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Australian Export Grains Innovation Centre

Australian sorghum for pigs: value and opportunity

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THE AUSTRALIAN GRAINS INDUSTRY CONFERENCE ASIA 2019

Department of Primary Industries and Regional Development
GOVERNMENT OF WESTERN AUSTRALIA

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

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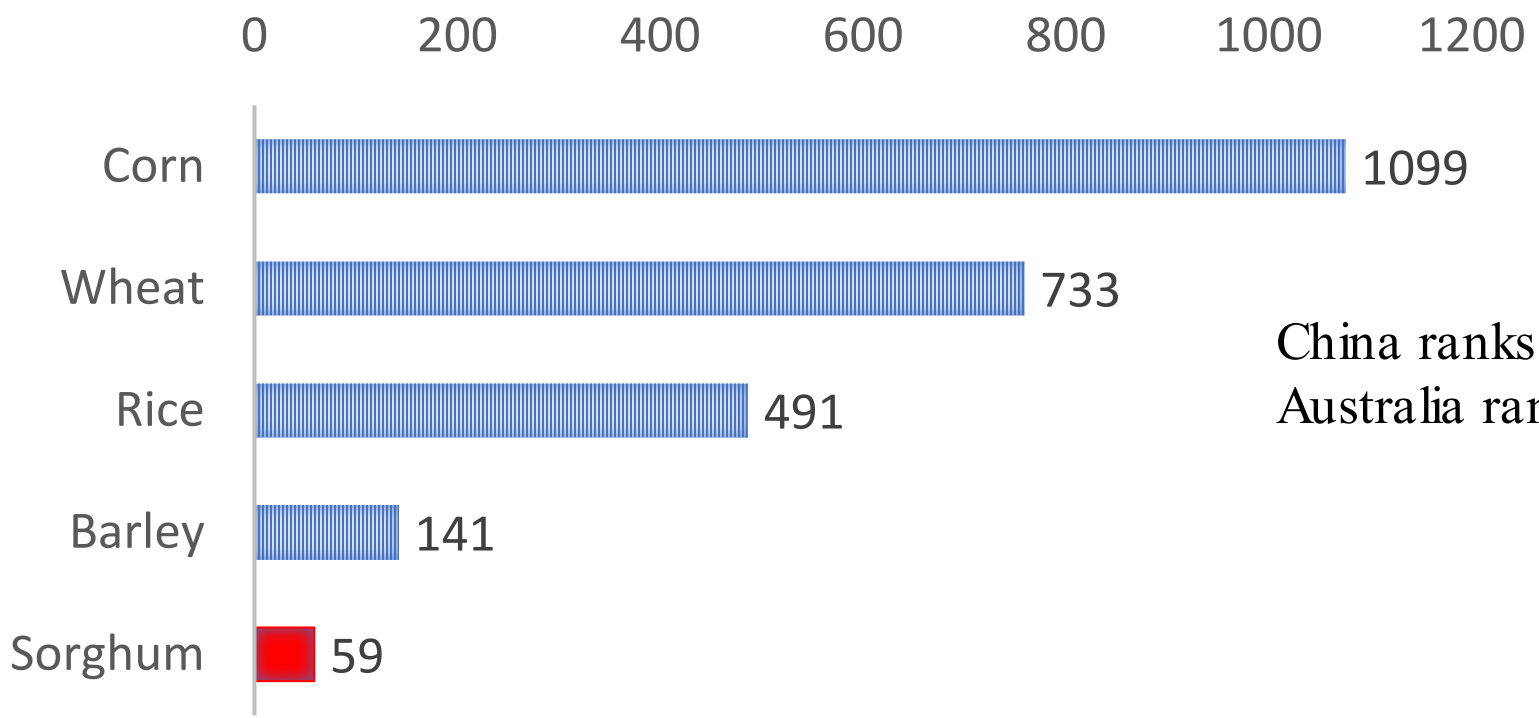
AEGIC is an initiative of the Western Australian State Government and Australia's Grains Research and Development Corporation

Australian Sorghum

- World grain
- Australian grain industry
- Value & opportunity applications in pig feeds

World Grain Production 2018/19

(million metric tonnes)



China ranks No 7 in sorghum production
Australia ranks No 9

USDA, Production, Supply and Distribution, January 2019

Sorghum is a useful grain for pigs – with some similarities to corn

Chemical, Functional & Physical differences –

- Composition, grain size, bulk density, hardness that contribute to differences in formulation, handling and milling

