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# The Impact of Thermal Processing Methods on the Protein Quality of Pulses, as Determined by *in vivo* and *in vitro* Methodologies

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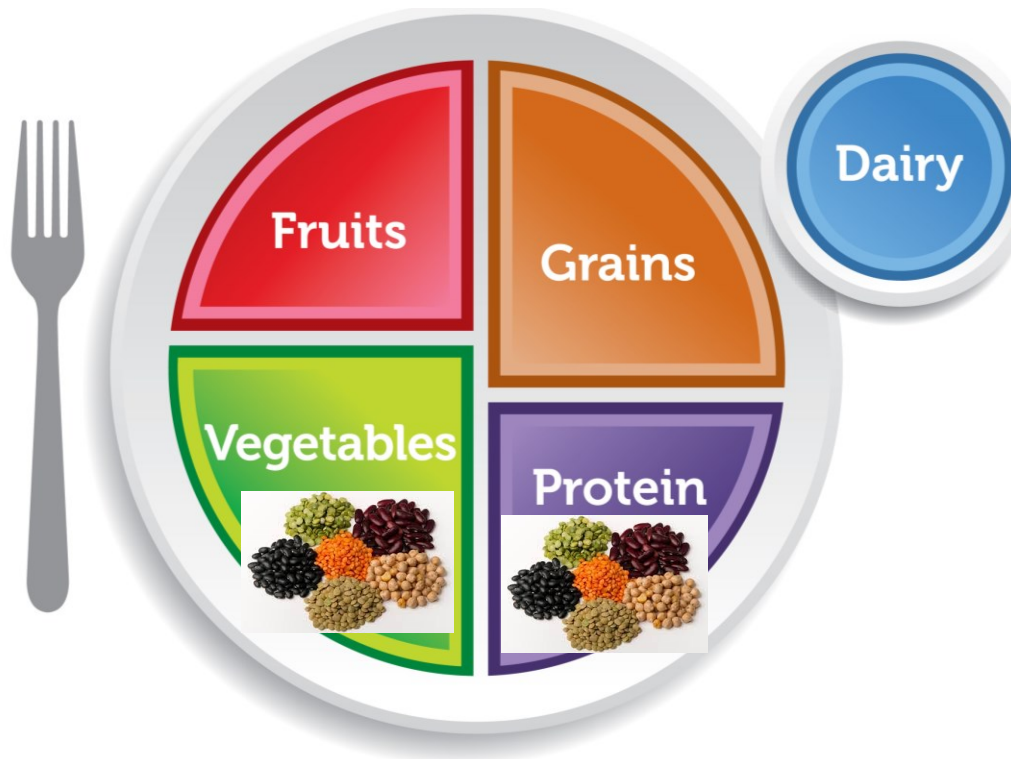
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UNIVERSITY  
OF MANITOBA

# Pulses and the Human Diet

USDA's "ChooseMyPlate"



Canada's Food Guide

Age in Years	Children			Teens		Adults			
	2-3	4-8	9-13	14-18		19-50		51+	
	Girls and Boys			Females	Males	Females	Males	Females	Males
<i>Vegetables and Fruit</i>	4	5	6	7	8	7-8	8-10	7	7
<i>Grain Products</i>	3	4	6	6	7	6-7	8	6	7
<i>Milk and Alternatives</i>	2	2	3-4	3-4	3-4	2	2	3	3
<i>Meat and Alternatives</i>	1	1	1-2	2	3	2	3	2	3
<p><b>Cooked fish, shellfish, poultry, lean meat</b> 75 g (2 1/2 oz.)/125 mL (1/2 cup)</p> <p><b>Cooked legumes</b> 175 mL (3/4 cup)</p> <p><b>Tofu</b> 150 g or 175 mL (3/4 cup)</p>									

