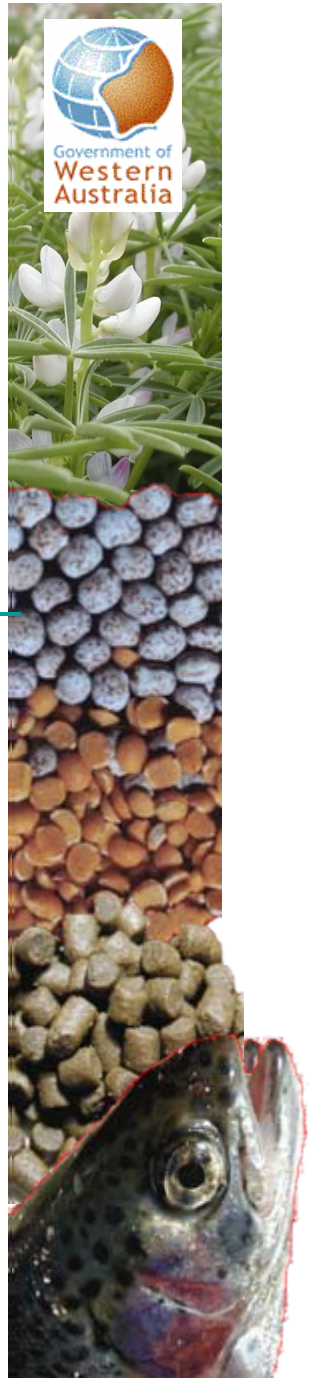


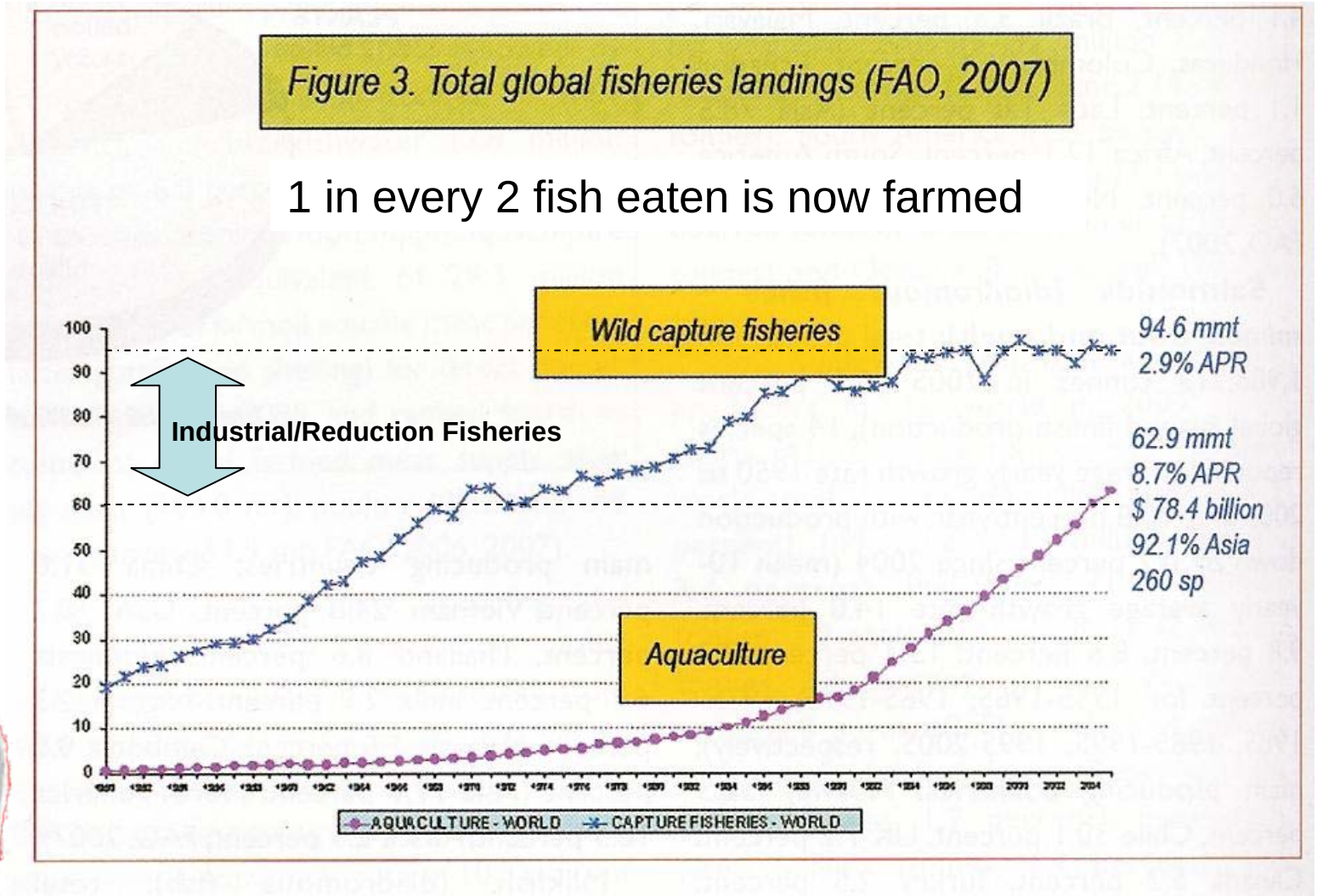
Dr Brett Glencross

Aquaculture Feed Grains Program
Department of Fisheries
PO Box 20, North Beach 6020
Western Australia

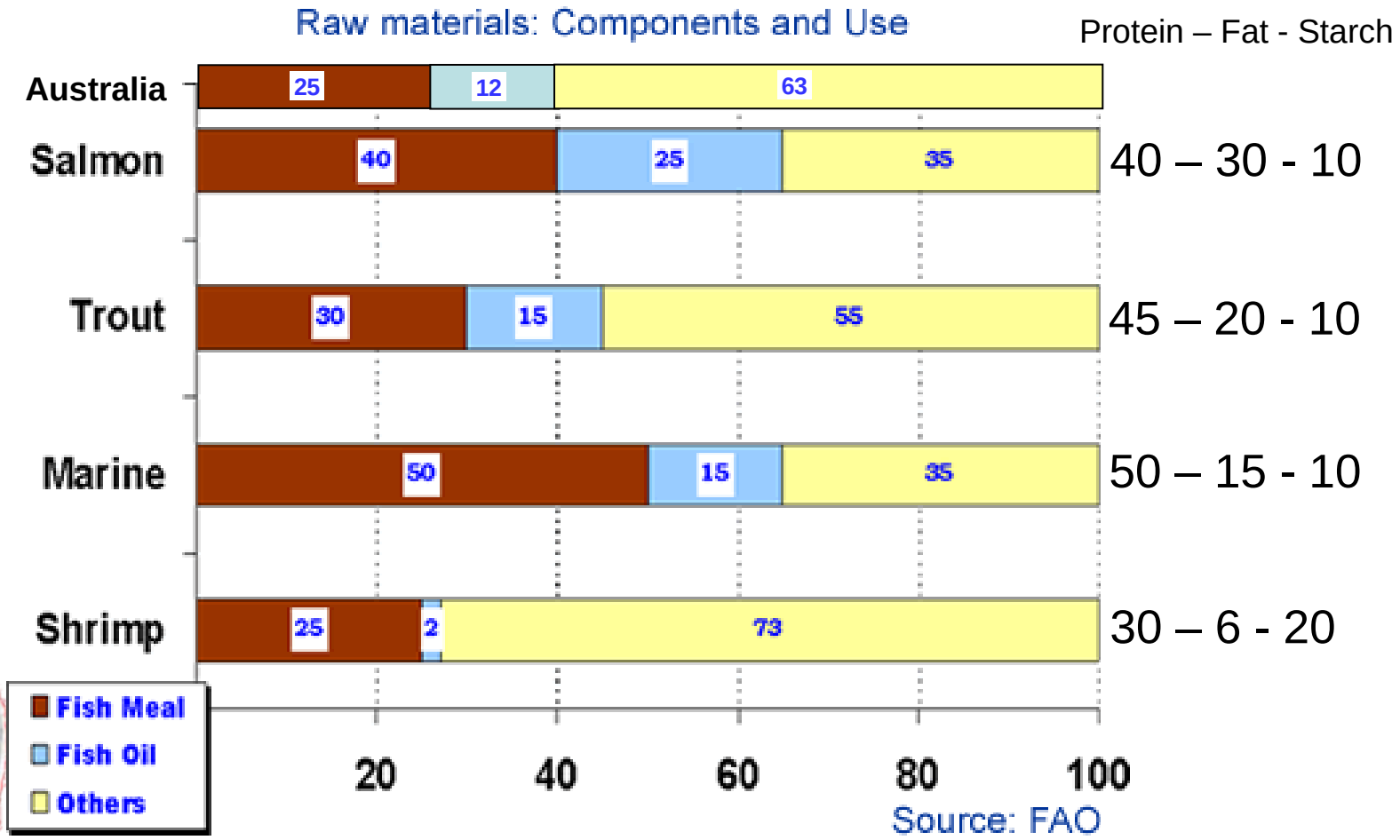
HARVESTING THE BENEFITS OF LUPINS IN AQUACULTURE FEEDS

International Lupin Conference – Fremantle, 14th - 18th September 2008

The Rise of Aquaculture

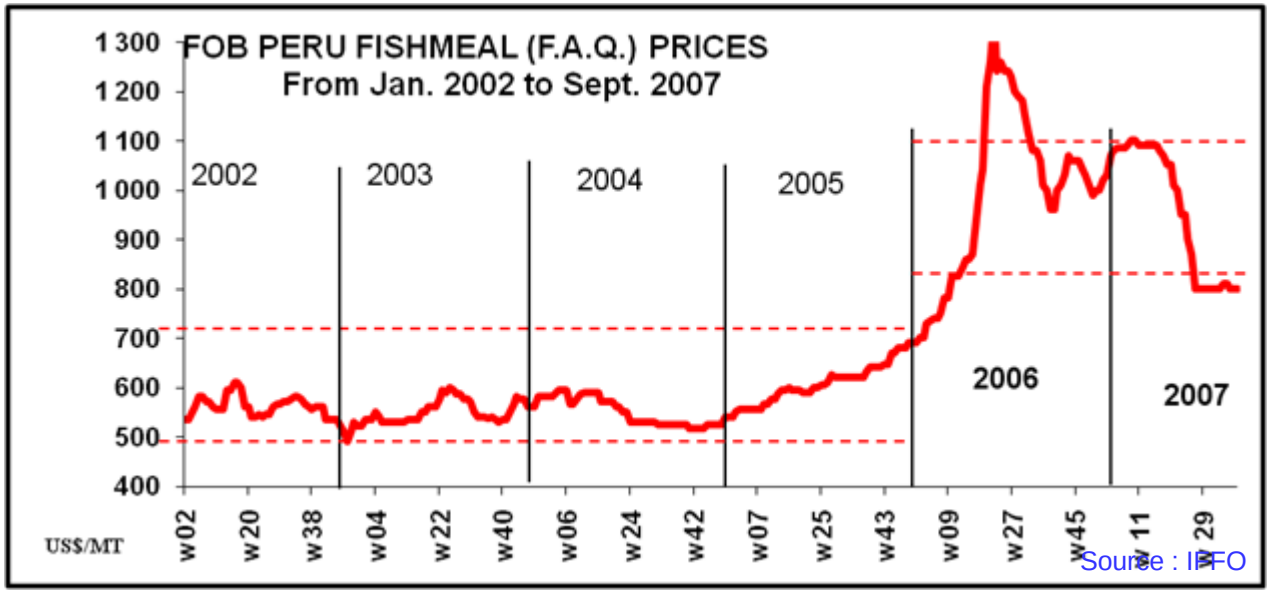


Feed Resource Limits

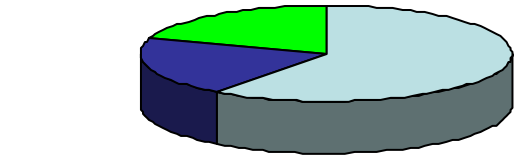


Managing Ingredient RISK

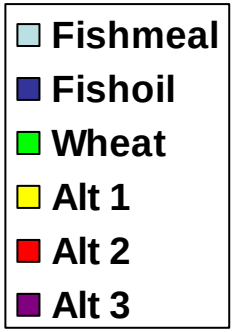
- Being too dependent on any one ingredient is a RISK due to:
  - Supply issues
  - Price volatility
  - Contaminant issues