To use it effectively

- Understand its characteristics and be ready to use it when opportunities arise

Cereal grains grown in Australia

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Crop production (kt) 2016–17 to 2018–19			
	2016–17	2017- 18	2018- 19
Winter crops			
Wheat	31,819	21,244	19,096
Barley	13,506	8,928	8,327
Canola	4,313	3,669	2,789
Summer crops			
Grain sorghum	994	1,439	1,559
Corn (maize)	436	392	383
Soybeans	31	63	44

Grain production is dominated by *wheat* followed by *barley* then *sorghum*

ABARE Crop Report, Sept 2018

Australian grain production

- Rigid quality standards and testing for trade across industry
  - Grower to end-user
  - All grains & meals
    - Refer to the Grain Trade Australia website for further information

      https://www.graintrade.org.au/
- Typically dry conditions at harvest - low moisture
- High quality storage facilities and management
- Low mycotoxin contamination - minimal risk to pigs, poultry, cattle

Australian stockfeed industry

- Utilizes a broad range of feedstuffs – most feedmills would have storage for at least 4 grains and at least as many protein meals at any time
- Composition of diets varies widely by region - sorghum/wheat in the north during winter; wheat and barley in the south and by season
- Competition for space – wheat, barley, canola, cotton and various legumes are all grown in the same geographical area; what is grown and in what quantities varies from season to season
- End users very flexible in what they use
  - Developed NIRs testing of grains
  - Routine use of SID formulations