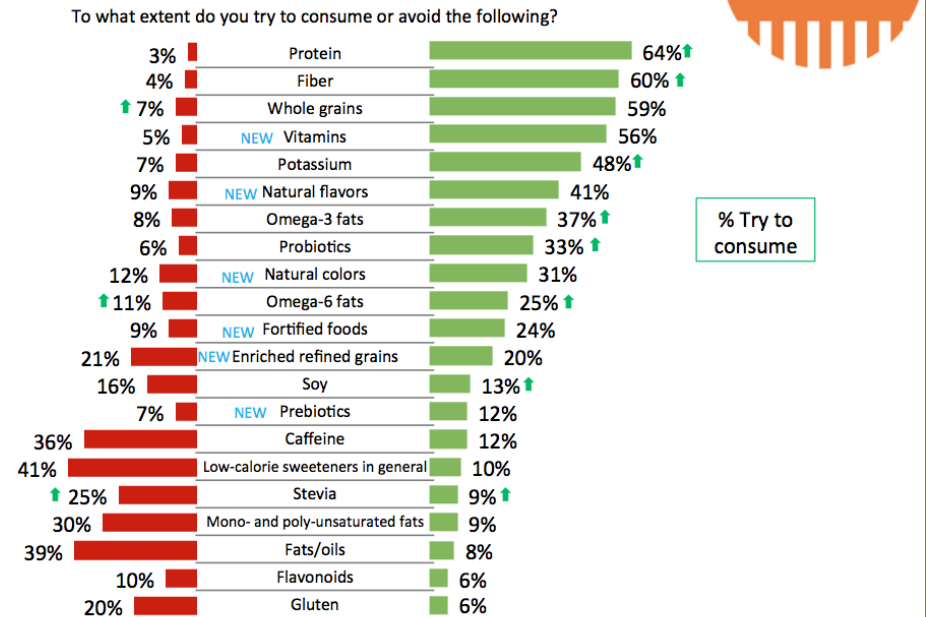
# Consumers are Seeking Protein



## 10 Key Trends in Food, Nutrition & Health 2016

<http://www.new-nutrition.com>

More Americans are trying to consume several nutrients and components, with protein and fiber topping the list.



2016 n=1,003; Arrows indicate significant (.95 level) differences vs. 2015.

- 64% of respondents try to consume protein
  - More prevalent in women and those with higher incomes

2016 Food and Health Survey. Food Insight, May 11, 2016. International Food Information Council

# Communicating Food Protein Messages

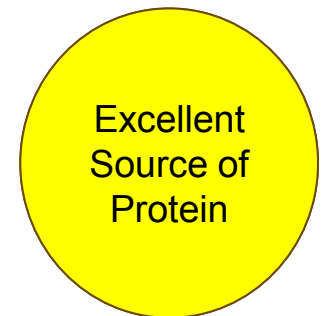
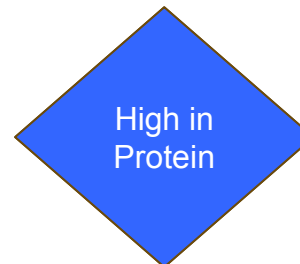
## • Nutrition Facts Panel

- Crude Protein Content
- % Daily Value (in US)




<b>Nutrition Facts</b>	
<b>Valeur nutritive</b>	
Per 1 bowl (300 g) / Pour 1 bol (300 g)	
Amount Teneur	% Daily Value % valeur quotidienne
<b>Calories / Calories</b>	440
<b>Fat / Lipides</b> 19 g	<b>29 %</b>
Saturated / Saturés 4 g	
+ Trans / Trans 0.2 g	<b>21 %</b>
<b>Cholesterol / Cholestérol</b>	35 mg
<b>Sodium / Sodium</b> 860 mg	<b>36 %</b>
<b>Carbohydrate / Glucides</b> 53 g	<b>18 %</b>
Fibre / Fibres 4 g	<b>16 %</b>
Sugars / Sucres 6 g	
<b>Protein / Protéines</b> 15 g	
Vitamin A / Vitamine A	45 %
Vitamin C / Vitamine C	4 %
Calcium / Calcium	20 %
Iron / Fer	20 %

## • Claims

- Origin Claims
- Composition Claims
- Symbols
- Nutrient Content Claims
  - Source → Excellent Source
  - Comparative Claims