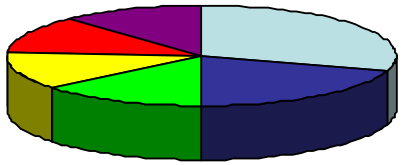


Managing Ingredient RISK



High Risk Formulation





Low Risk Formulation

- The RISK can be reduced by using alternative ingredients to provide nutrients and energy
- However some types of alternatives introduce new variety of RISKS
  - Contaminants (e.g. Mycotoxins)
  - Anti-nutritional factors (e.g. Saponins)
  - Quality variability (e.g. Digestible protein variability)

Aquaculture Feed Grains Program

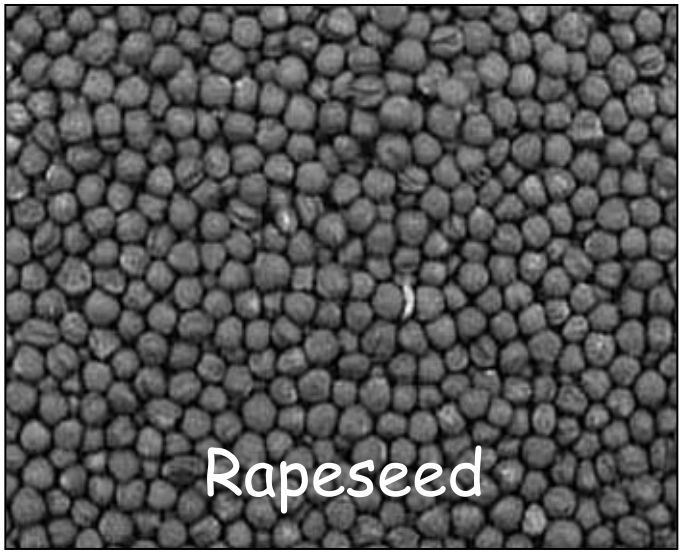
- From 1992 – 2002 Forerunner Fishmeal Replacement Research Programs undertook studies on a wide range of ingredients

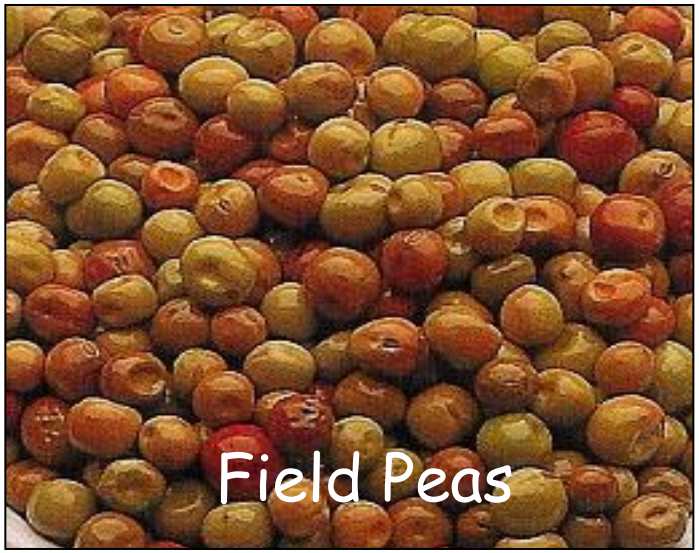
- From 2002 to 2008 a focus of studies was made to understand
  - Grain processing technology
  - Protein concentrate technology
  - Nutrient and energy digestibility
  - Growth and feed intake variability
  - Anti-Nutritional Factor assessment
  - Fish Gut health
  - Extrusion processing assessment

- Involved a large multidisciplinary research team from 7 different organizations (research and industry) with skills in grain breeding, grain processing, grain chemistry, animal nutrition, feed manufacturing and grain marketing

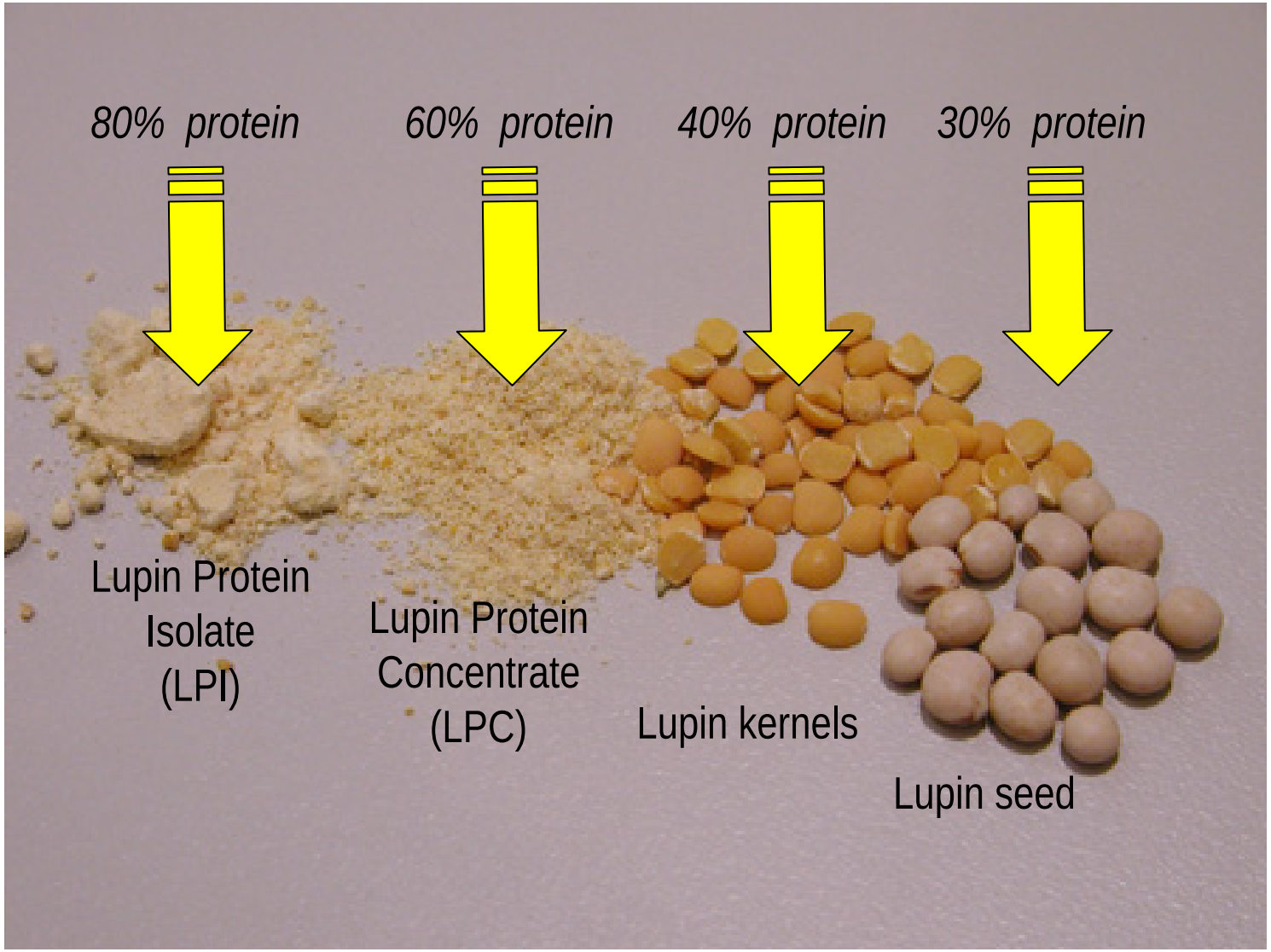
http://www.fish.wa.gov.au/docs/pub/ResAquaNutEnviron

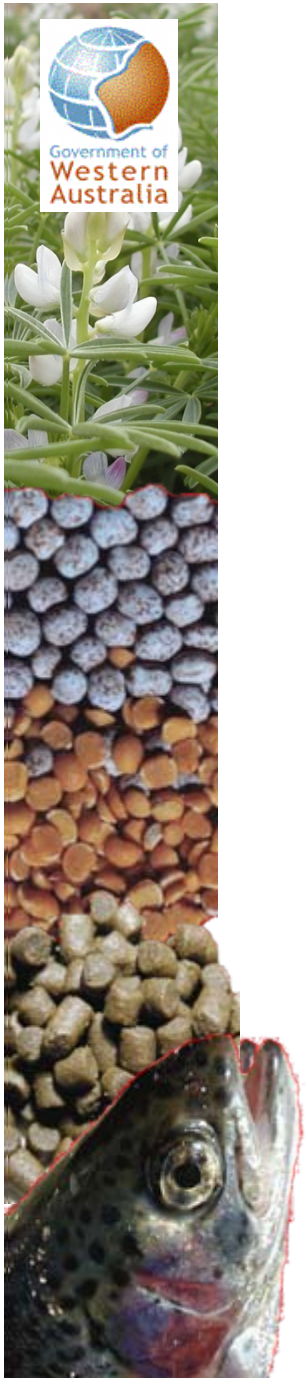
Grain Species





Processing Lupins



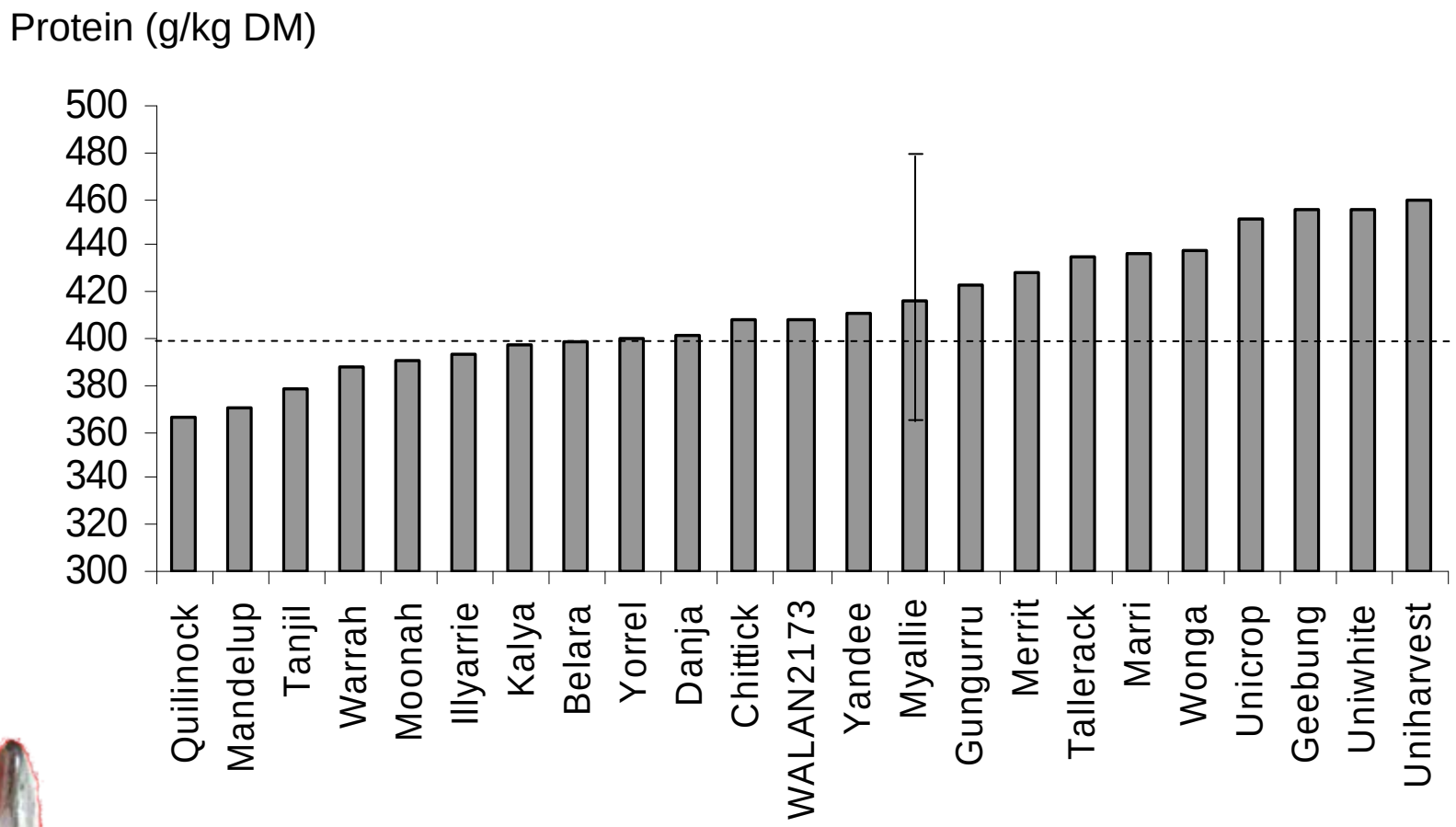


Grain Composition

Grain	DM	Protein	Fat	Ash	Starch	NSP
Soybean						
Solevent-extracted	89	48	1	9	1	31
Full-fat	91	42	20	5	1	24
Lupin						
L. angustifolius seed	91	32	6	3	1	50
L. angustifolius kernel	90	39	7	3	1	41
L. albus kernel	92	44	11	4	1	33
L. luteus kernel	90	52	7	4	1	27
L. mutabilis kernel	91	52	17	4	1	18
Rapeseed						
Expellet-extracted	90	34	12	4	1	39
Solevent-extracted	90	39	2	6	1	43
Field Pea						
Whole seed	90	23	1	3	32	33
Kernel meal	91	26	2	2	45	17

