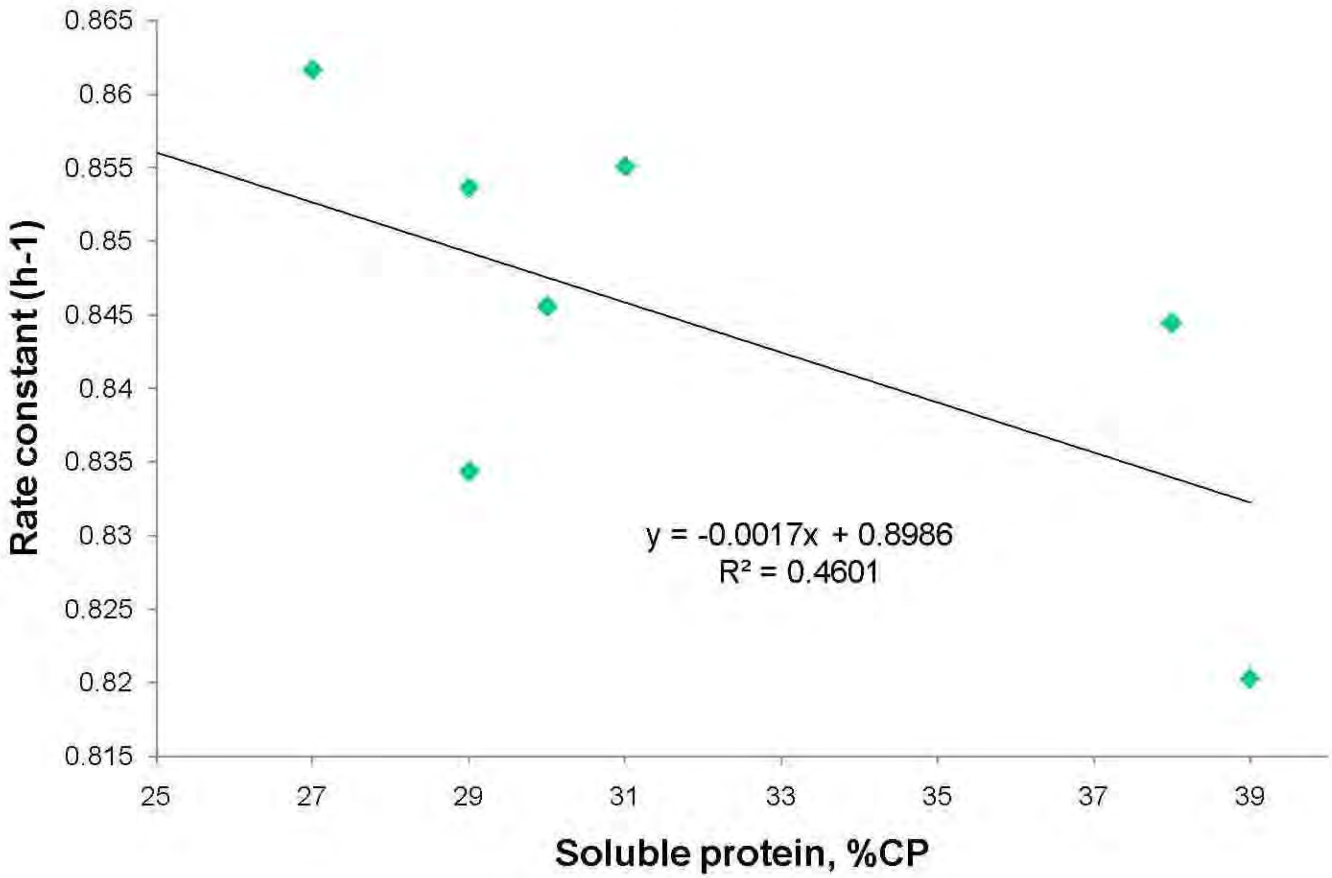

High starch
Low starch
Gas production mL/g DM
200
160
120
80
40
0
White (Brennan)
Whiite (Sentinel)
Red (95102.1)
Red ((Tennant)


High starch
Low starch
Rate constant (h-1)
0.90
0.85
0.80
0.75
White (Brennan)
White (Sentinel)
Red (95102.1)
Red (Tennant)

