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Barley, Wheat and Sorghum from Australia as alternative grains in pig diets in Asia

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Government of Western Australia
Department of Primary Industries and Regional Development

GRDC Grains Research & Development Corporation

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

Key messages

Pig production is competitive and cost sensitive

Feed is the single biggest cost. Need to be flexible regarding ingredients

Pigs are adaptable and can meet their nutrient requirements from a broad range of feeds

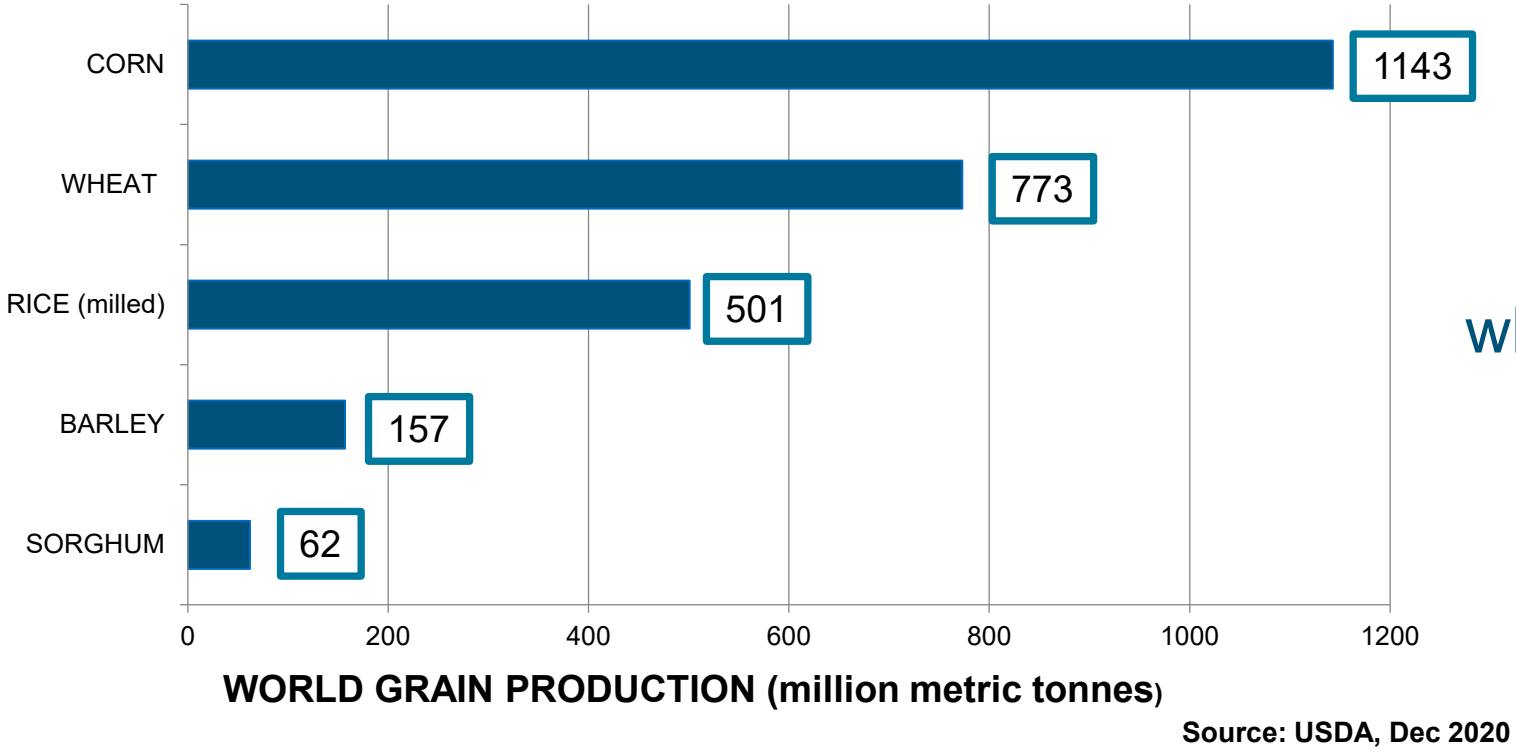
Corn and soy are not essential ingredients for diets