Sorghum Production by State 2017-18, tonnes

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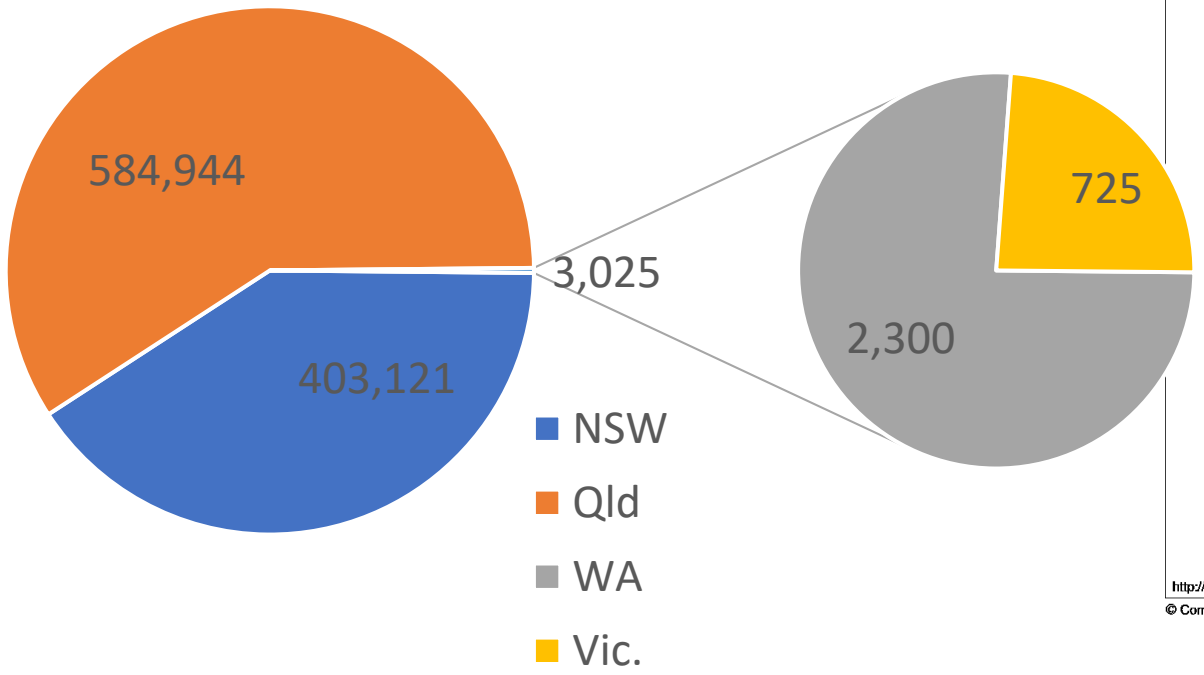
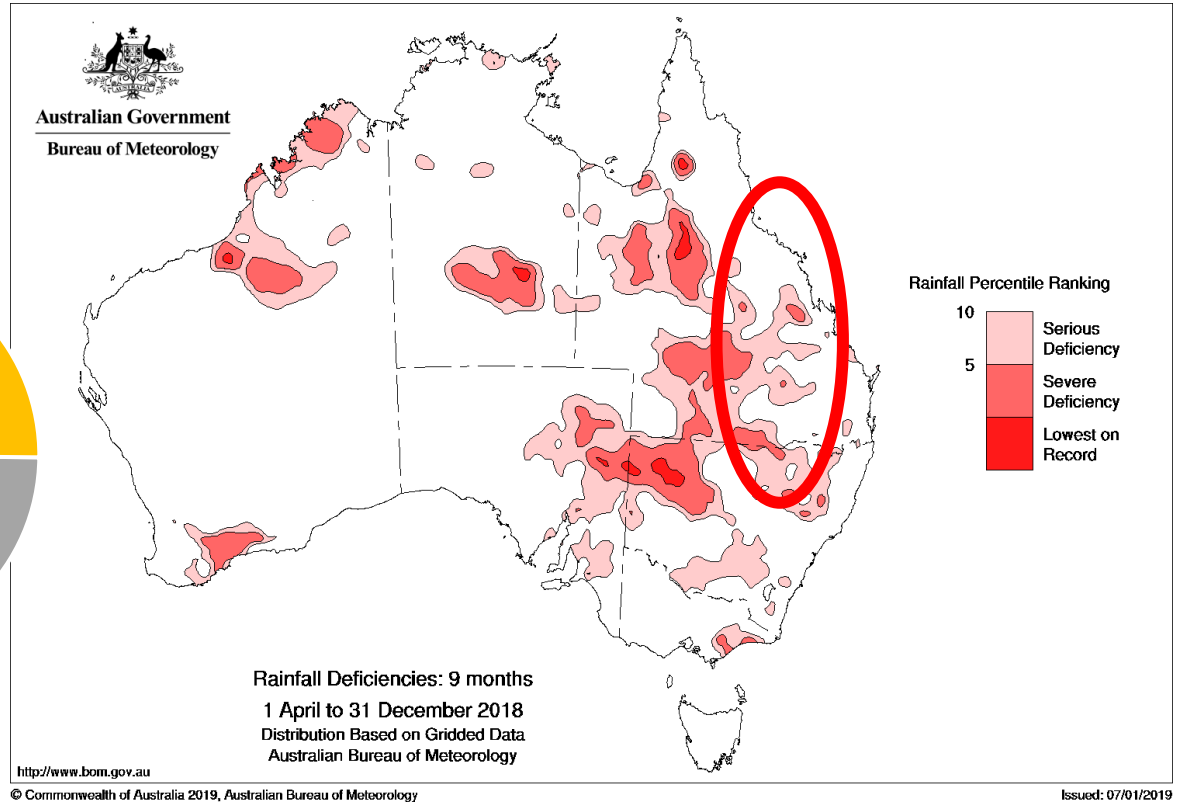
Used primarily for animal feed – beef, dairy, pig & poultry





ABARES forecast %change in production 2017–18 to 2018–19, –24%

Australian sorghum

- Small grain size, no hull, no serious antinutritional factors

- More than 95% of the sorghum grown in Australia is "red" *Sorghum bicolor* var.
  - Seed coat colour can be yellow, brown, red
  - Tannin-free (nil condensed tannins)
  - Seed colour not good indicator of tannin content or phenolic compounds for Australian sorghum – bred for low tannin content

Physical differences between barley, corn, wheat and sorghum

Constituent	Barley	Corn	Sorghum	Wheat
100 Grain Weight (g)	4.2	35	3.0	3.4
Bulk Density (kgm^{-3})	620	720	720	750
Particle size (mm)[a]	-	0.554	0.502	-
Particle size (mm)[b]	0.538	-	0.577	0.527
Gelatinization temperature (^0C)	52-59	62-72	71-80	58-64

[a] hammered through 3.2 mm screen

[a] Martin, 1985 [b] Sopade et al, 2013

Sorghum is a small grain, no hull, hard endosperm. It generally gelatinizes at a higher temperature than other grains – processing considerations?