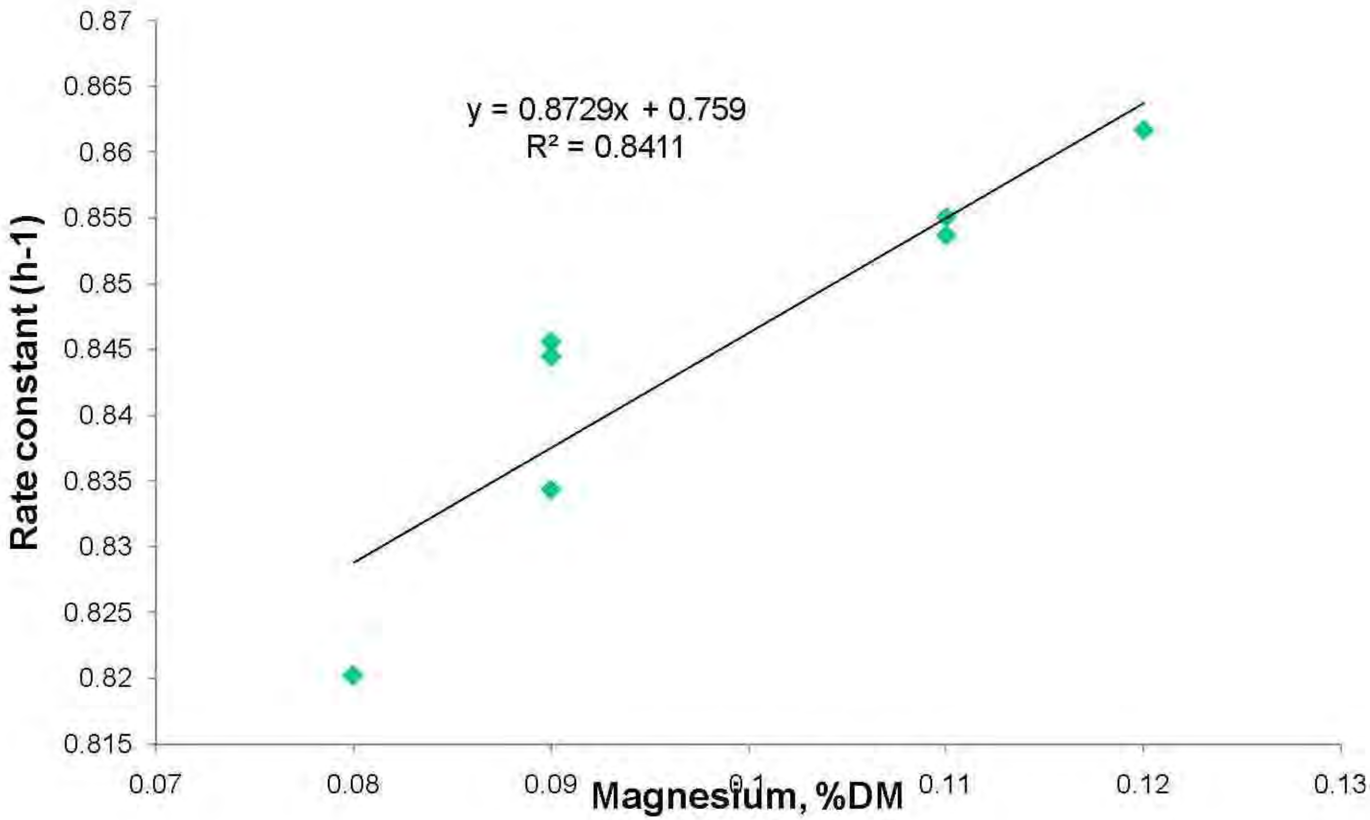
# The rate of fermentation is negatively related to total NSP