Australian pigs use mainly barley, wheat, legumes and canola meal with excellent results

Australia will produce 12 million metric tonnes of barley in 2020/21

Australian barley is accessible and attractively priced

World Grain Production 2020 / 21



Source: USDA, Dec 2020

Dominated by corn but substantial volumes of wheat and barley available for animal feeding

Applications:

Human Food

Brewing / Distilling

Animal Feed

Ethanol

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Major Producers and exporters of wheat & barley: 2020 / 21 (million metric tonnes)

WHEAT

COUNTRY	PRODUCTION	EXPORT
China	136.0	1.0
EU	135.8	26.0
India	107.6	-
Russia	84.0	40.0
USA	49.7	27.0
Canada	35.2	26.0
Australia	30.0	18.0
Pakistan	25.7	-
Ukraine	25.5	17.5
Turkey	18.3	6.7
Other	125.9	29.9
TOTAL	773.7	192.1

BARLEY

COUNTRY	PRODUCTION	EXPORT
EU	63.4	6.5
Russia	20.6	5.4
Australia	11.0	5.0
Canada	10.7	3.0
Turkey	8.1	-
Ukraine	8.0	4.0
Kazakhstan	3.8	1.5
Iran	3.7	-
USA	3.6	0.2
Argentina	3.5	2.5
Other	20.7	-
TOTAL	157.2	28.9

Source: USDA, Dec 2020

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Australian Crop Production 2020/21 (million metric tonne)

CEREALS	
Wheat	31.2
Barley	12.0
Sorghum	1.7
Oats	1.6
Corn	0.37
Triticale	0.13

LEGUMES	
Chickpeas	0.74
Lupins	0.71
Faba Beans	0.52
Lentils	0.62
Peas	0.29

OIL SEEDS	
Canola seed	3.7
Soybeans	0.04

TOTAL	51.5

Source: ABARE, Dec 2020

FEATURES:

- Wheat and Barley dominance
- Wide range of cereals and legumes
- Low levels of Corn and Soy

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Feed ingredients used in stockfeed manufacturing in Australia

CEREALS	LEGUMES	ANIMAL PROTEIN	VEGETABLE PROTEIN	MILLING OFFAL	SYNTHETIC AMINO ACIDS	FOOD INDUSTRY BY-PRODUCTS	SUNDRY
Wheat *	Lupins *	Meat meal *	Soybean meal *	Millmix *	Lysine *	Whey *	Minerals *
Barley *	Peas *	Blood meal *	Full fat soya *	Rice pollard *	Methionine *	Brewers yeast	Vitamins *
Oats *	Faba Bean	Fishmeal *	Cottonseed meal *	Oat offals	Threonine *	Bread	Tallow *
Sorghum *	Chickpeas	Poultry meal	Canola meal *	Pea offals	Tryptophan *	Biscuits	Vegetable oil *
Triticale	Mung Bean	Milk Powder	Sunflower meal	Hominy	Isoleucine *	Cereals	Chicken oil
Corn	Lentils	Yeast	Peanut meal		Valine *	Confection waste	Lucerne
Rye	Vetch	Feather meal	Safflower meal		Arginine	Pet food waste	Molasses
Rice		Plasma	Copra			Distillers grain	Cassava

* Major use materials

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Comparative typical proximate analyses of grains

SPECIFICATION		CORN	WHEAT	BARLEY	SORGHUM
Moisture (%)		13	12	12	13
Protein (%)		8	11	11	9.5
Fat (%)		4	2.3	2.6	3.5
Ash (%)		1.15	1.7	2.2	2.0
Fibre	Crude (%)	2	2	4.8	2.3
	NDF (%)	9	8.5	16.0	8.0
	ADF (%)	2.2	2.5	5.5	2.5
Starch + Sugar		64.6	63	53.9	63
DE MJ/kg (Kcal/kg)		14.5 (3465)	14.0 (3345)	13.0 (3105)	14.25 (3404)
ME MJ/kg (Kcal/kg)		14.0 (3345)	13.6 (3246)	12.6 (3005)	13.9 (3324)
NE MJ/kg (Kcal/kg)		11.18 (2670)	10.61 (2535)	9.66 (2310)	10.97 (2620)