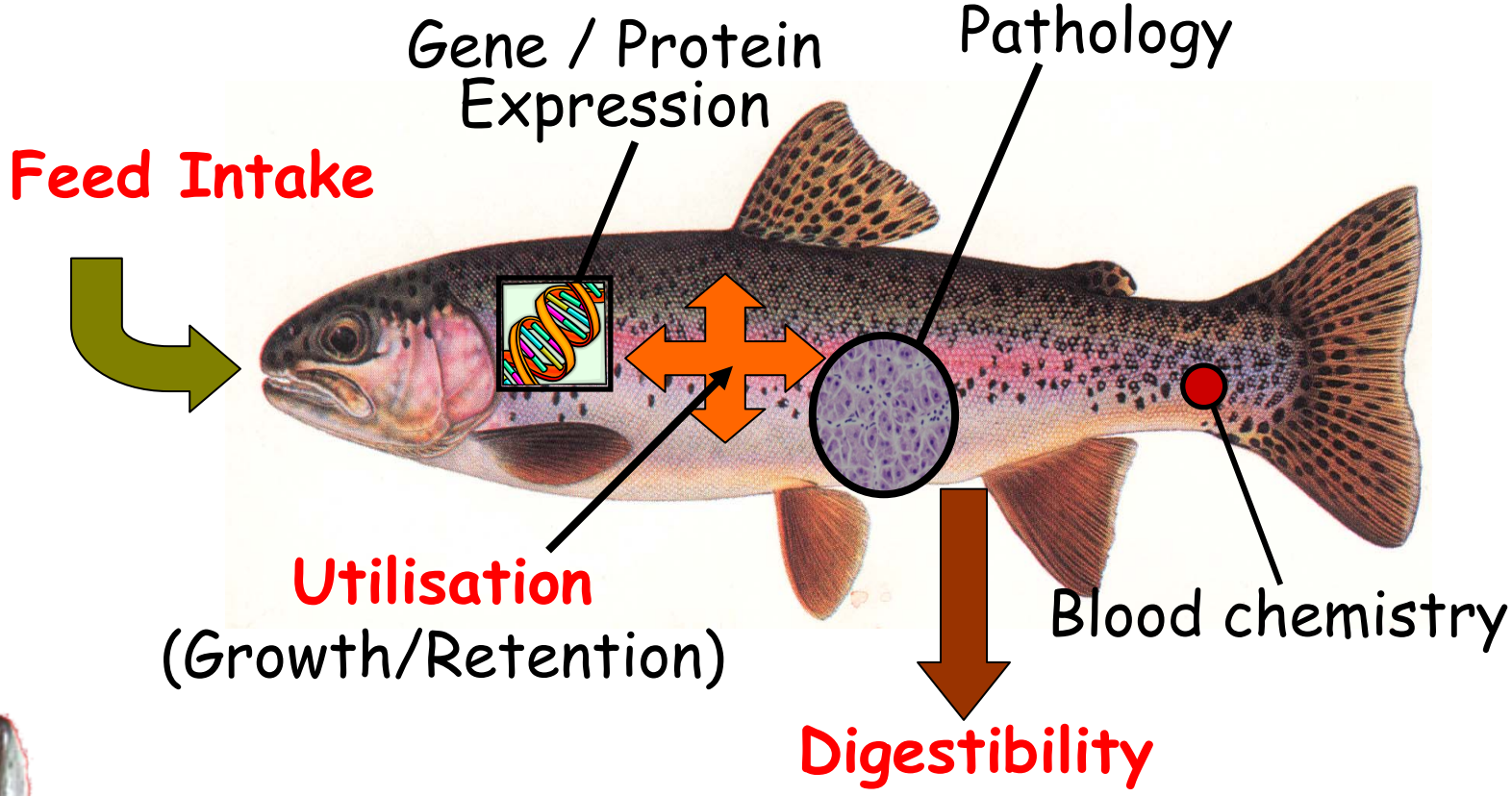
All samples are expressed as % as received basis

Variability in Composition



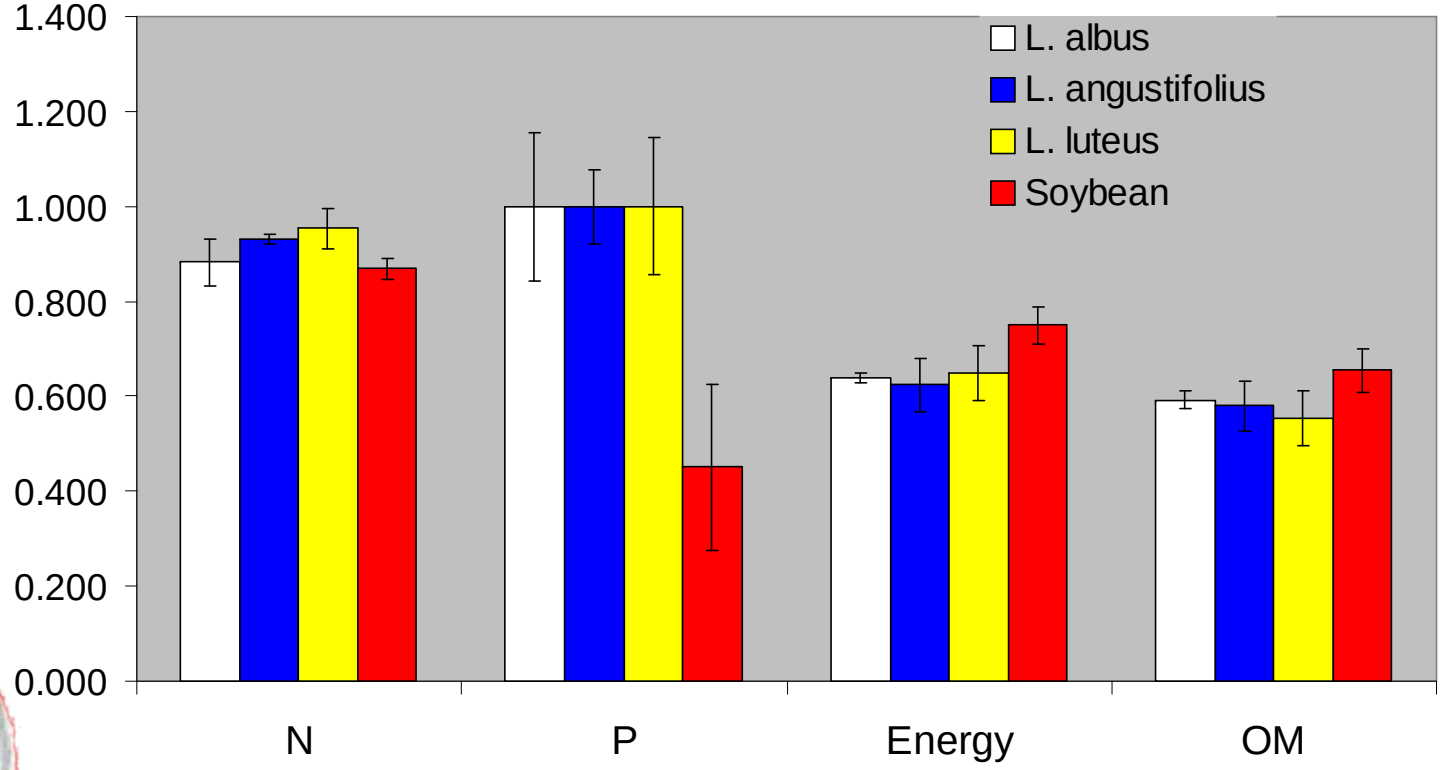
All samples are dehulled (kernel) *Lupinus angustifolius* cultivars produced in same year from same site