# What Evidence is Needed to Support Content Claims?

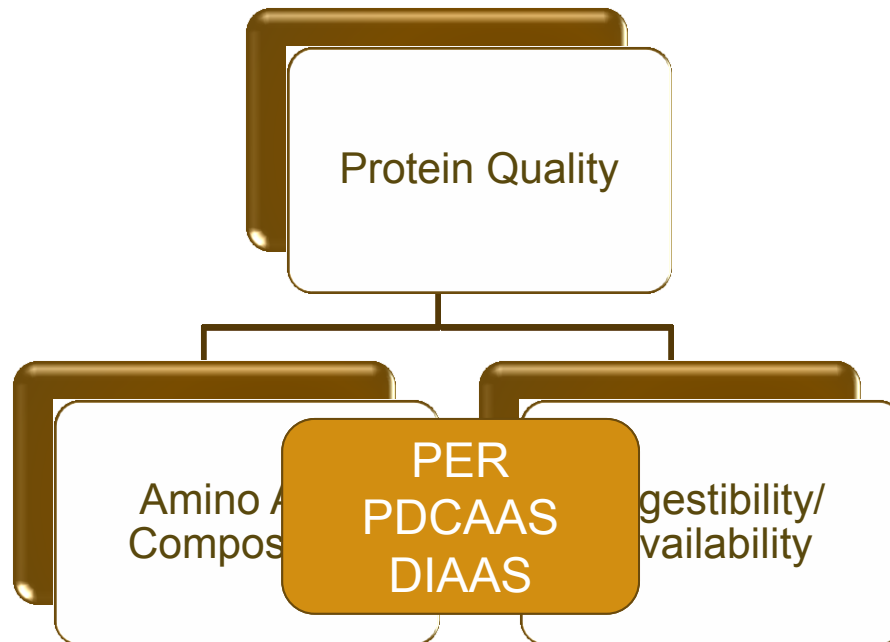
Jurisdiction	Basis for Protein Content Claims	Methodology
	Protein Quality & Quantity	Protein Rating System based on the Protein Efficiency Ratio ( <b>PER</b> )
	Protein Quality & Quantity	Protein Digestibility-Corrected Amino Acid Score ( <b>PDCAAS</b> )
	Protein Quantity	Expression of protein content relative to energy content

**Proposed Method:** Digestible Indispensable Amino Acid Score (**DIAAS**)

# Establishing Evidence for Protein Content Claims

## *Protein Quality Assessment*

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How well does the amino acid pattern match human amino acid needs?