Source: Premier Atlas (2008)

NOTE: Typical values only

- Composition can vary widely with different agronomic conditions

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Grain SID Amino Acid, Calcium, Phosphorus and Phytate content at typical protein levels

	CORN	BARLEY	WHEAT	SORGUM
PROTEIN (%)	**7.6**	**10.5**	**11.7**	**9.2**
SID Lys	0.18	0.29	0.27	0.15
SID Met	0.14	0.14	0.16	0.13
SID M+C	0.28	0.33	0.40	0.25
SID Thr	0.22	0.28	0.28	0.23
SID Iso	0.22	0.30	0.35	0.28
SID Try	0.05	0.11	0.13	0.09
SID Arg	0.32	0.45	0.52	0.27
SID His	0.19	0.19	0.24	0.15
SID Leu	0.81	0.59	0.69	0.96
SID Val	0.31	0.41	0.44	0.34
SID Phe	0.32	0.43	0.48	0.38
Calcium (%)	0.01	0.05	0.04	0.01
Phosphorus (%)	0.22	0.28	0.26	0.24
Phytate P (%)	0.17	0.16	0.17	0.17

Source: Evonik AminoDat 5.0

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Variability in faecal digestible energy as detected by AUSSCAN

GRAIN	PIG FAECAL DE MJ/kg		
	Minimum	Median	Maximum
Wheat	12.75	13.89	15.11
Barley	10.80	12.91	14.71
Sorghum	14.08	14.56	15.23

Source: Australian Pork CRC – AUSSCAN calibration (2012)

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Raw material variation monitoring

PARAMETER ANALYZED	VALUE
Ileal & Faecal DE	Site of digestion and yield data allow to define NE-values
Faecal DE intake index	Estimate energy intake (palatability, throughput, density)
Major nutrients	Protein, Moisture, Fibre, Fat, Starch, Ash
Fibre components	Crude, ADF, NDF
NSP characterization	Soluble & Insoluble content, NSP type - arabinoxylan, ß-glucan
Hydration capacity	Pelleting effect, gelatinisation properties and enzyme access

AusScan

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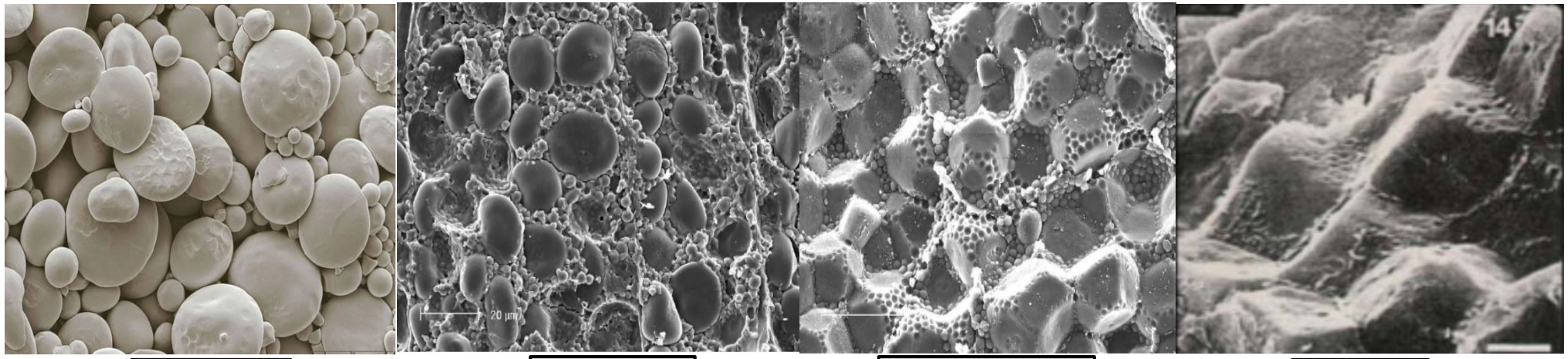
Structure of grain starch

- Starch stored in different ways in grains
- Impact availability of starch for digestion
- Complex structures → less available starch
  - Processing can increase availability