Concentrations of Key Nutrients for Pigs[a]

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		Barley	Corn	Sorghum	Wheat
Moisture[b]		12.8	13.7	12.1	13.1
Protein %		10.1	8.2	9.4	12.7
Fat %		1.8	3.7	2.9	2.4
NDF %		18.7	10.4	9.3	12.4
ADF%		5.5	2.6	3.7	3.1
Starch %		52.2	64.1	64.1	59.6
DE swine	Kcal/kg	3060	3390	3370	3580
	MJ/kg	12.8	14.2	14.1	15.0

[a] Evapig, 2018; [b]Feedtables.com, 2018

Sorghum provides similar energy and starch content to corn; maybe more protein and a little less fat.

Digestible (SID)[a] amino acid and selected mineral contents of corn, barley, wheat and sorghum at typical protein content

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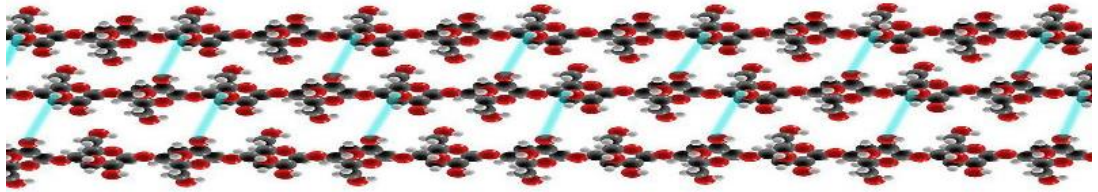
		Barley	Corn	Sorghum	Wheat
Protein	%	10.1	8.2	9.4	12.7
Lysine	%	0.29	0.19	0.16	0.25
Methionine	%	0.15	0.16	0.13	0.15
Isoleucine	%	0.29	0.27	0.33	0.34
Tryptophan	%	0.1	0.04	0.08	0.11
Phenylalanine+Tyrosine	%	0.78	0.74	0.89	0.82
Valine	%	0.42	0.35	0.41	0.40
Calcium	%	0.07	0.04	0.03	0.06
Phosphorus	%	0.34	0.25	0.30	0.31
Phytate P	%P	55	75	70	65
Digestible P	%	0.11	0.07	0.08	0.09

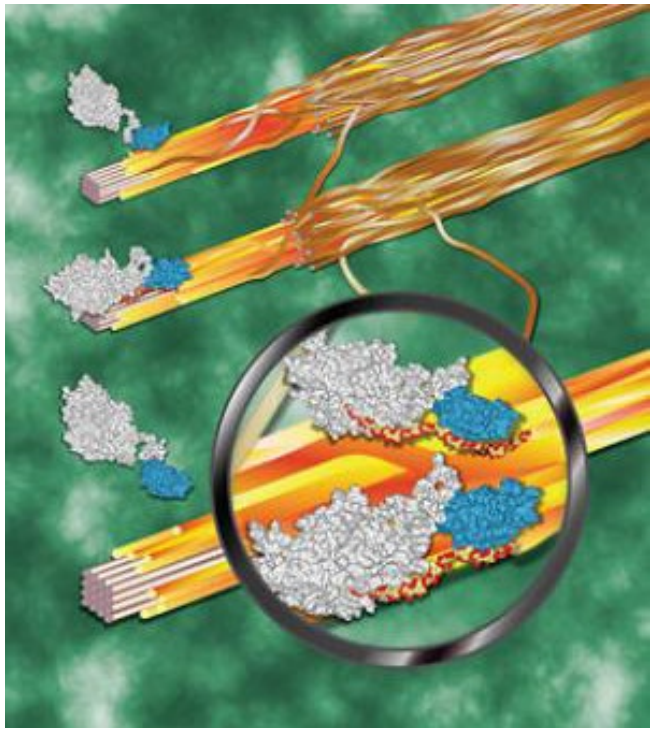
[a]Evapig 2018

Non-starch polysaccharides (NSP) affect hydration, enzymolysis & digestion

- In corn & sorghum- insoluble NSP pose a physical barrier to hydration & enzymolysis



- In barley and wheat - the presence of soluble NSP alters viscosity in the gut



images from Wikipedia

Differences between barley, corn, wheat and sorghum in NSP content and composition

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	Barley	Corn	Sorghum	Wheat
Arabino-xylan	7.9	5.2	2.1	8.1
ß-Glucan	4.3	-	0.2	0.8
Cellulose	3.9	2.0	2.2	2.0
Soluble:Total NSP	0.23	0.01	0.04	0.18
Total NSP	19.9	9.1	5.9	13.2