# The rate of fermentation is negatively related to soluble CP



# The rate of fermentation is positively related to Magnesium (also P and Fe)



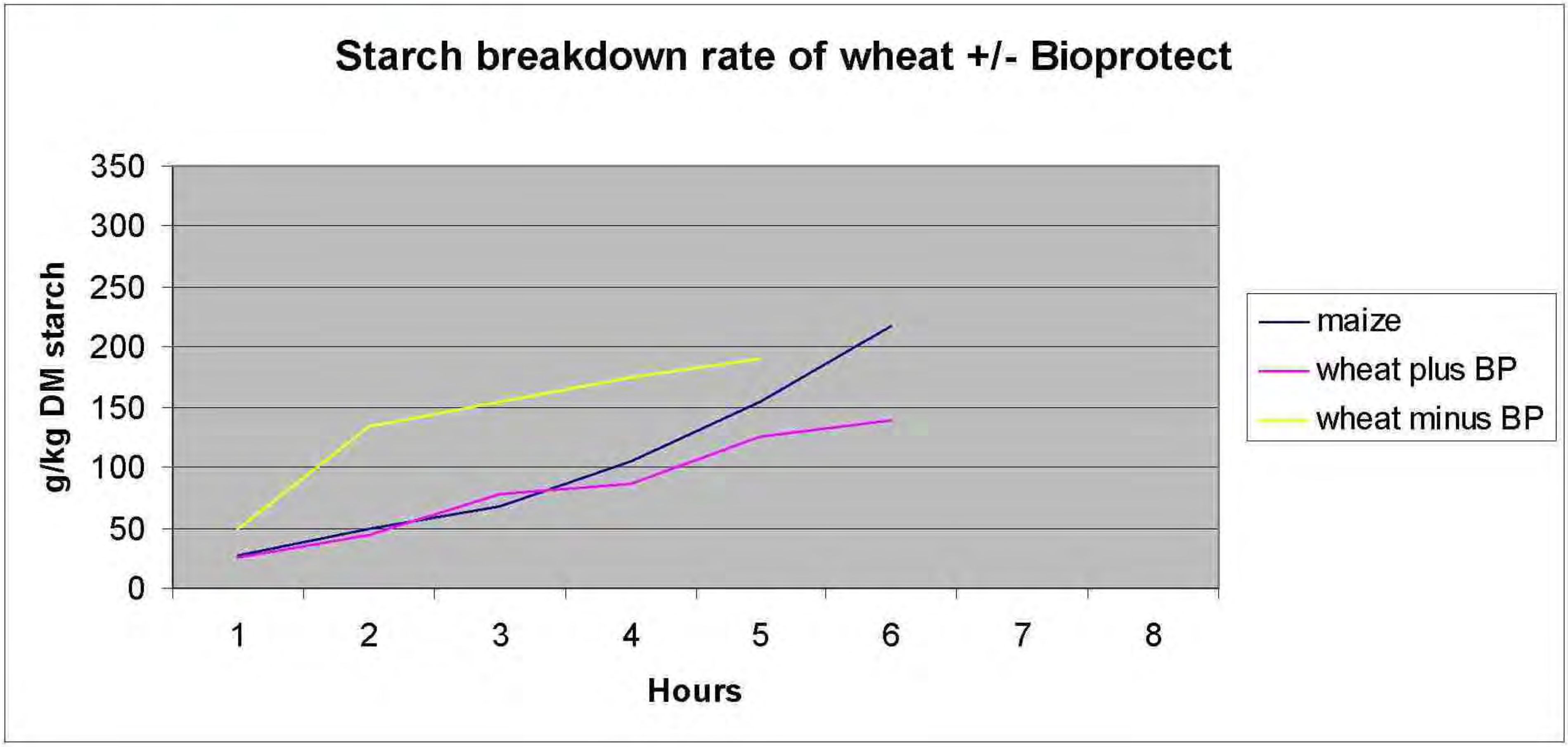
# Where to next for wheat

Evaluate the in vitro gas production characteristics of different wheats with varying proximate analyses

Investigate red *vs* white wheat at high intakes in highly productive cows

Investigate treatments such as Bioprotect on any wheats (red or white) with high levels of starch and soluble protein and high rates of gas production