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Features of Australian barley

- Temperate winter crop (harvest October – December)
- Mainly 2 – Row varieties, spring type – malting characteristics
- Medium grain size, white with hull
- Low mycotoxin contamination – harvested and stored dry.
  - High quality storage facilities and management
- No yellow pigments
- Viscous: contains soluble NSP's = β-glucans + Arabinoxylans
  - But easily managed with supplementary enzymes and of no real concern to pigs

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Features of Australian barley (continued)

- Lower in energy than corn, wheat or sorghum due to higher fibre content and lower starch
  - Fibre content considered an asset in regard to gut health
- Protein typically higher than corn but similar or lower than wheat and of higher biological value
- Used extensively in pig diets as a safe and reliable feed component
- Robust and reliable grading system for grain trading

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Anti-Nutritional Factors

- Compounds limiting the availability of nutrients for digestion
- Structural ANF's
  - Non-Starch Polysaccharides (NSP) – Soluble & Insoluble
  - Xylan, Beta-glucan, Galactan, Pectin
- Mineral binding
  - Phytate
  - Oxalates
- Reduce protein digestion and utilization
  - Protease inhibitors
  - Tannins
- Know how to overcome these challenges

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NSP levels in feedstuffs (%DM)

- Solubility & type of NSP influence impact on raw material digestion

RAW MATERIAL	SOLUBLE	INSOLUBLE	TOTAL
Wheat	2.4	9	11.4
Barley	4.5	12.4	16.9
Corn	0.1	8.0	8.1
Soybean meal	2.7	16.5	19.2
Canola meal	11.3	34.8	46.1
Peas	2.5	32.2	34.7

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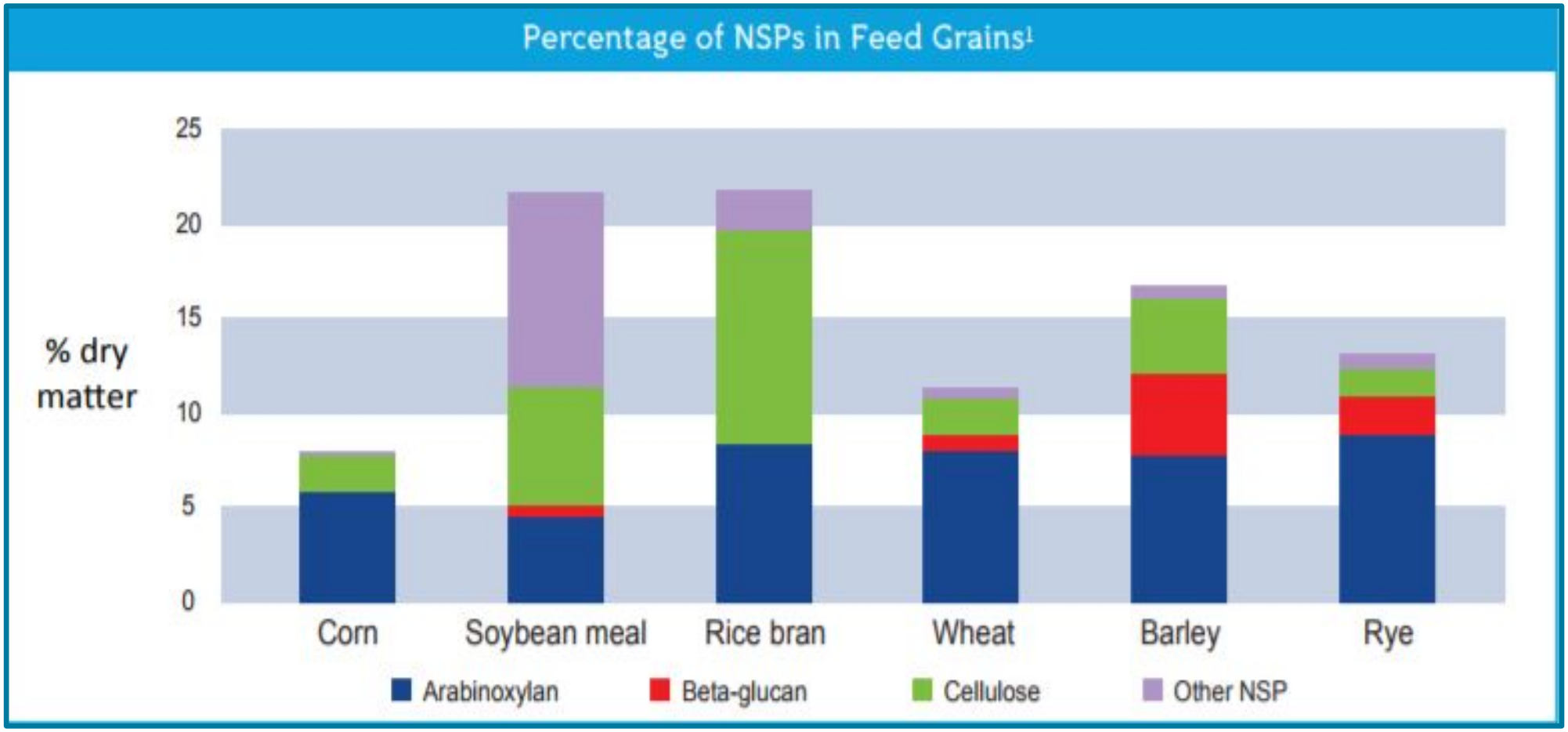
NSP profile of raw materials