Sorghum is more similar to corn than wheat or barley in NSP content and composition

- Low **soluble** NSP content – low viscosity
- Physical barrier to digestion from **insoluble** NSP
- Responds to carbohydrase enzymes in a similar way to corn

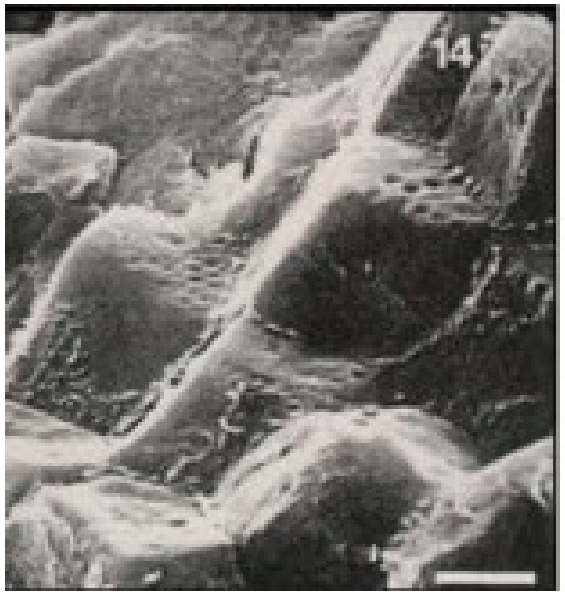
Responses in component digestibility (%) to phytase in pigs fed corn, barley or red sorghum

Grain	Phytase (FTU/kg)	Phosphorus	Calcium	Nitrogen	Digestible Energy (MJ/kg)
Corn[a]	0	44	62	89	89
	500	60	79	87	87
Barley[b]	0	46	44	83	83
	150	68	59	89	85
Sorghum[b]	0	52	56	81	88
	150	58	59	80	87

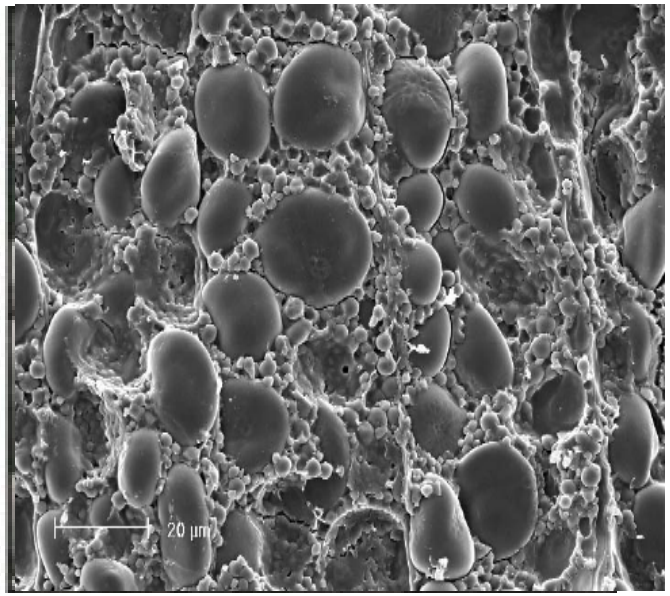
after [a]McCormick et al., 2017 [b]Hosking et al., 2010

Like other cereals, sorghum is responsive to phytase supplementation with improvements in calcium and phosphorus digestion

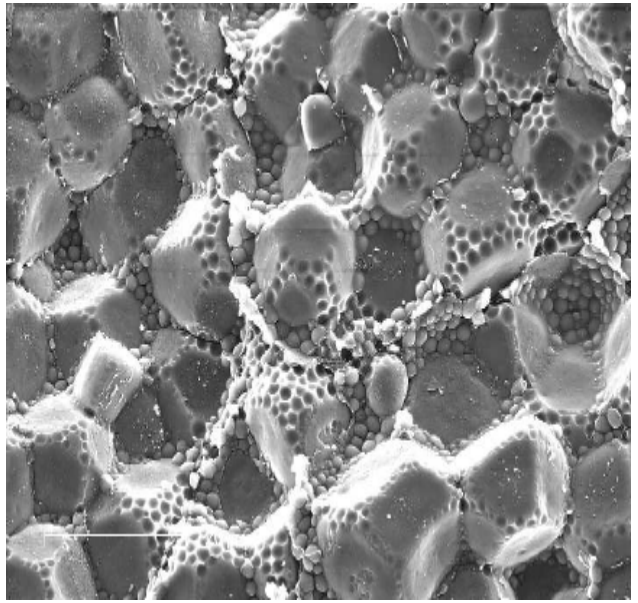
Starch granules in the endosperm of cereal grains are imbedded in a prolamin:starch matrix.