# There are treatments (eg. Bioprotect) that can slow starch degradation so that wheat behaves more like corn



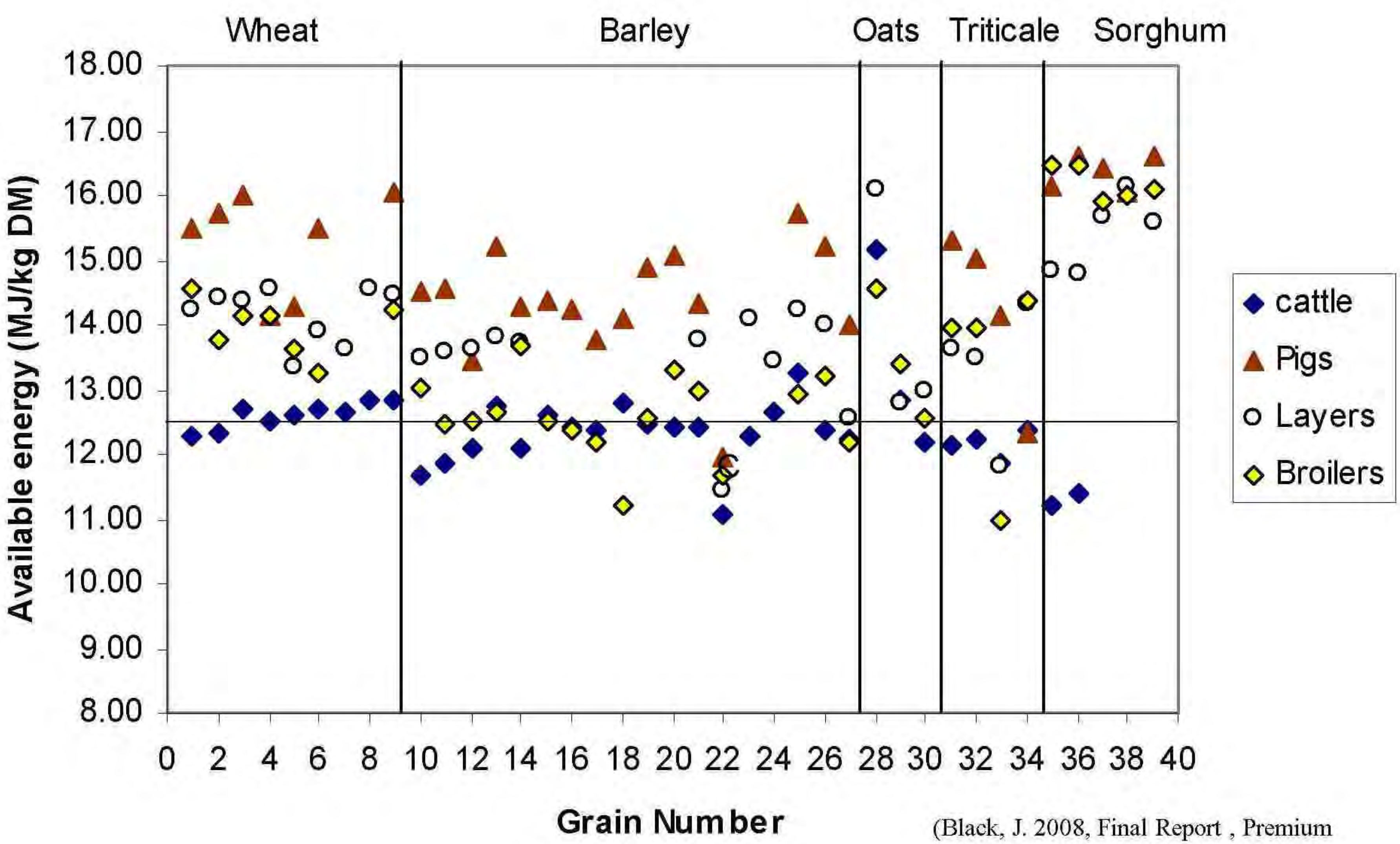
# Issues with sorghum

Sorghum is a high yielding grain that can be grown in low rainfall areas

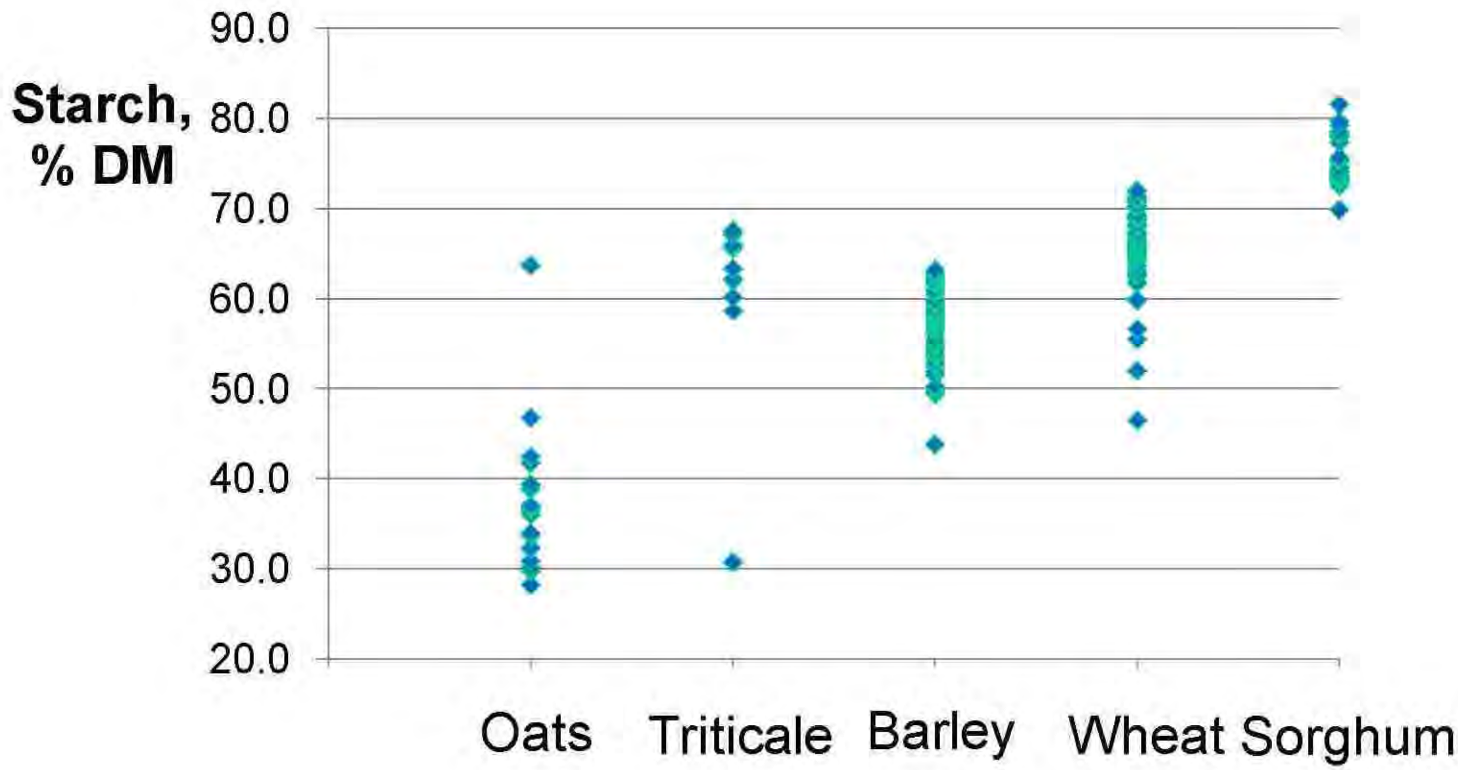
Chemical analyses of sorghum indicates a relatively high starch content