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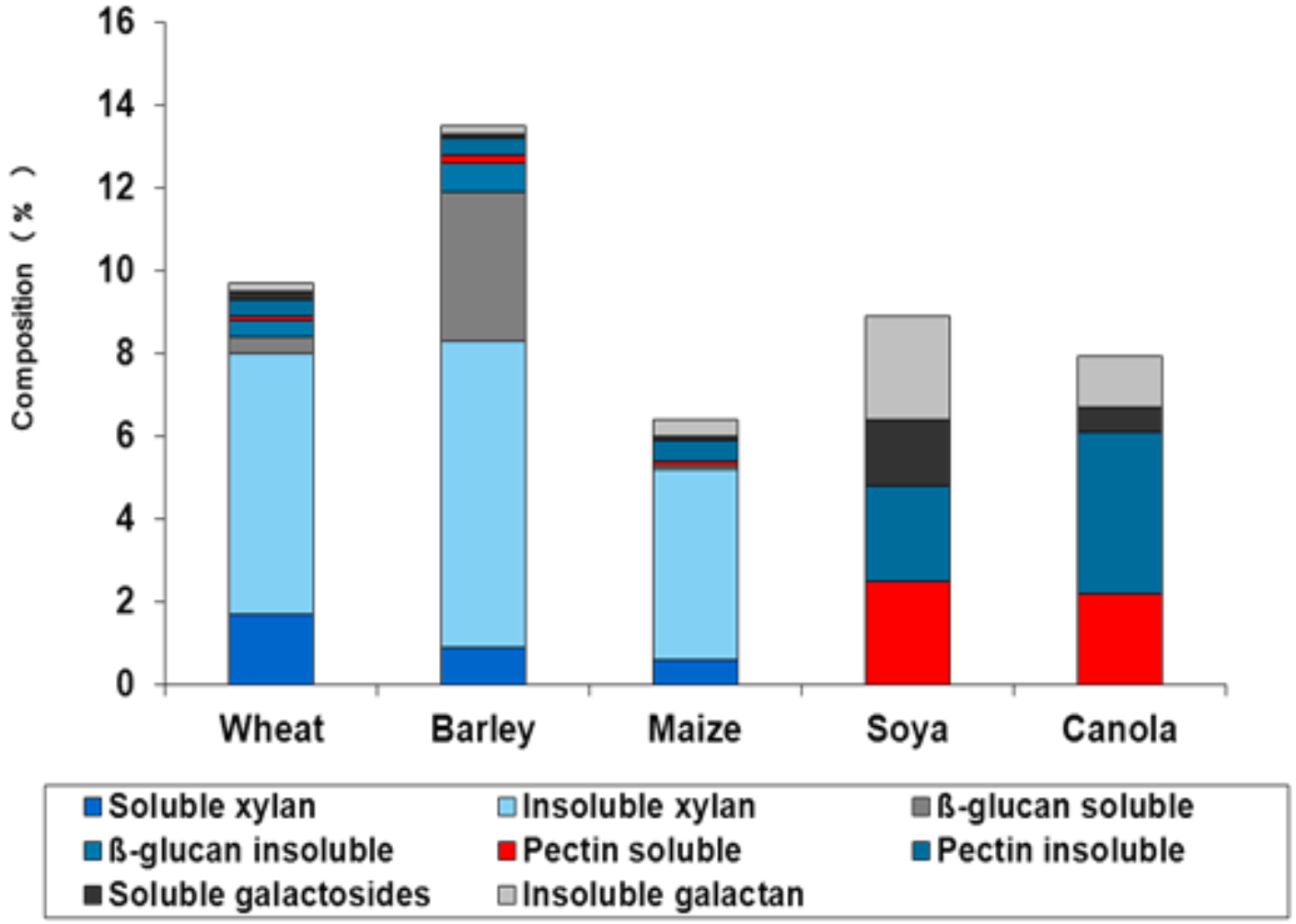
NSP profile of raw materials