Corn[a]



Barley[b]

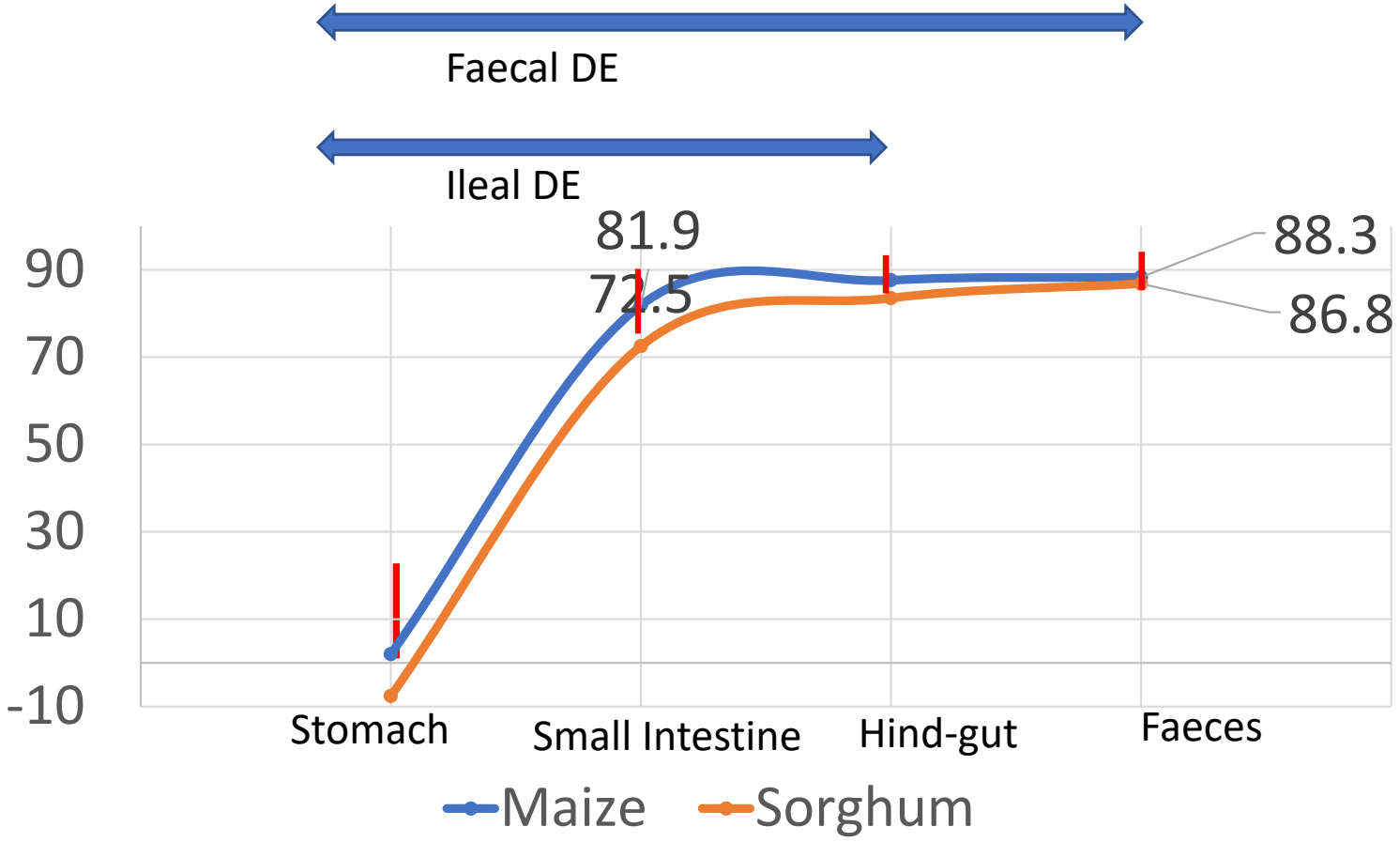


Sorghum[b]