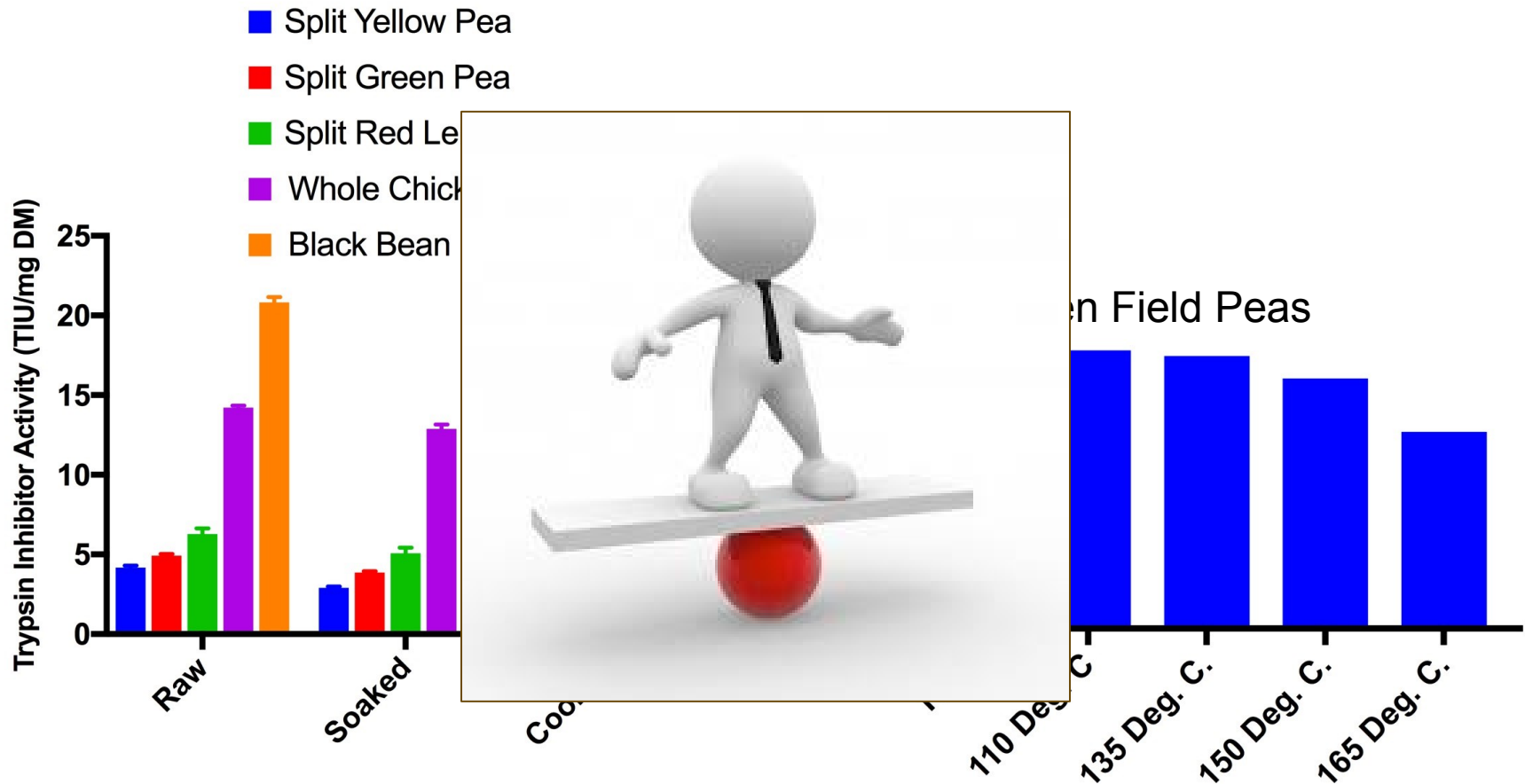
To what extent are the amino acids digested, absorbed and ultimately made available for metabolic demands?

# Protein Digestibility & Thermal Processing

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- Native pulse flours typically present with reduced protein/amino acid digestibility
- Anti-nutritive factors
  - **Serine protease inhibitors:** Impact trypsin and chymotrypsin activity
  - **Lectins:** glycoproteins that impact nutrient absorption
- Sensitive to thermal inactivation

# Impact of Thermal Processing on Nutritional Quality of Pulses



Shi et al., 2017. J. Food Sci. Technol. 54: 1014-1022.

Van Barneveld et al., 1994. Brit. J. Nutr. 72: 221-241.



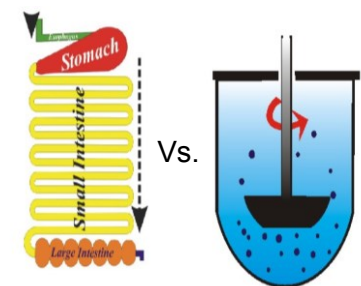
# Objectives

- Determine the protein quality of composite pulse samples subjected to 3 thermal processing steps

PER  
PDCAAS  
IVPDCAAS  
DIAAS



in vivo vs. in vitro



## Materials & Methods

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- Pulse samples secured from major Western Canadian suppliers
  - Min. of 3 suppliers per pulse class
  - Samples blended to yield 30-50 kg composites
  - Pulse classes:

Green peas

Yellow peas

Red lentils

Green lentils

Chickpeas (Kabuli)