Source: Bach Knudsen KE., 1997; Choct. M.,1997

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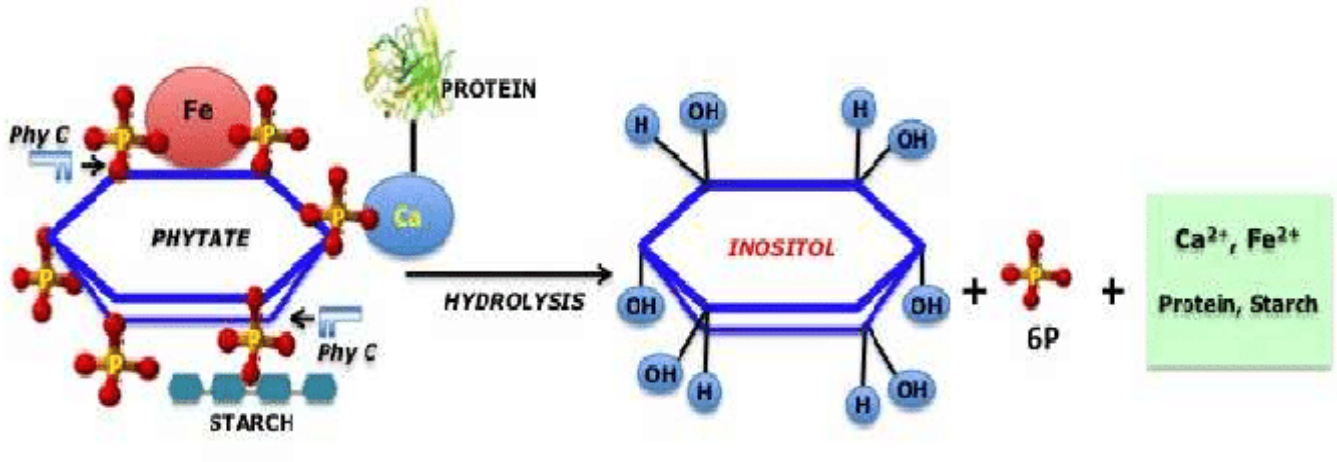
Phytate content of raw materials



RAW MATERIAL	TOTAL P (g/kg)	PHYTATE (g/kg)	PHYTATE-P (g/kg)	PHYTATE-P / TOTAL P (%)
BARLEY	3.2	7.0	1.9	61
CORN	2.6	6.7	1.9	72
WHEAT	3.1	7.8	2.2	72
SORGHUM	3.0	7.7	2.2	73
SOYBEAN MEAL	6.5	13.8	3.9	60
CANOLA MEAL	9.7	22.9	6.5	66

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Managing Anti-Nutritional Factors

- Exogenous Enzymes
  - NSPases: ß-Glucanase, Xylanase
    - Structural NSP's limit endogenous enzymes access to nutrients / animal produce limited quantity
    - Various commercially available products able to address specific NSP challenges
  - Phytase
    - Cleaves Phytate-P – increase P availability
  - Protease
- Heat treatment
  - Reduce activity of deleterious compounds:
    - Trysin inhibitor = Soybean Meal

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Typical Formulation Limits on Grains

Maximum % inclusions

DIET	WHEAT	BARLEY	SORGHUM	CORN
Starter	100	10	-	50
Weaner	100	20	15	100
Grower	100	100	60	100
Finisher	100	100	70	100
Lactating Sow	45	60	40	100
Dry Sow	45	100	60	100

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Raw material processing

- The digestibility of feed components are directly related to particle size.