Digestibility/fermentability of starch in ruminants is lower than potential perhaps because starch is inaccessible

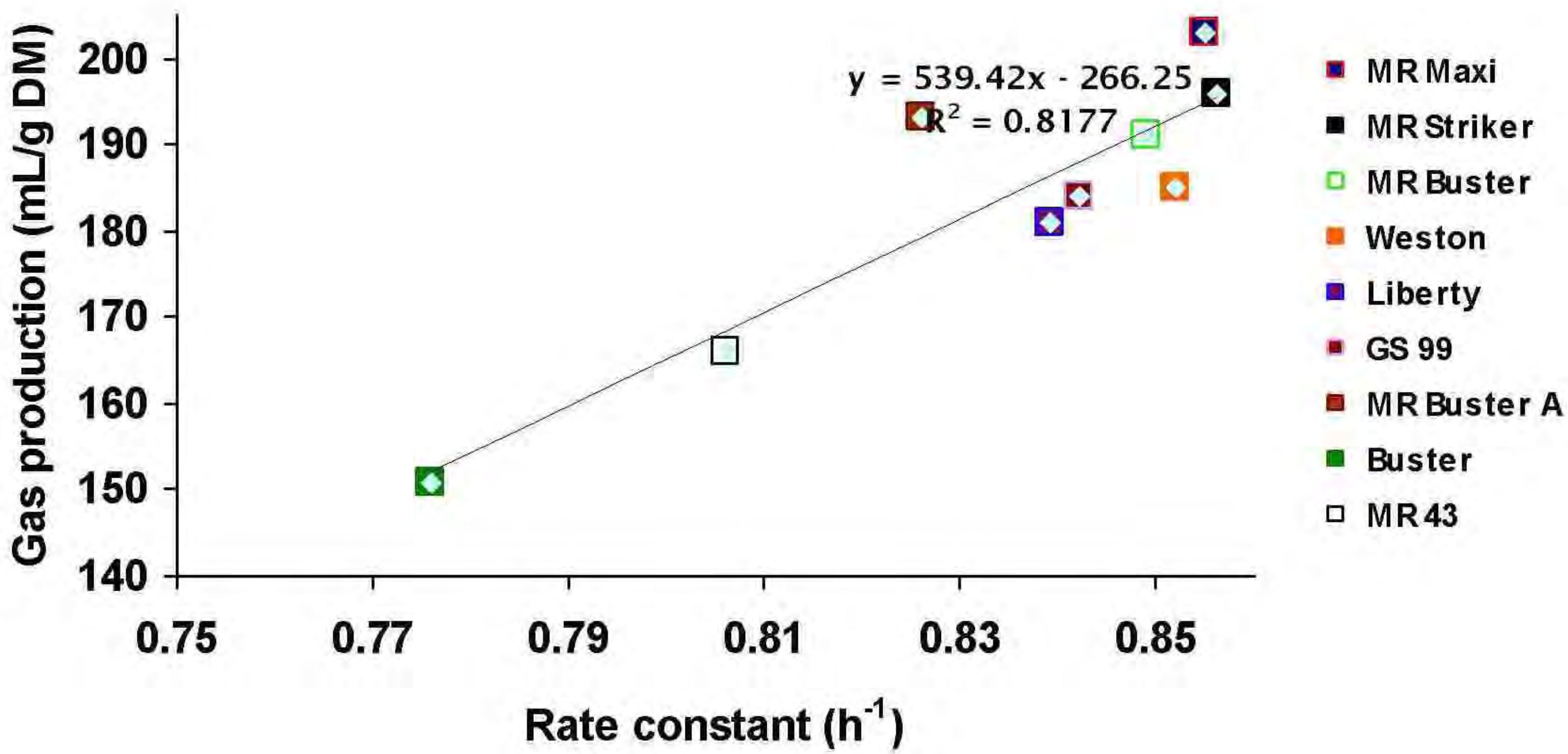
Problem may be related to tannin (polyphenols), phytate and/or kaffarin content