Size of starch granules is not uniform: Corn>Barley>Sorghum
Sorghum prolamin (kafirin) shows high content of disulphide bonding that further restricts hydration and enzyme access

after Hoseney, 1986[a]; Black, 2001[b]

Site & extent of digestion varies with grain-type

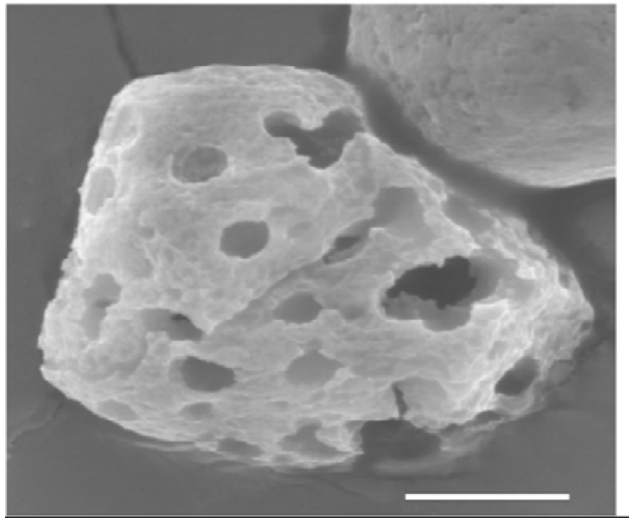


Grain composition and the prolamin:starch matrix reduce sorghum ileal digestibility

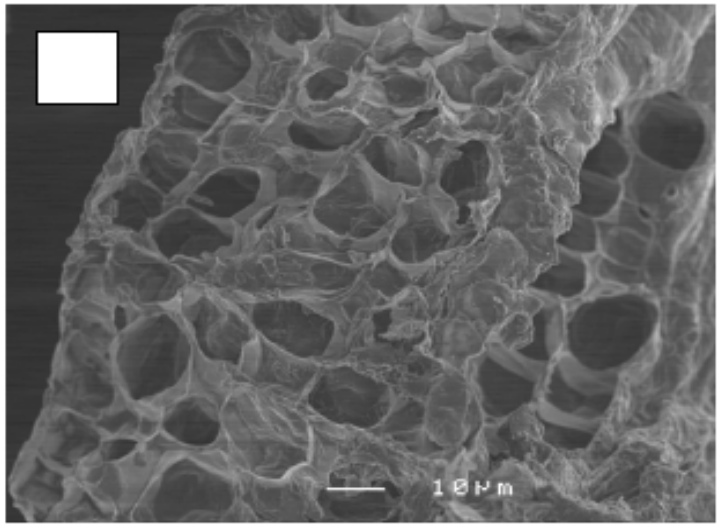
In vivo data from growing pigs; after Pascual-Reas, 1997

in vitro starch digestion

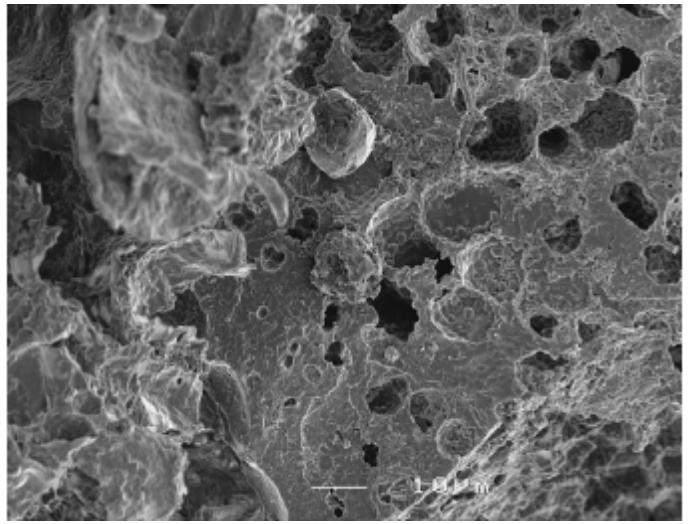
Scanning electron micrographs of showing differences in starch digestion related to differences in the prolamin matrix surrounding individual starch granules.