- Optimum particle size of grain is determined by:

• Type	• Milling cost relative to benefits
• Production stage	• Affect palatability and feed intake
• Other processes involved	• Physical handling (especially fat)
• Incidence/Risk of GIT disturbances	• Levels of respireable dust

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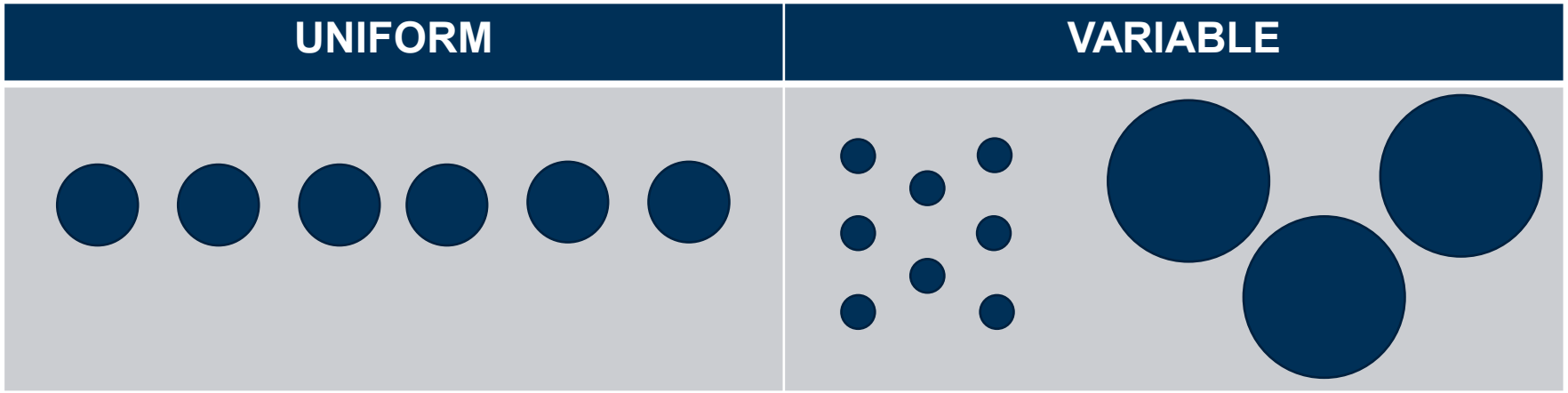
Particle size variability



- Limit digestive upsets
- Uniform digestion
- Limit particle separation
- Uniform mixing

- Digestion rate
- Handling issues
- Palatability issue
- Respirable dust
- Gut irritation

- Delayed digestion due to limited enzyme access
- Synchrony issues

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Grain Particle Size

- Variability in particle size may be equally as important as average particle size
- Effect of sieving and regrinding large particle grains
  - Barley hammer milled through 4mm screen - Mash/Pellet

Effect of Particle size & diet form on performance of grower pigs

TREATMENT	ADFI (kg)	ADG (g)	FCR
Barley, Ground, Mash	1.621	801	2.038
Barley, Ground, Pelleted	1.660	841	1.959
Barley, Reground*, Mash	1.597	855	1.880
Barley, Reground*, Pelleted	1.617	852	1.900

*Particles larger than 1700µ were screened out and reground through a 3.2mm screen and added back

Source: Gidley et al., 2010

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Grain Particle Size

- Australian Pork CRC – Commercial study
- >3000 Grower-Finisher pigs
- Diet = Wheat + Barley + Pea + Canola
- Diets ground (disk mill) and pelleted
- Treatments = Average particle size of diet
  - 600 or 1200 µm
- Result:
  - Finer grind improved FCR:
    - 3.1 % in Grower phase (30 – 60 kg)
    - 5.6 % in Finisher phase (60 – 100 kg)