Assessing Effects of Grains



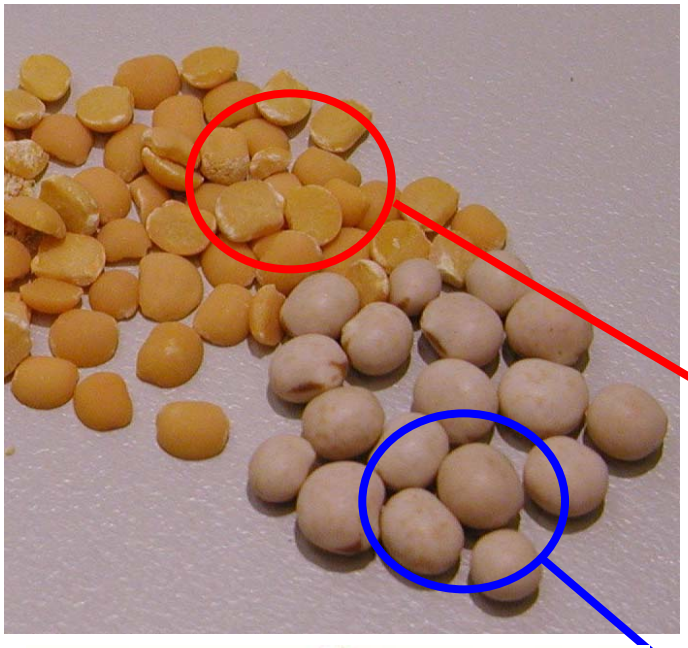
Grain Variability

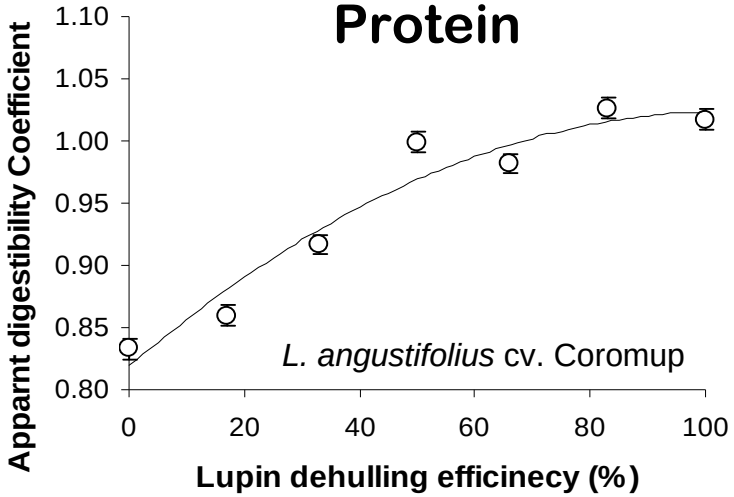
Apparent Digestibility Coefficients

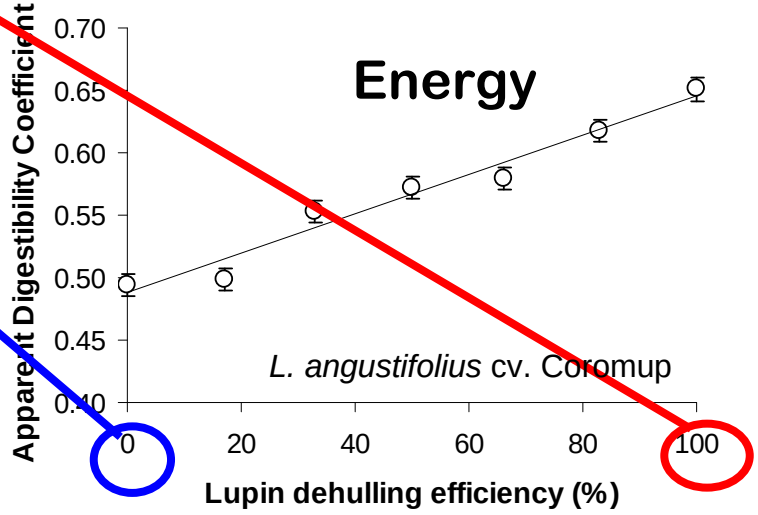


Glencross, B.D., Hawkins, W.E. (2004). **Aquaculture Nutrition. 10, 65-73.**

Dehulling Lupins - Digestibility

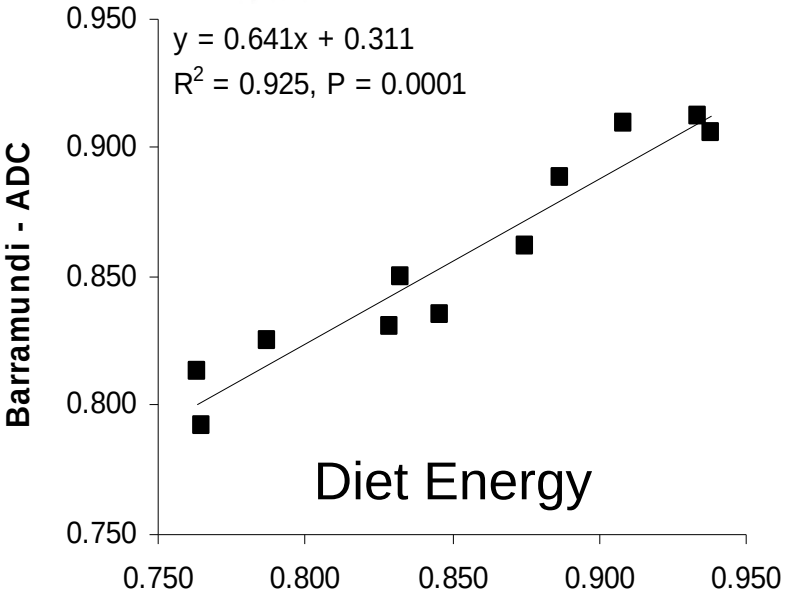


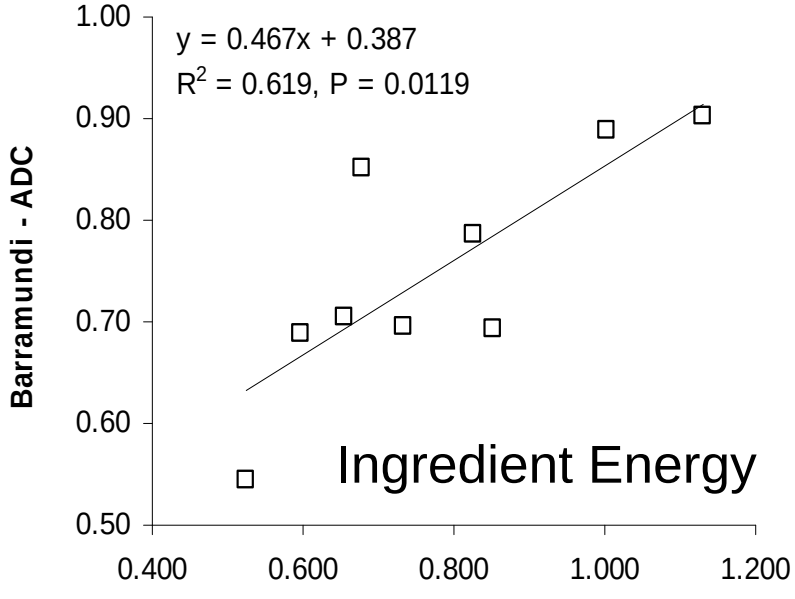




Glencross et al. (2004) **Aquaculture Nutrition 13, 462-470**

Differences among Species



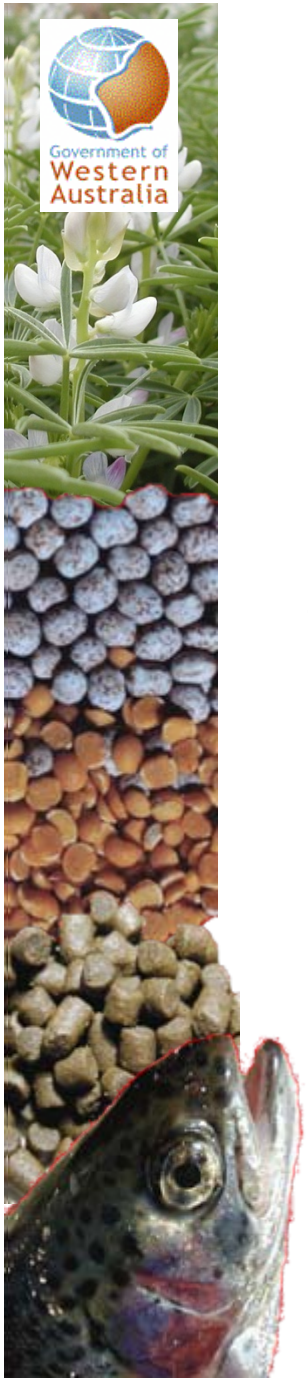


Trout - ADC

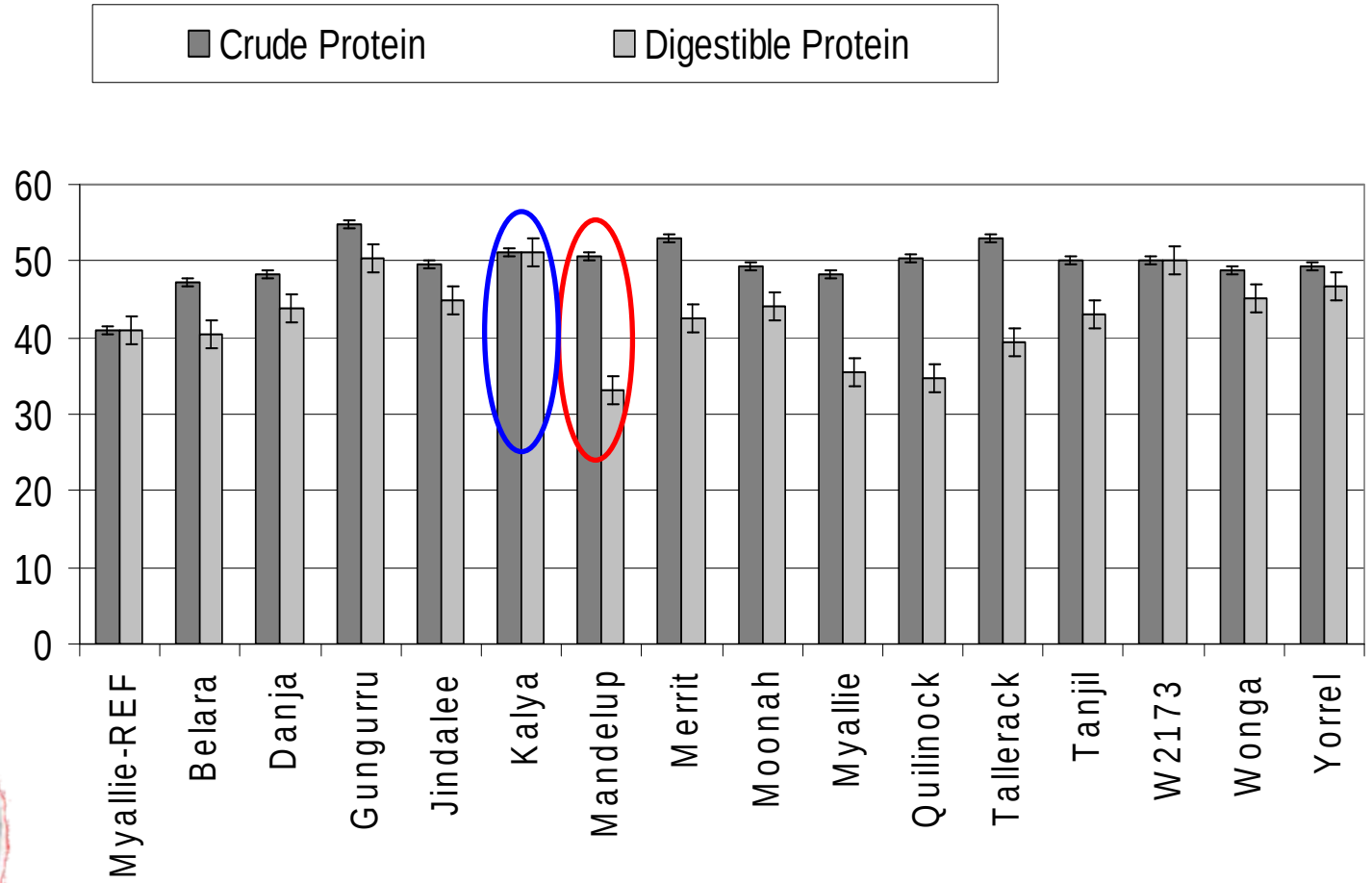
Trout - ADC

Response of each species to ingredient energy digestibilities of a range of ingredients.