Maize[a]



Barley[b]



Sorghum[b]

Almost complete removal of starch from barley and maize granules

Partial removal of starch from sorghum

after [a] Meireles et al., 2009; [b]G. J. Al-Rabadi et al., 2011

Digestibility coefficients and measured digestible energy in pigs fed sorghum with protease supplementation

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Grain type	Protease (ppm)	Digestibility coefficient (%)	Digestible Energy (MJ/kg as fed)
Wheat Control	0	83.6a	14.9a
Sorghum	0	80.9b	14.3b
	50	81.0b	14.3b
	100	82.8a	14.6a
	500	83.3a	14.7a
SEM		0.24	0.04

after Cadogan, 2015

The prolamin:starch matrix in sorghum can be disrupted and DE improved with the use of protease. The 0.4 MJ/kg increase in DE for the sorghum diets is worth approximately $8.75 per tonne if the cost of 1 MJ/kg DE is $25.

Inclusion levels of selected grains used in conventional Australian grain-based pig diets

Feed ingredient	Inclusion levels and characteristics affecting inclusion levels
Wheat	No limit, can be used as the only cereal grain. High in energy with average protein. The most common cereal grain used in Australia.
Barley	No limit, generally not used in diets for young pigs due to low energy and high fibre.
Sorghum	No limit, can be used as sole grain; use with other grains is often preferred. Some mills report difficulty pelleting when sorghum exceeds 50%
Maize	Limit to 30%of grain component. Unsaturated fat and pigments affects fat quality in domestic market.

Indicative growth performance for Australian red sorghum in pigs

Diet	Live weight (kg)	Daily weight gain (kg)		Feed/unit gain	
		Barley	Sorghum	Barley	Sorghum
Weaner[b]	7-15	0.25a	0.27a	1.93a	2.22b
SEM			0.013		0.094
Grower[a]	20-45	0.82a	0.82a	1.94a	2.03b
SEM			0.031		0.051
Grower[b]	20-45	0.89a	0.86a	1.70a	1.72a
SEM			0.033		0.052

after [a]Al-Rabadi et al., 2017; [b]Sopade et al, 2013

Single grain diets – not balanced for SID. The higher feed:gain for sorghum indicates why sorghum is often used with other grains in diets for younger pigs

Indicative growth performance of low and high tannin sorghums for growing pigs

Sorghum type	Live weight (kg)	Daily weight gain (kg)		Feed/unit gain		Feeding value %Corn
		Corn	Sorghum	Corn	Sorghum	
Non-bird-resistant: low tannin						
Average	16–94	0.77	0.78	2.98	3.08	96
Bird-resistant: high tannin						
Average	19-97	0.76	0.76	3.13	3.46	87

USA data, after Meyer et al., 2017

Australian red sorghum is low tannin, <0.25g/100g; high tannin varieties may contain >0.5g/100g

Relative value (%) of sorghum v corn in nursery and finisher pigs

	Nursery	Finisher
Live weight gain	98	103
Feed Intake	99	106
Feed efficiency	99	98

Tokach et al., 2010

Sorghum, correctly processed and formulated according to its nutritional advantages, can be used as an effective alternative to corn in all pig feeds.

Australian sorghum - features relative to selected feed grains

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Feature	Unit	Corn	Barley	Sorghum	Wheat
Moisture[a]	%	13.6	13.3	13.5	11.8
Australian data[b]	%	12.8	10.7	11.0	10.1
Mycotoxin	risk	?	low	low	low
Tannins	risk	X	low	low	low
Pigment	yellow	✓	X	X	X
Pelletability	FPQF[c]	5	5	4	8
Enzyme	Phytase	✓	✓	✓	✓
	Complex	✓	✓	✓	✓

[a] Evapig; [b] Hosking 2018; [c]FPQF - Feed Pellet Quality Factor (Borregaard LignoTech); after Walker, 2018

Sorghum summary

- Australian sorghum can be used in all types of pig feeds
  - used successfully in Australia (and elsewhere)
  - similar processing and handling considerations to corn
  - usually used in combination with other grains to reduce ration variation & lower risk

- Understand characteristics of each grain so you can be prepared to use alternatives when opportunities arise

Sorghum summary

- Plan for the use of 'alternative' grains – in the current World market it is likely to be the new "normal"
  - in many cases this is likely to be a simple matter of adjusting inventory and ingredient codes and reformulation of existing mill rations
- Use 'alternative' grains when economic
  - if you can be prepared - you can act quickly
  - opportunities may not last long

Note: Values provided in this presentation are indicative only and should not be used for purchase assessment or feed formulation

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Thank you

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