Description		Fine	Medium	Coarse	P-value	SEM
Grower Pigs	ADG g/d	810	836	839	0.228	7.58
	ADFI kg/d	1.71	1.77	1.81	0.116	0.02
	Feed:Gain	2.09	2.11	2.15	0.154	0.012
Finisher Pigs	ADG g/d	961	951	960	0.709	5.38
	ADFI kg/d	2.41[a]	2.52[b]	2.56[b]	0.011	0.021
	Feed:Gain	2.51[a]	2.64	2.60[b]	0.001	0.019
Mortality 1.5%; N > 3400 pigs						

Source: A.C. Edwards., 2014

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Comparison of Pig Grower Diets: Australia (%)

RM cost (USD/t)	Raw material	Barley Base	Wheat Base	Sorghum Base	Combination
160	Barley	56.4	-	-	32.5
210	Wheat	-	61.88	-	15.0
215	Sorghum	-	-	59.8	10
245	Peas	20	20	20	20
280	Canola Solv. 37	15	11.6	15	15
525	Meat meal	2	3.6	2	2
910	Canola Oil	4	0.9	0.5	2.8
	Macro Minerals	+	+	+	+
	Amino Acids	+	+	+	+
3500	Grow Premix*	+	+	+	+
DE MJ/kg		14.1	14.1	14.1	14.1
SID Lys%		0.99	0.99	0.99	0.99
RM Cost/t (USD)		249.43	256.35	256.84	252.75

* Includes Phytase, NSP - enzymes

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Comparison of Pig Grower Diets: Philippines (%)

RM cost (USD/t)	Raw material	Std Base	+ Wheat	+ Barley	+ Sorghum	Combination
265	Maize	26.5	-	27.8	-	-
270	Wheat	15.0 (UKR)	46.85 (AUS)	-	-	14.0 (AUS)
250	Barley	-	-	29.07	-	21.67
260	Sorghum	-	-	-	42.71	20
220	WH. Pollard	15	12	3	15	5
250	Rice Bran FF	10	10	10	10	10
490	Soybean meal 46%	19.8	17.4	16.2	18.6	15.4
230	Copra meal	10	10	10	10	10
800	Coconut OIl	0.5	0.5	0.5	0.4	0.5
	Macro Minerals	+	+	+	+	+
	Amino Acids	+	+	+	+	+
3500	Grow Premix*	+	+	+	+	+
DE MJ/kg		14.1	14.1	14.1	14.1	14.1
SID Lys%		0.99	0.99	0.99	0.99	0.99
RM Cost/t (USD)		310.85	309.11	307.12	306.10	304.97

* Includes Phytase, NSP - enzymes

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Selecting the preferred grain base for diets

- The pig is a very adaptable omnivore that can utilize a wide range of different feedstuffs most effectively
- A megajoule of energy or a gram of standardized ileal digestible amino acid can come from any source with equal efficacy
- Feed formulation is more about nutrient delivery than ingredient use
- All feedstuffs have their specific properties that we need to be cognisant of when combining with other components to make up a complete diet

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Selecting the preferred grain base for diets (continued)

- With a full appreciation of the available nutrient content of feedstuffs and any peculiar constraints to use, the prime determinant becomes the relative cost of delivering the necessary nutrients
- To be economically competitive, we need to maintain an open mind to all options
- Corn + Soybean meal may be dominant components in much of the world's pig foods but they are not essential

Conclusions

- The pig has an ability to utilise a broad range of feedstuffs to meet its nutritional needs.
- Traditionally in Asia, corn has been the predominant grain employed. However with increasing international trade, other grain alternatives have emerged representing a real economic advantage.

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Conclusions

- Australia is enjoying a very productive barley harvest this year resulting in significant quantities being available for export at competitive prices.
- The domestic Australian pig industry will take advantage of this situation and utilise barley as the dominant grain.
- The opportunity also presents itself to near Asian neighbours and is well worth considering.

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