Glencross 2008. **Unpublished.**



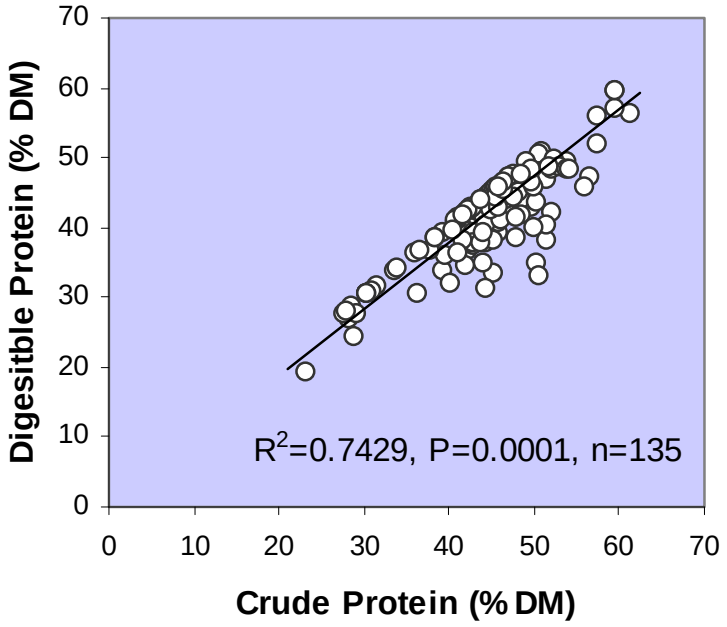
Digestibility Complexity

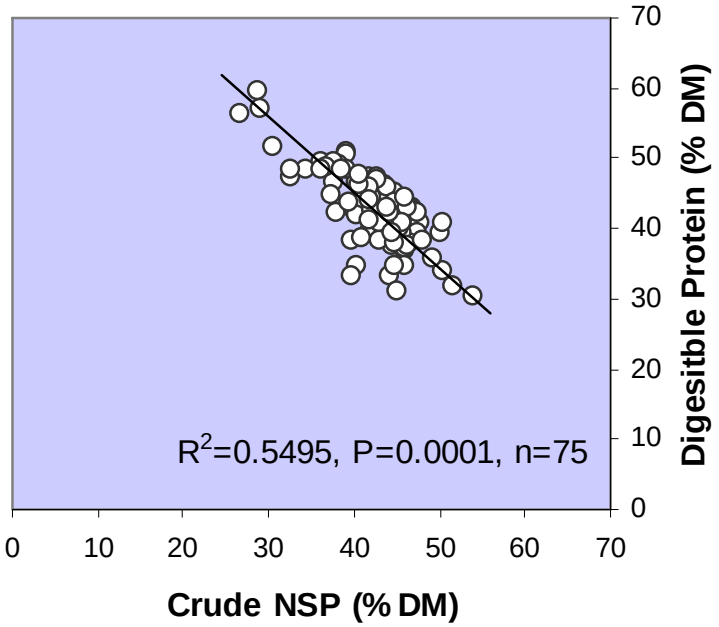


L. angustifolius varieties (kernel meals)

Glencross et al. (2008) **Aquaculture 277, 251-262.**

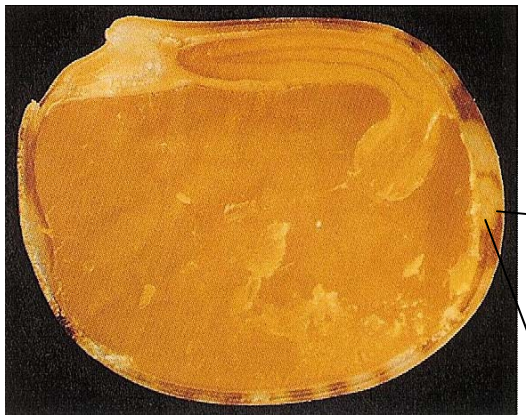
Influence of Composition

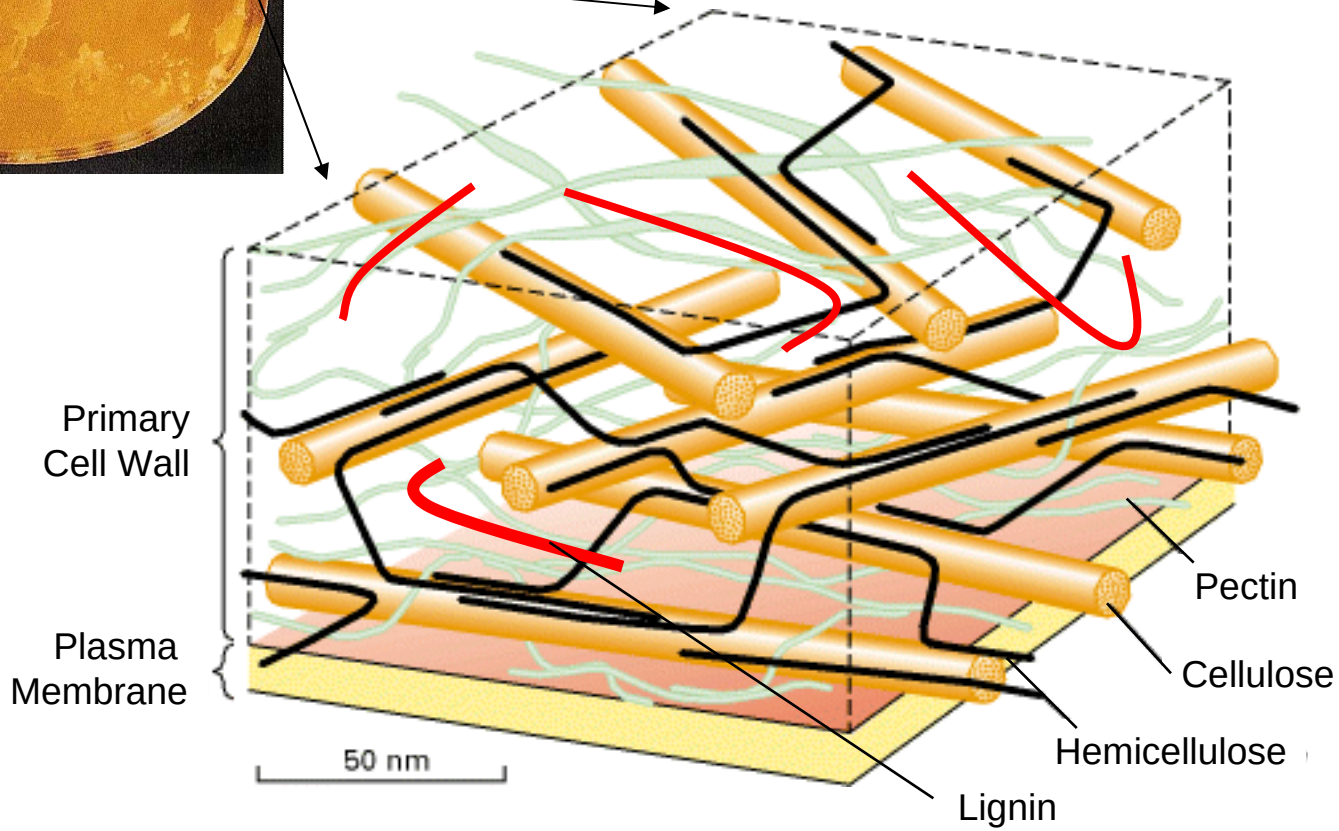




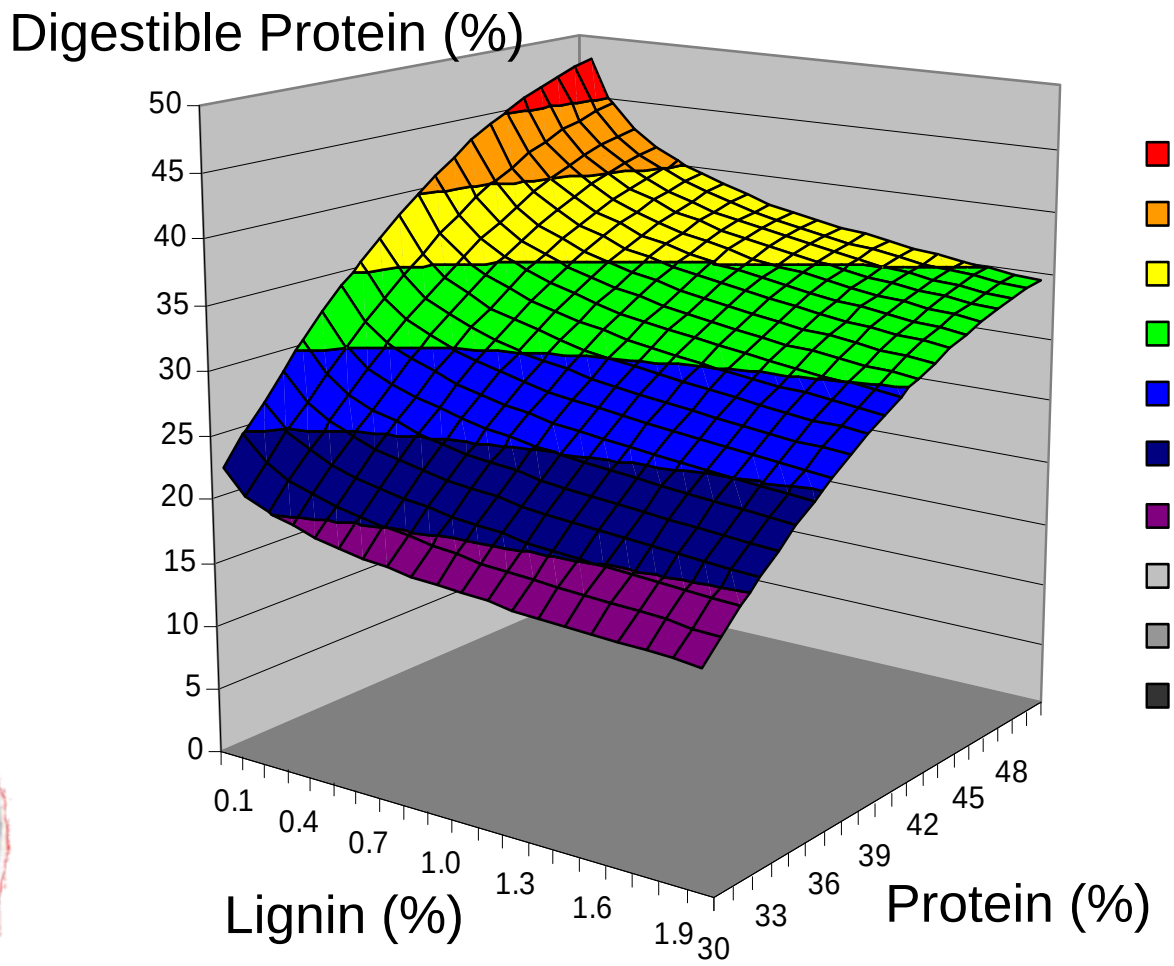
Digestible protein level is positively affected by kernel meal protein content and negatively affected by the kernel meal Non Starch Polysaccharide (NSP) content.