Red kidney beans

Black bean

Pinto bean

Faba bean

Navy bean

# Materials & Methods

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## Treatments

- Whole pulses as received
  - Consumer cooking method
    - Soaking & boiling with times specific to each pulse class
- Milled pulse flours
  - Extrusion
    - Cleextral Evolum® HT 25 twin screw extruder
    - Flow rate: 36 kg/hr with moisture addition of 0.8 kg/hr
    - Screw speed: 650 rpm
    - Extrusion barrel temperatures: 30-50°C, 70-90°C and 100-120°C.
  - Baked (simulated cracker)
    - 2:1 flour:water; sheeting; 190 deg. C for 35 min

# Materials & Methods

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- Measurements

- **PER**: gain per unit of protein intake
- **PDCAAS**: product of true fecal protein digestibility (TPD) and Amino Acid Score (AAS)
  - AAS = lowest value for ratios of amino acid content relative to reference requirement pattern
- **IVPDCAAS**: product of *in vitro* protein digestibility (IVPD) and AAS
  - IVPD determined by method of Tinus et al (2012)



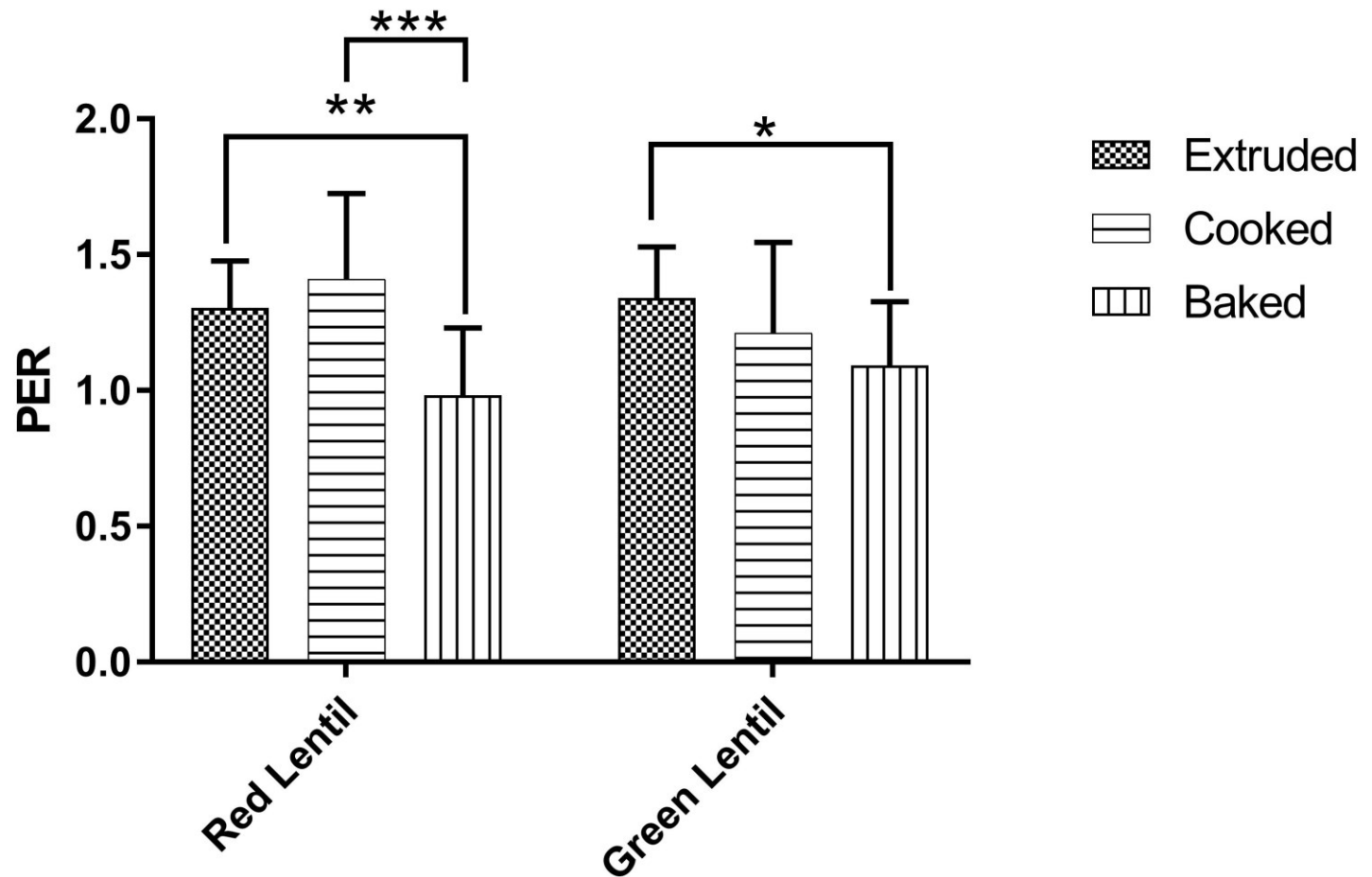
# Results

	Adj. Per	AAS <sup>a</sup>	%TPD <sup>b</sup>	IVPD <sup>c</sup>	PDCAAS <sup>d</sup>	IVPDCAAS <sup>e</sup>
Casein	2.50	1.03	96.1 (1.4)	91.4 (0.7)	99.1	94.2
Red Lentils						
Green Lentils						
Split Yellow Pea						
Split Green Pea						
Chickpeas						

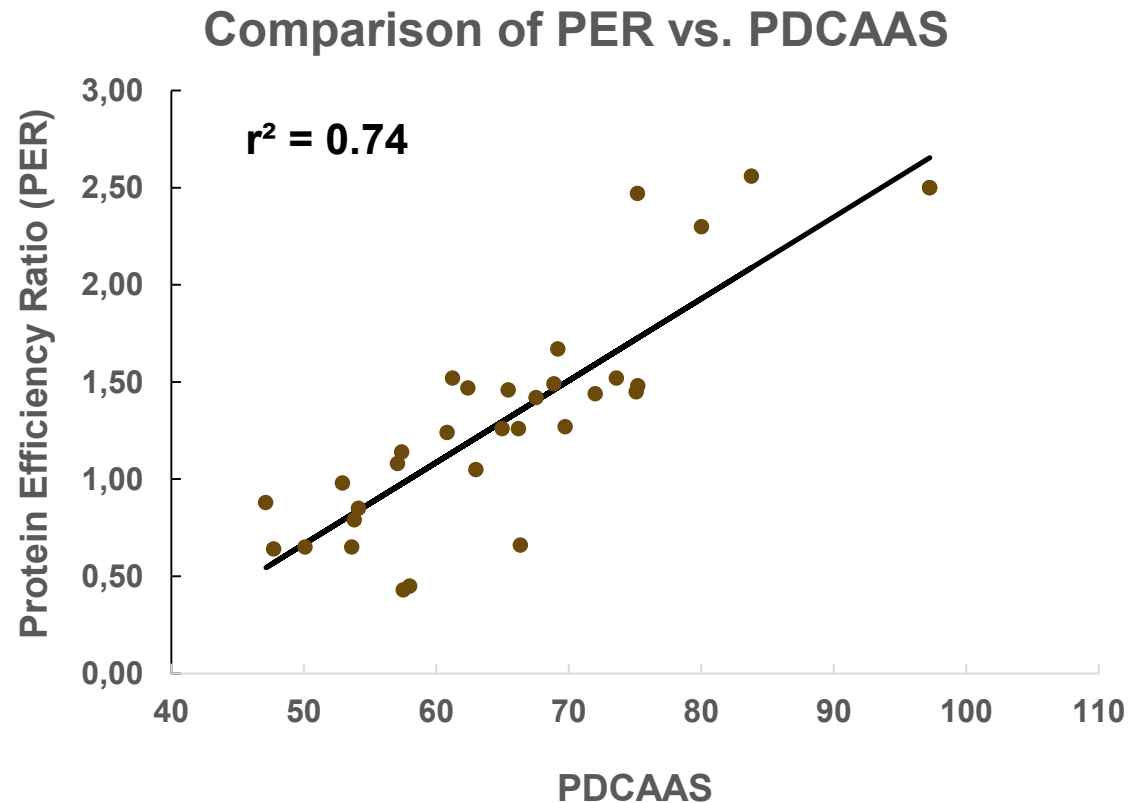
# Results

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Black Beans						
Faba Beans						
Navy Beans						
Pinto Beans						
Red Kidney Beans						