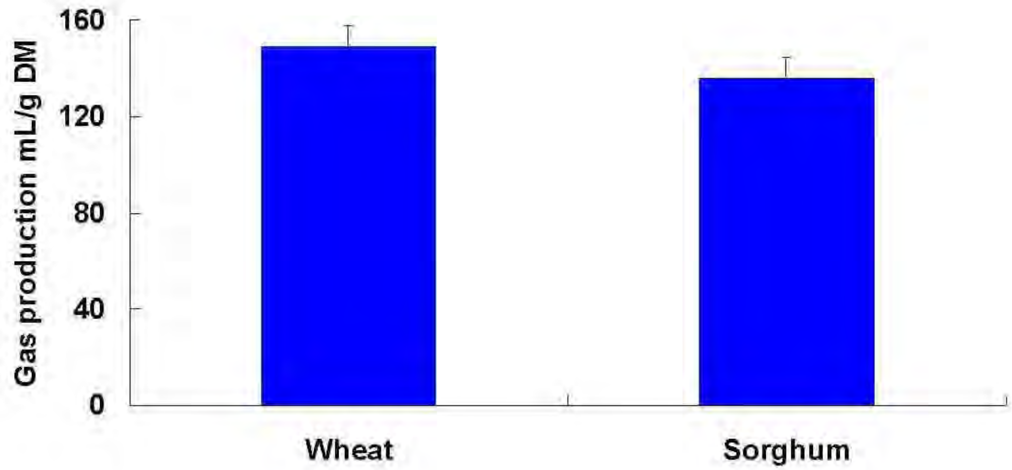

(Black, J. 2008, Final Report , Premium Grains for Livestock Program)



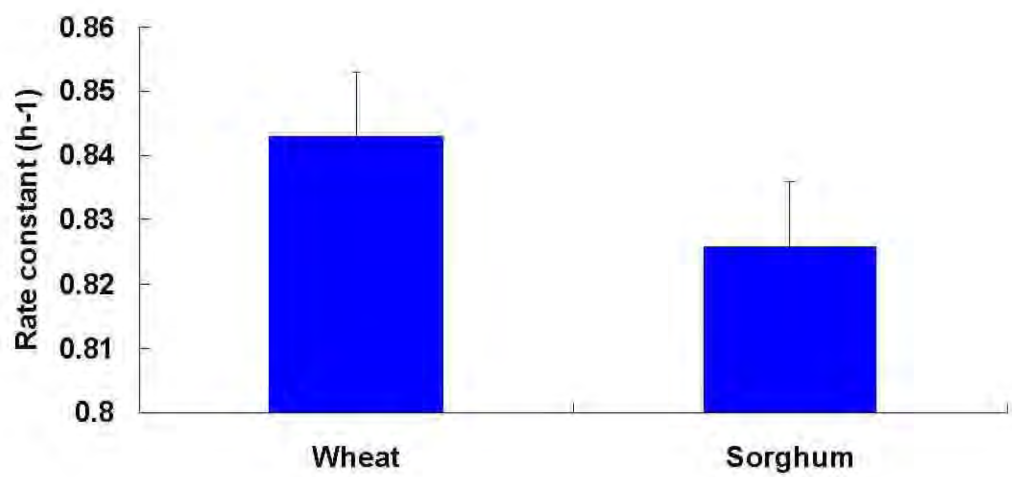

(Black, J. 2008, Pers comm. , Premium Grains for Livestock Program)



Gas production (mL/g DM)
200
190
180
170
160
150
140
0.75
0.77
0.79
0.81
0.83
0.85
Rate constant (h-1)
y = 539.42x - 266.25
R2 = 0.8177
MR Maxi
MR Striker
MR Buster
Weston
Liberty
GS 99
MR Buster A
Buster
MR 43