Grain Structure





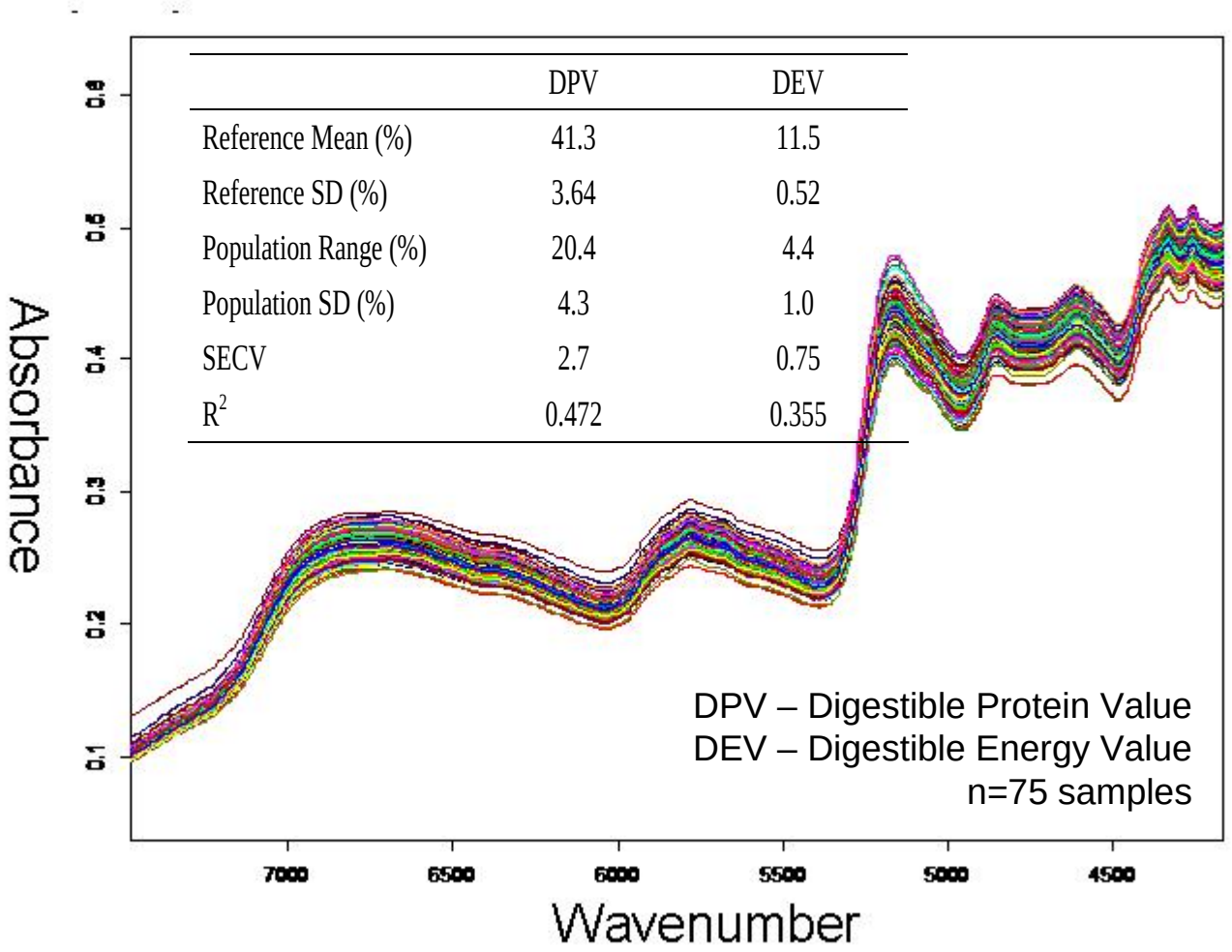
Digestibility Complexity



Glencross et al. (2008) **Aquaculture 277, 220-230.**

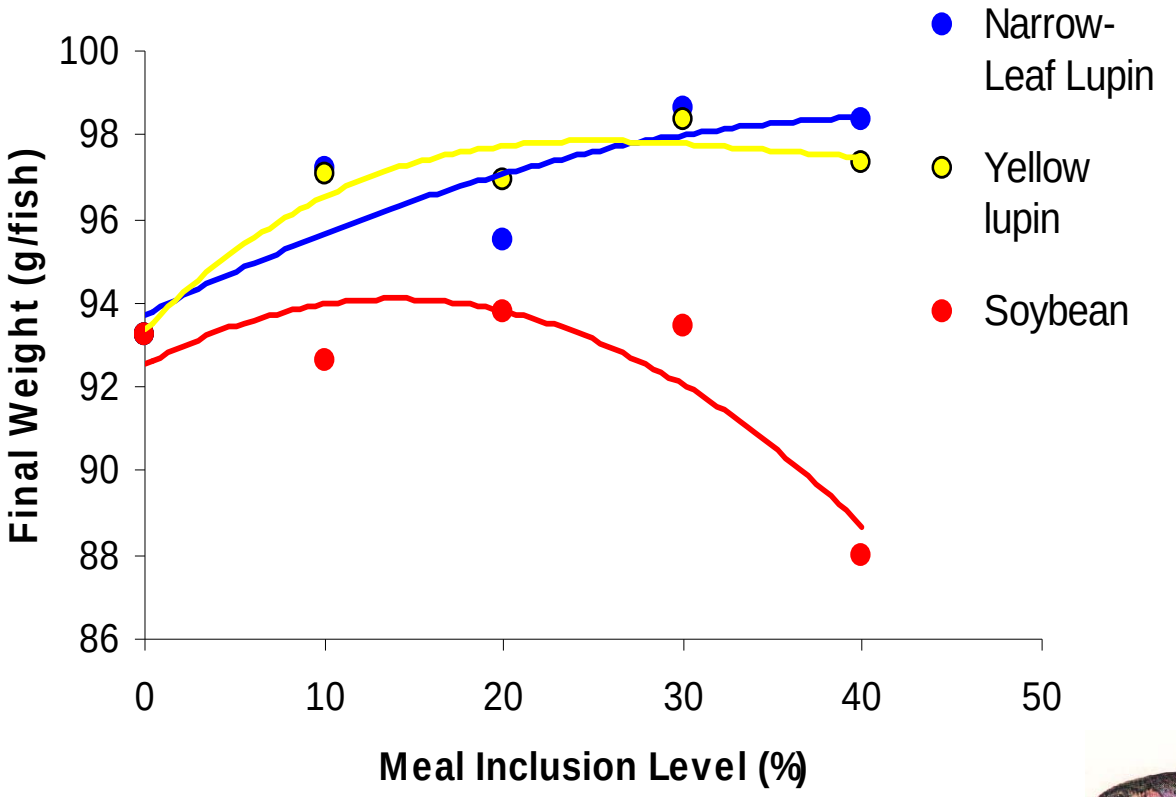
Lupin kernel meal NIRS spectra

	DPV	DEV
Reference Mean (%)	41.3	11.5
Reference SD (%)	3.64	0.52
Population Range (%)	20.4	4.4
Population SD (%)	4.3	1.0
SECV	2.7	0.75
R^2	0.472	0.355



Comparative Growth Value

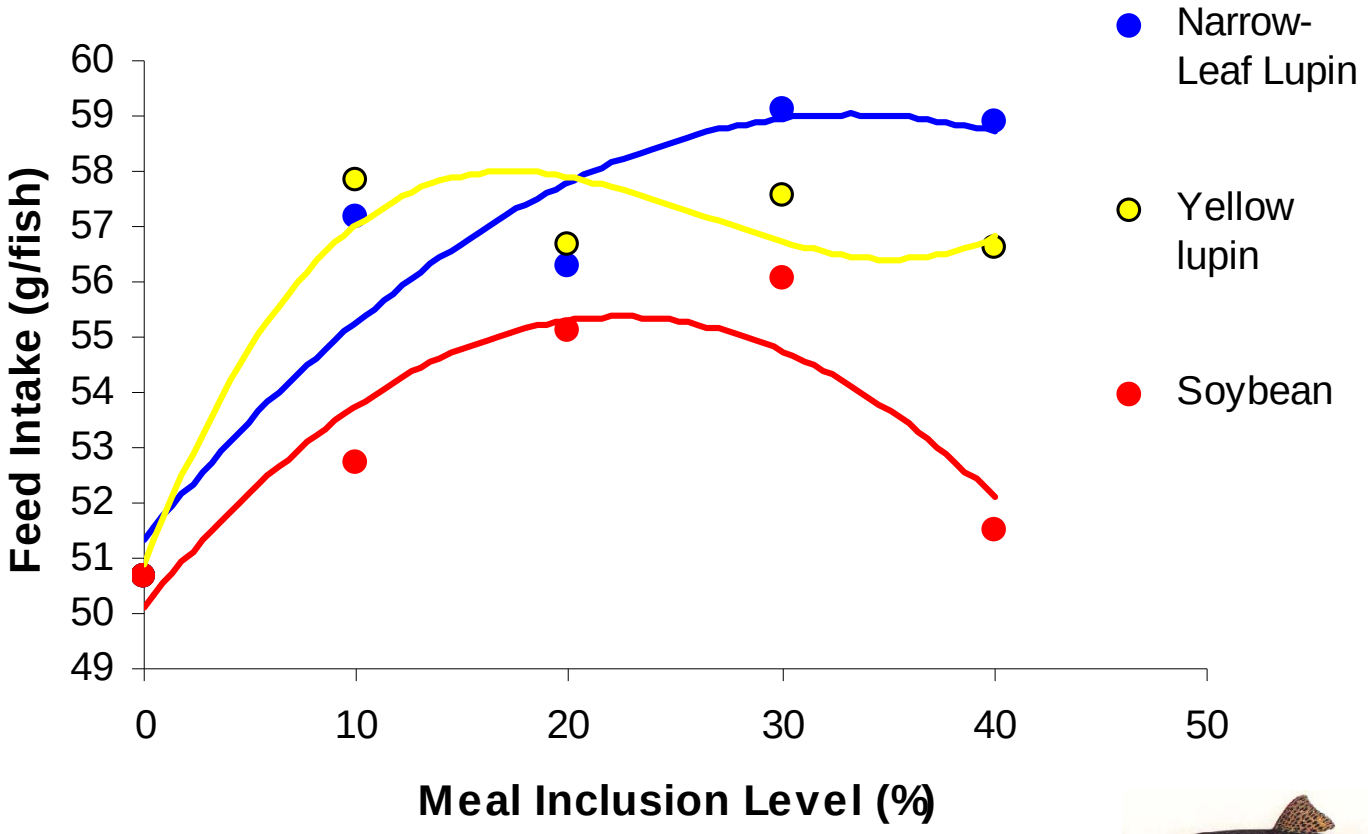
All diets were formulated to the same digestible protein (38%) and energy (18.0 MJ/kg) levels



Glencross et al. (2008) **Unpublished.**

Comparative Feed Intake

All diets were formulated to the same digestible protein (38%) and energy (18.0 MJ/kg) levels



Glencross et al. (2008) **Unpublished.**

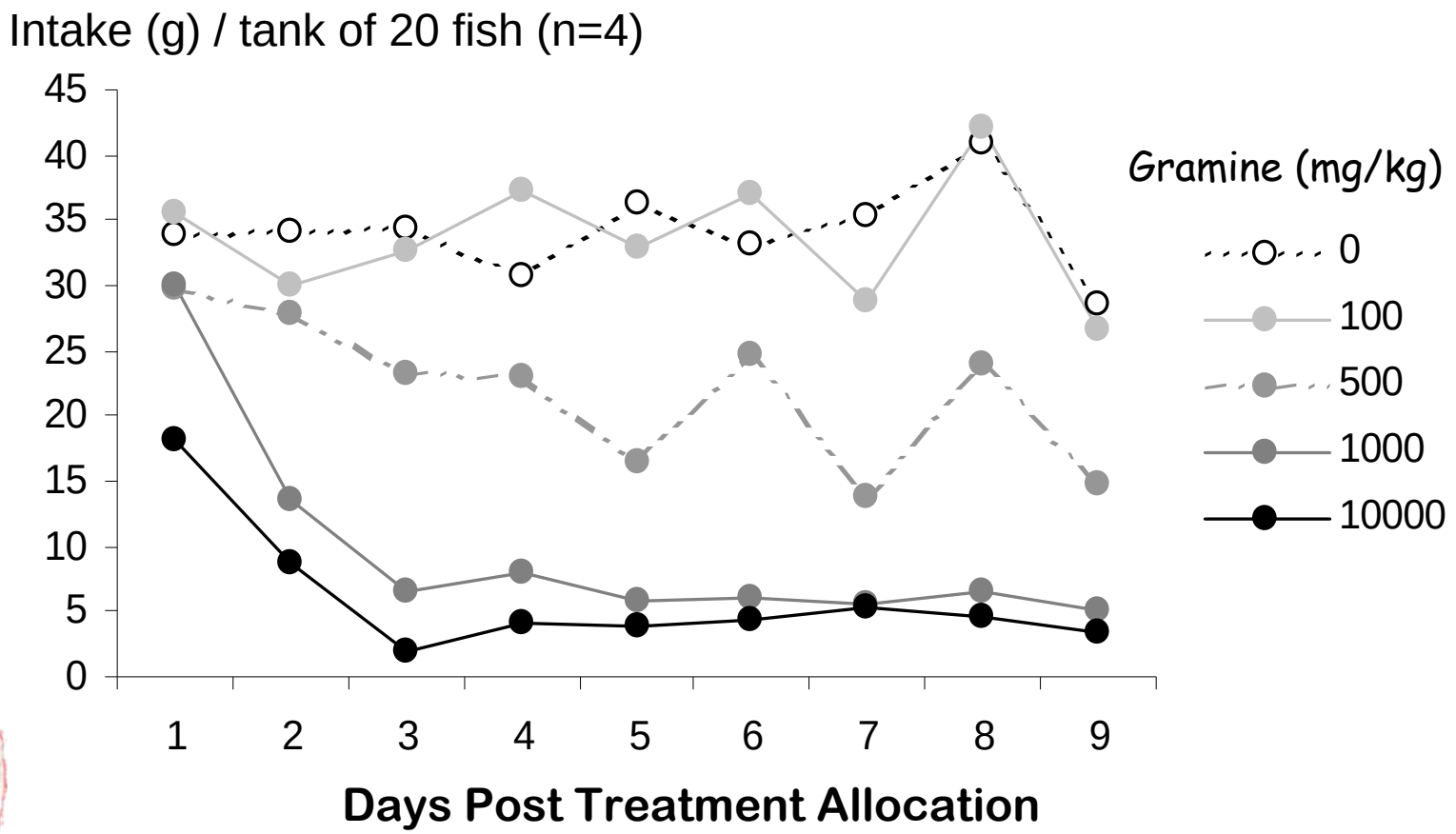
Anti-Nutritional Factors

Plant anti-nutritional factors are natural chemical defense mechanism evolved by plants to protect them against being eaten