## Lentil PER Data



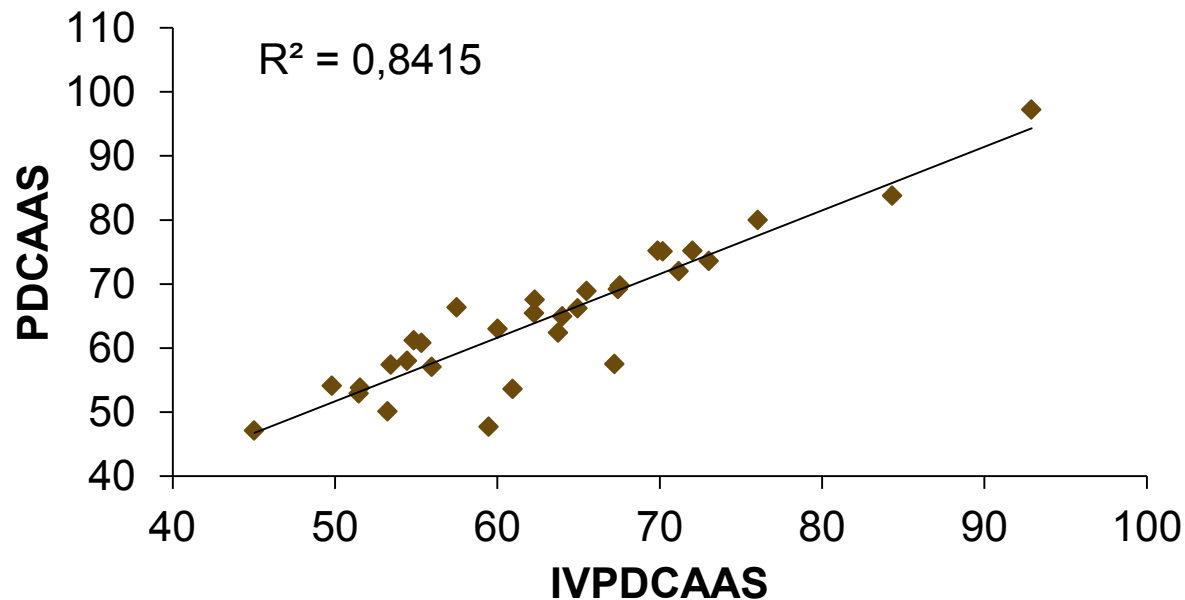
# PER vs. PDCAAS: All pulses





# in vivo vs. in vitro PDCAAS: All pulses

**Comparison of in vivo vs. in vitro  
Protein Quality Measures**



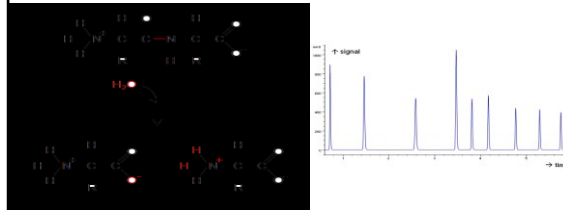
# Substantiating Protein Content Claims

## Technical Considerations

### Quantity vs. Quality



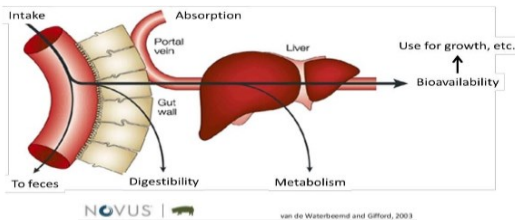
### Analytical Issues



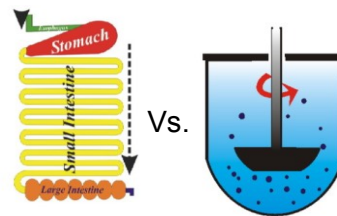
### Choice of Species



### Digestibility vs. Availability



### in vivo vs. in vitro



### The Numbers

*Reference Pattern*

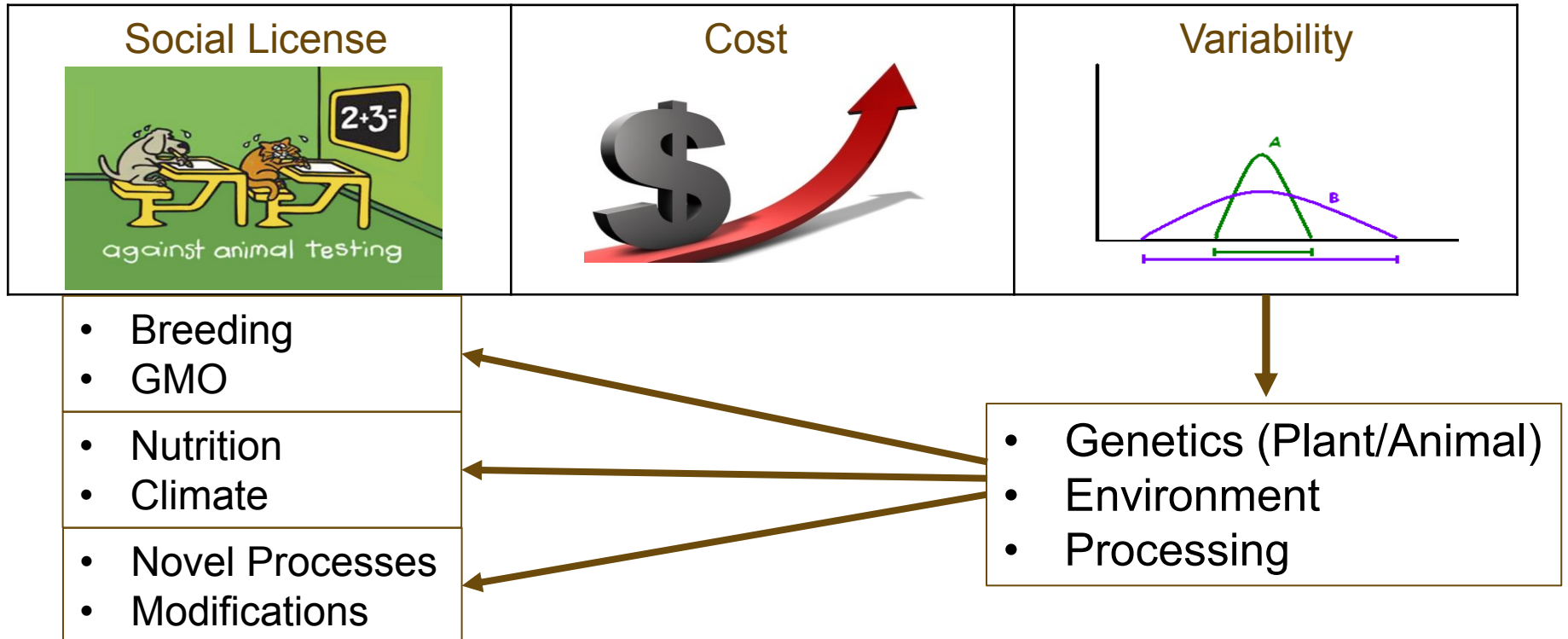
*Serving Size*

*Threshold Values*

*Conversion Factors*

# Substantiating Protein Content Claims

## Technical Considerations



## Summary

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- In general, for protein quality
  - Boiling > Extrusion >> Baking
  - Pea and chickpea flours more resistant to thermal impacts
- *In vitro* methods hold promise as alternatives to bioassay for routine protein quality assessment
- Opportunities to position pulses and pulse-based ingredients as plant-based protein sources in food applications

# Acknowledgments

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- Jason Neufeld, Gerardo Medina, Kristen Hill, Jessica McEvoy, Casey Kunzelman-Gall

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- Pulse industry partners

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