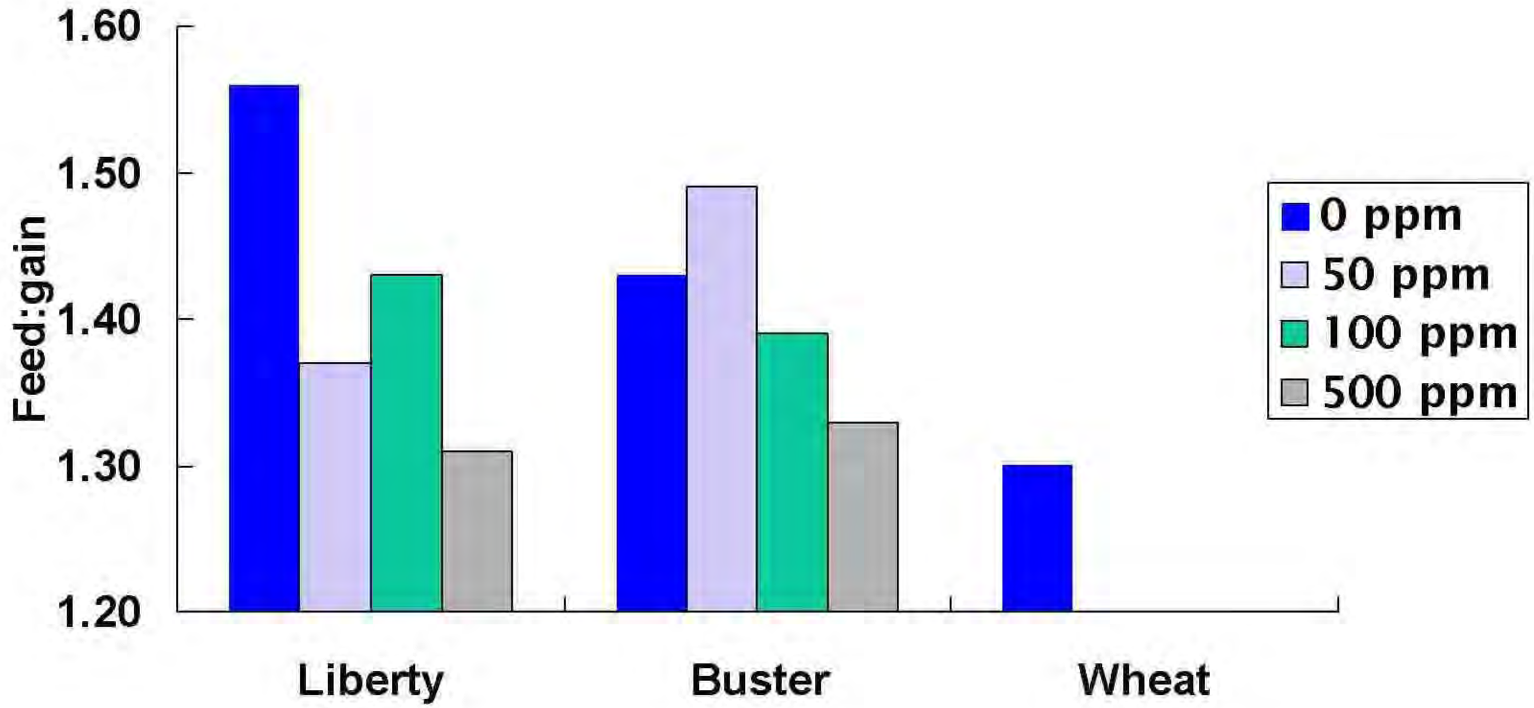


Gas production mL/g DM
160
120
80
40
0
Wheat
Sorghum

Rate constant (h-1)
0.86
0.85
0.84
0.83
0.82
0.81
0.8
Wheat
Sorghum

# Protease inclusion can improve performance of pigs fed sorghum




Cadogan, unpublished

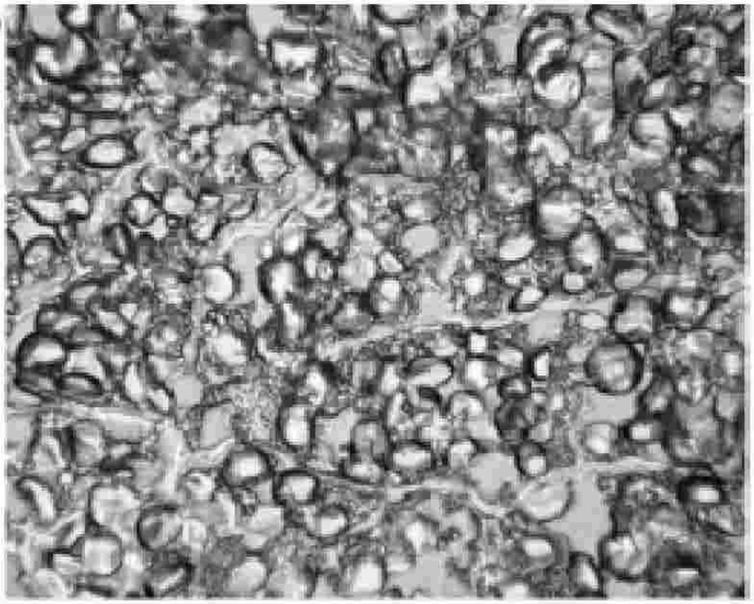
# Where to next for sorghum

Further evaluate the in vitro gas production characteristics of different sorghums with varying proximate analyses

Investigate treatments such as enzyme supplementation on any sorghums with low levels of starch and soluble protein and low rates of gas production