All values mg/kg DM	Alkaloids	Phytate	Tannins	Trypisin Inhibitor	Oligosaccharides
L. angustifolius cv Mandelup KM	33	5,222	0	9,222	85,556
L. angustifolius cv Myallie KM	43	4,839	0	5,161	62,366
L. angustifolius cv Merrit KM	11	5,761	0	1,957	64,130
L. angustifolius cv Belara KM	11	5,889	0	6,444	88,889
L. luteus cv Wodjil KM	143	7,253	0	2,857	102,198
L. albus cv Kiev mutant KM	231	4,545	568	6,250	78,409
Whole Soybean	292	8,202	0	22,247	40,449
Solvent Extracted Soybean meal	44	8,889	0	10,000	62,222
Solvent Extracted Canola Meal	22	12,043	1,505	10,860	11,828
Whole Canola (Surpass 501TT)	22	10,440	549	9,451	12,088
Whole Field Pea (Laura-Dunwa)	11	5,435	7,826	8,152	33,696
Dehulled Field Pea (Laura-Dunwa)	11	6,154	989	10,989	36,264

All values are mg/kg of dry matter unless otherwise detailed

Alkaloids

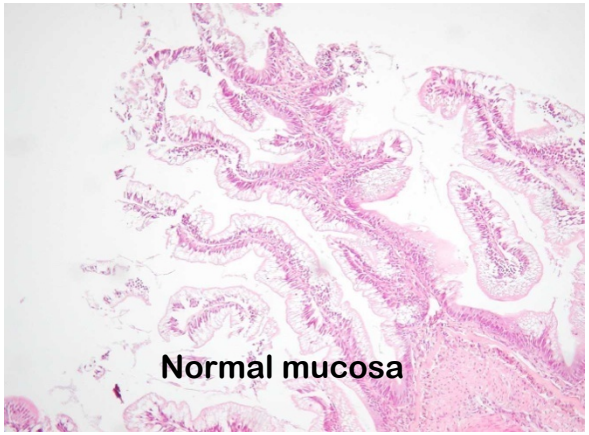


Glencross, et al., (2005). **Aquaculture 253, 512-522.**

Intestinal Pathology

Degree of Intestinal Damage with Atlantic salmon

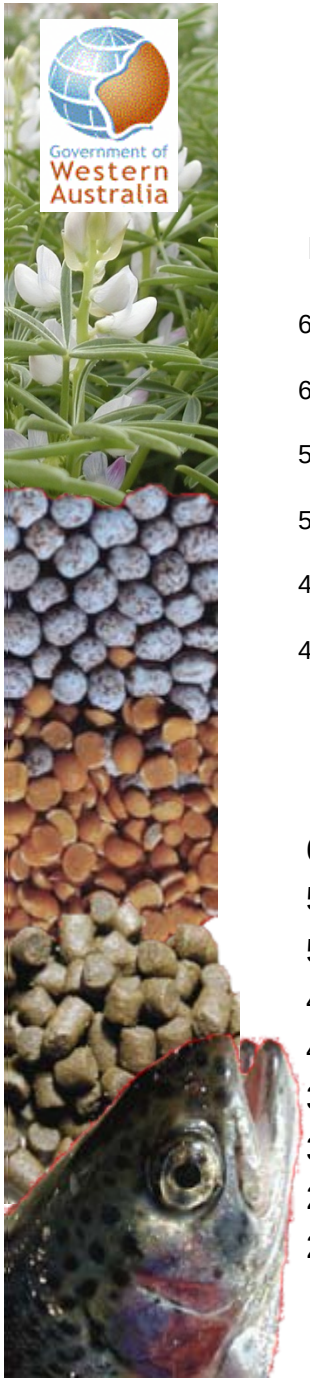
Diet	Normal	Moderate	Severe
Fishmeal	3	2	1
L. luteus KM	6		
L. angustifolius KM	4	1	1
Soybean Meal	1		4



Refstie et al., (2006). **Aquaculture 261, 1382-1395.**

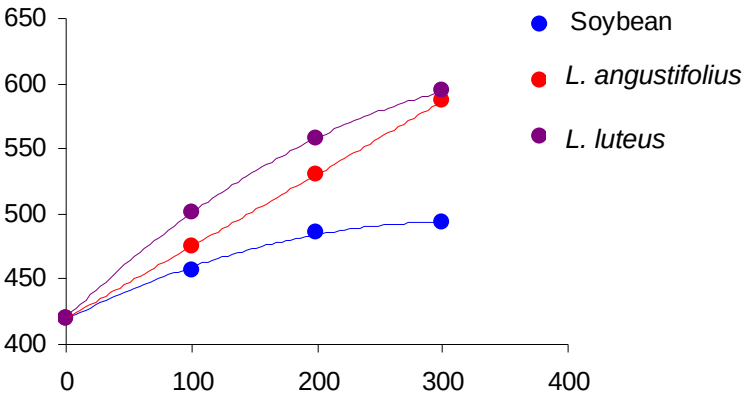
Functional/Technical Aspects

- Ingredients need to be made into pellets with key physical attributes, including:
    - Binding strength
    - Oil absorption
    - Durability
    - Sinkability
    - Water stability
- Extrusion followed by tests on various physical parameters is the best way to test ingredient influence on feed production

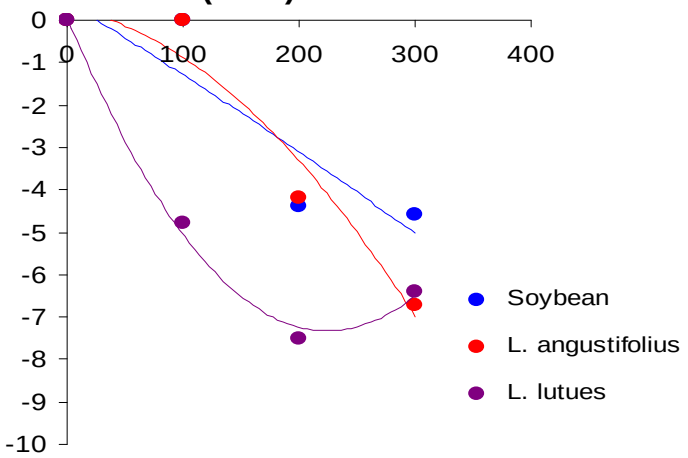


Grain Inclusion Effects

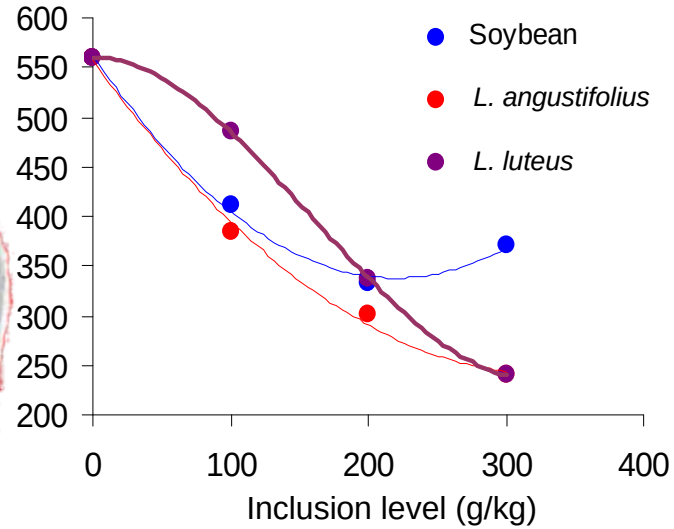
Bulk Density - Precoated (g/L)



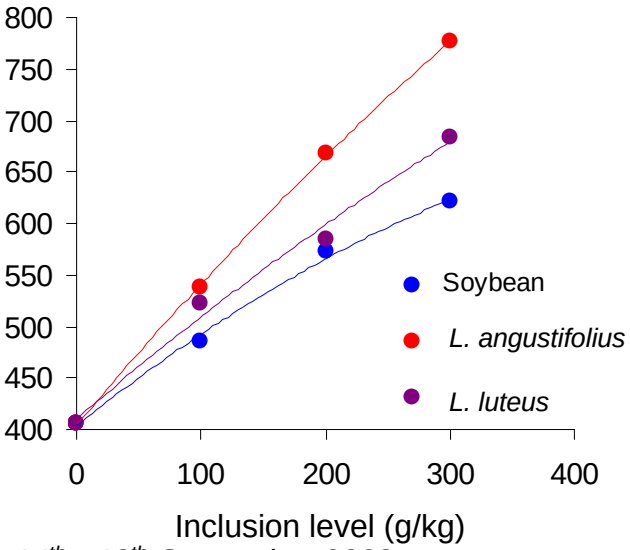
Sink rate (cm/s)



Vacuum oil uptake (g/kg)



Hardness (force (g) to split)



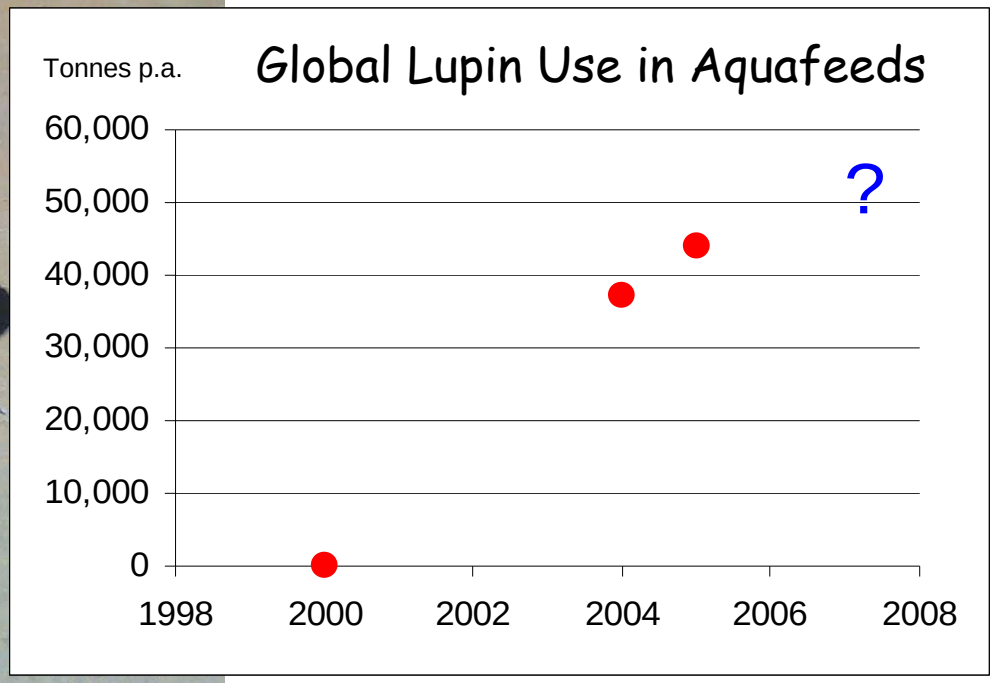
Industry Development

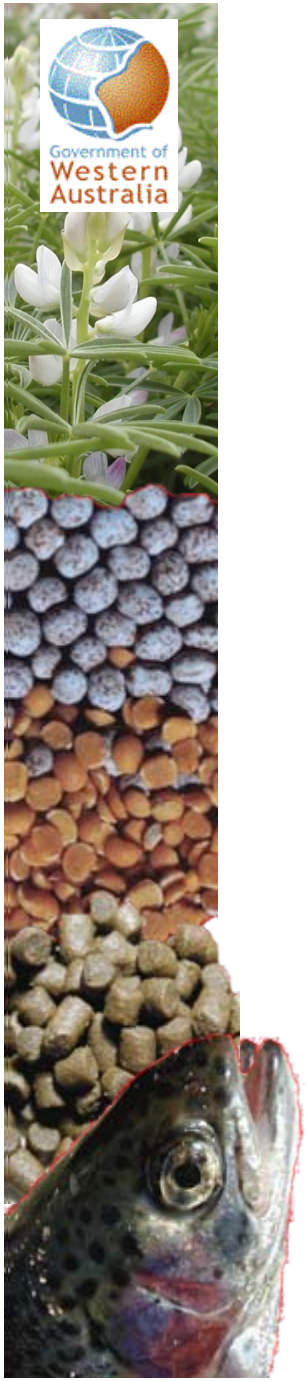
Most Australian fish feeds now contain a lupin component

2000 - 0 tonnes @ $350 = $0

2004 – 38kT @ $350 = $13.3M

2005 – 44kT @ $350 = $15.4M





Market Values

Market	Seed Equivalent	Kernel Meal	Hulls
Human	?	?	?
Aqua + Feedlot	$275	$350	$100
Aqua	$245	$350	-
Feedlot	$220	-	-
Market Price	$200	-	-
Pigs	$190	-	-
Poultry	$180	-	-
Feedlot	$30	-	$100

Based on kernel meal value of $350 / tonne and hull value of $100 / tonne
Dehulling yields of 70%
All values are FOB basis.
All values are NON drought year basis.