# Further understanding grain chemistry

- Need to identify grains that are more suitable for animals than for industrial purposes
- Technologies such as NIR absorptiometry can be used to rapidly assess the nutrient content of grain and fodder; this would enable strategic use of feeds for specific animal species or for specific purposes.
- Some grains are more appropriate for some animal species than for others and advances in knowledge of the digestibility of starches and the effects of starch polymer conformation on digestibility would help to determine which grains are appropriate for particular livestock species.
- Electron spectroscopy and synchrotron microspectroscopy have great potential to determine starch characteristics and secondary structures of proteins of grains



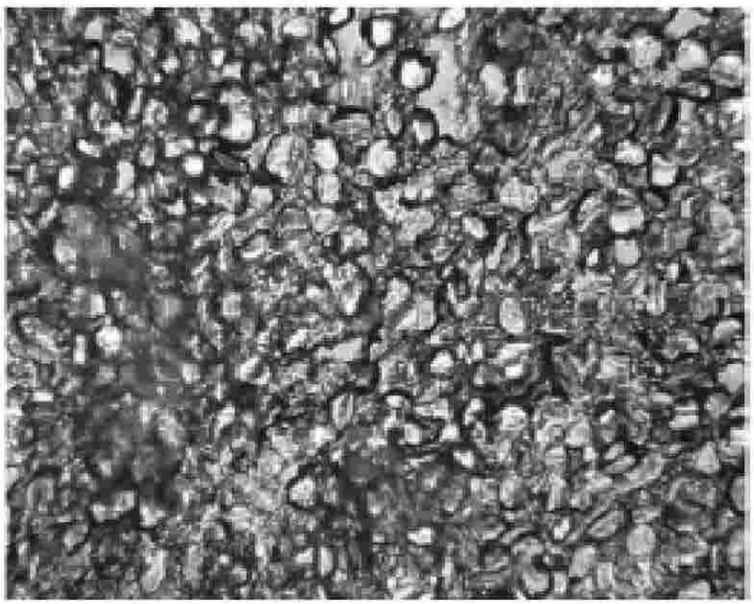


Fig. 7. (a) Photomicrograph of cross-section of the endosperm of Harrington (malting-type) barley. (b) Photomicrograph of cross-section of the endosperm of Valier (feed-type) barley (Olympus BH-2; 10 × 40 magnification; photomicrograph width 108·4 mm (4·267 inches) and height 86·7 mm (3·413 inches)). (From Yu *et al.* 2004 *b*.)

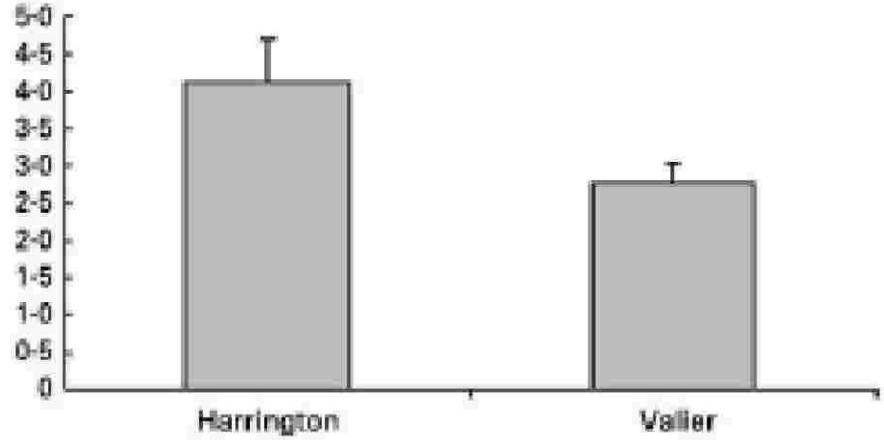



Fig. 8. Starch:protein synchrotron radiation-based Fourier transform infrared absorbance intensity (log 1/R) ratio in the endosperm tissues of Harrington (malting-type) and Valier (feed-type) barley. Mean values are shown, with their standard errors represented by vertical bars. The mean values are significantly different ($P<0·05$). (From Yu *et al.* 2004 *b*)

Synchrotron microscopy detects chemical differences in the ultrastructural matrix of endosperm tissue between Harrington (malting-type) and Valier (feed-type) barley in relation to rumen degradation characteristics. These data indicate that the greater association of the protein matrix with the starch granules in the endosperm tissue of Valier barley may limit the access of ruminal micro-organisms to the starch granules and thus reduce the rate and extent of rumen degradation relative to that of Harrington barley.

# Conclusions

Red wheat does not necessarily appear to be inferior to white wheat for ruminants

However, there is large variability in nutritive value between and within wheats and sorghums perhaps due to yield (genetics and agronomy)

Potential to use enzymes (eg. proteases for sorghum) or other treatments (eg. Bioprotect) to improve utilisation of various grains

Need to use NIR and other technologies combined with calibrations against in vivo and in vitro measures of performance to rapidly screen grains

# Acknowledgements

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Peter Jefferis, RealisticAgri