Industry Development

- **Commenced commercial kernel meal production in 2007**
- **Capacity for 200,000 tonnes**

Summary

- A variety of lupin products exist with promising potential for the aquaculture feeds sector.
- The kernel meals of several varieties are already being used in salmonid and marine fish diets throughout the world.
- Lupins show excellent nutritional attributes for use in fish diets
- Use of lupins can improve the physical properties of fish feeds in which they are included
- Adoption of lupin kernel meal use by the aquaculture feed sector, has been steady, but limited by volatile world grain prices.

Acknowledgements

Neil Rutherford, David Evans, Brian Jones

Wayne Hawkins, Sofia Sipsas, Mark Sweetingham, Max Karopou[illegible]s, Bevan Buirchell, Shandell Pursell

Peter McCafferty, Ken Dods, David Harris, Lincoln Morton

David Smith, Kevin Williams, Simon Tabrett, Margaret Barclay

[illegible]ris Carter, Keith Irwin, Louise Ward

Mark Tucek, Jason Craig, Peter Portmann, Ros Jettner

Mirjana Prica, Cathy Fryirs, Sherry Duckworth, Peter Schultz

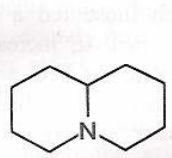
Rhys Hauler, Craig Foster, Wolfgang Koppe, Gunvor Baardsen

http://www.fish.wa.gov.au/docs/pub/ResAquaNutEnviron/

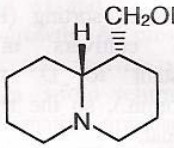
Alkaloids

L. Luteus kernel meals

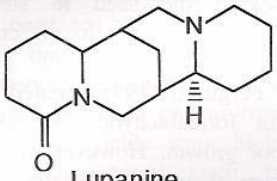
	Teo	Wodjil
Gramine	691	6
Epinine	155	279
Spartine	12	18
Multiflorine	23	26
TOTAL	**881**	**329**



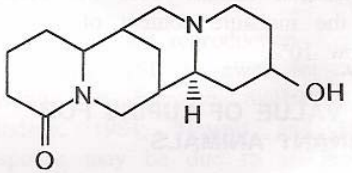
Quinolizidine



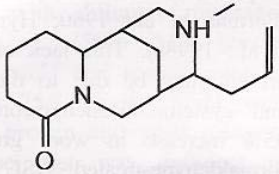
Lupinine



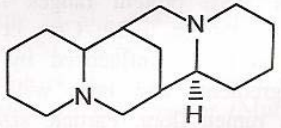
Lupanine



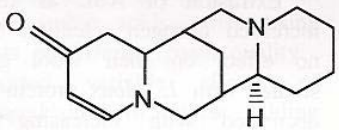
13–Hydroxylupanine



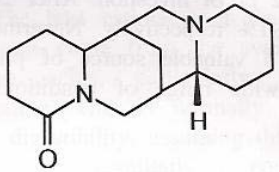
Angustifoline



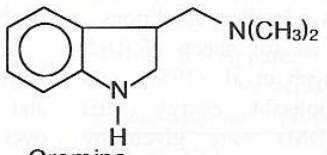
Sparteine



Multiflorine

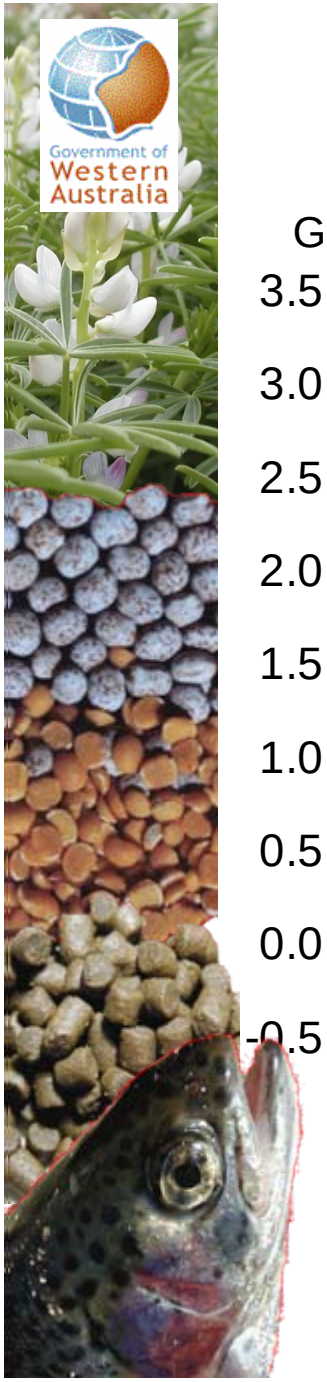


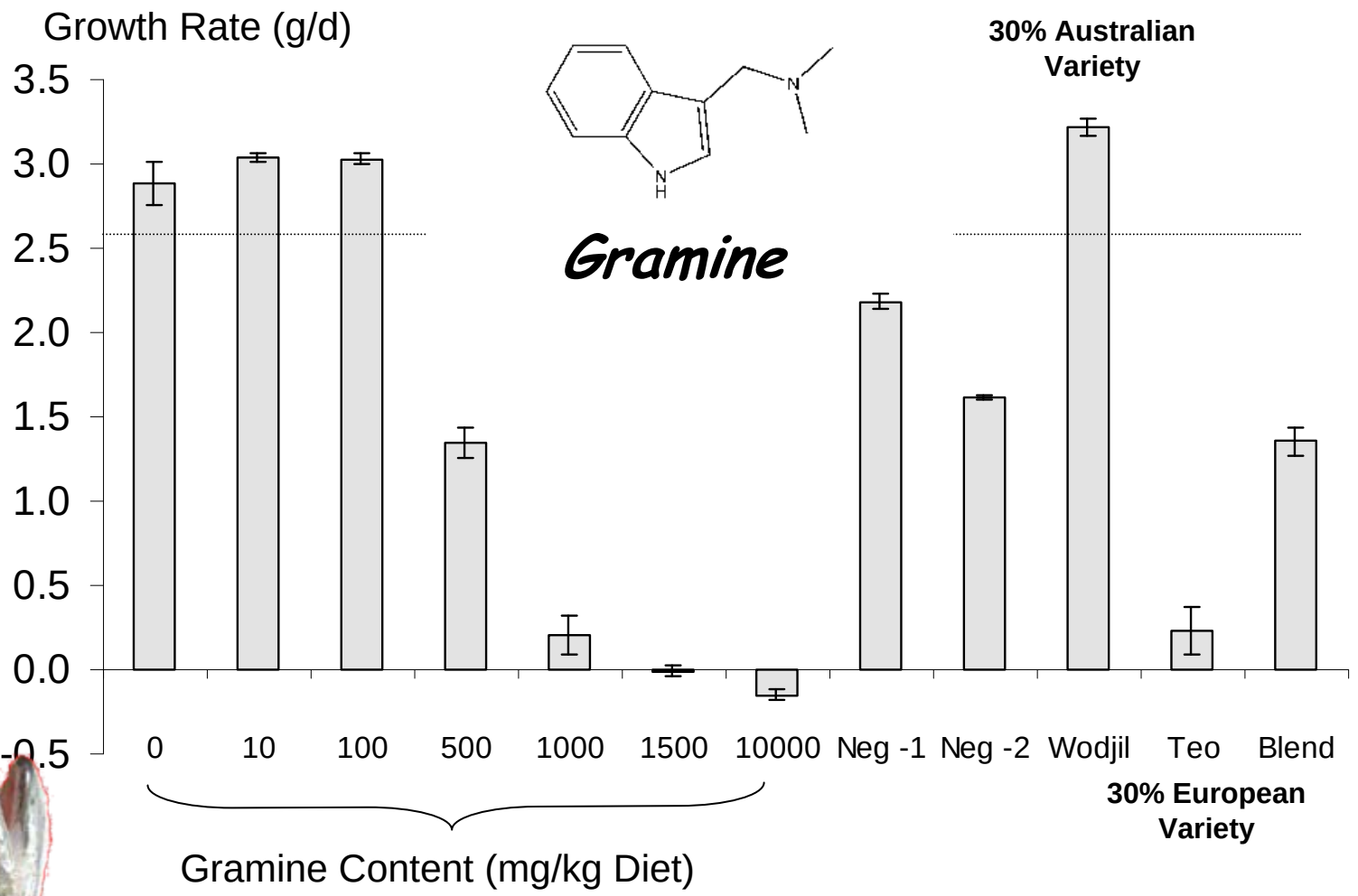
α –isolupanine



Gramine

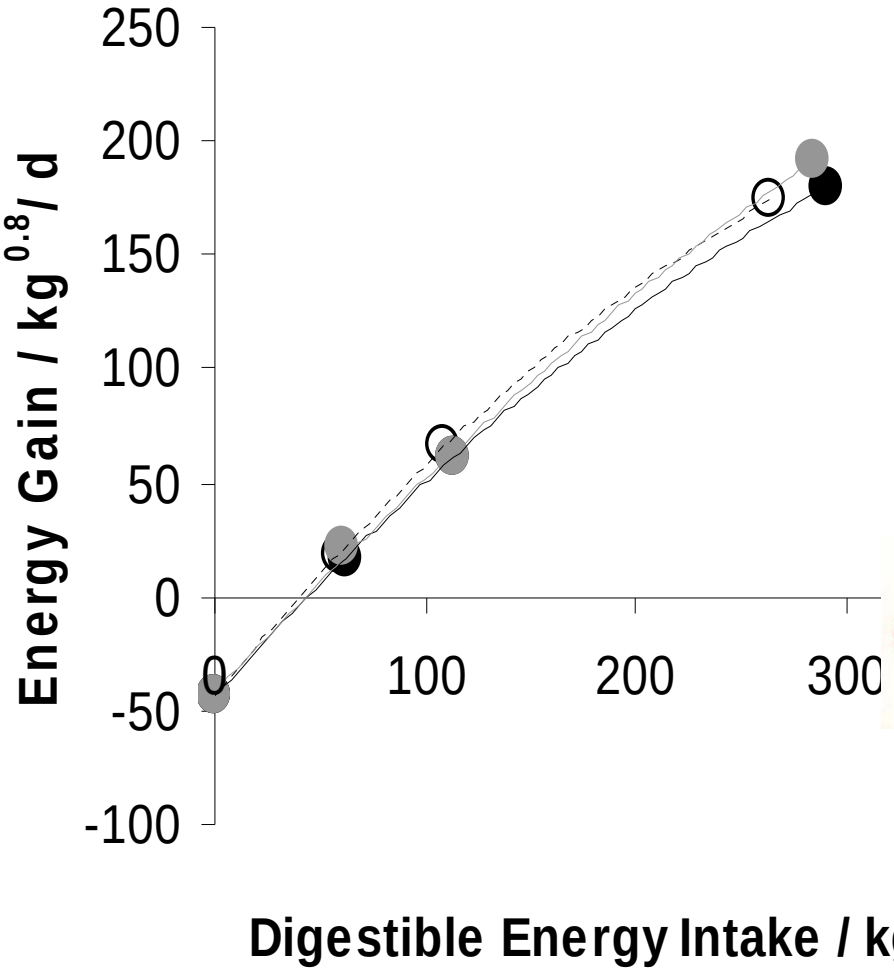
Growth Rate





Glencross, et al., (2005). **Aquaculture 253, 512-522.**

Efficiency of Energy Use



Glencross et al. (2008) **Aquaculture Nutrition, 14, 129-138.**

International Lupin Conference – Fremantle, 14th - 18th September 2008

Near Infra-Red Spectroscopy

- Development of technology to rapidly assess the composition and nutritional value of lupins for aquafeeds

- Widely used by industry