Cropping location and year effect protein content and amino acid score of different lentil varieties

Matthew G. Nosworthy, [1] Jason Neufeld, [1] Tom Warkentin[2] and James D. House [1]

[1]Department of Food and Human Nutritional Sciences, University of Manitoba, Winnipeg, MB R3T 2N2, Canada.

[2]Crop Development Centre/Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK, S7N 5A8, Canada

Lentils

- Edible pulse crop
  - Cultivated in over 48 countries
- Largest exporter – Canada (1.8 MT in 2013)
  - 95% produced in Saskatchewan
- Largest importer – India (0.7 MT in 2013)
- Average protein content of 28%
  - Range between 16-31%
- Rich in lysine, limiting in sulfur amino acids/tryptophan
- Multiple varieties, growing locations

Location

Desi Chickpea	Protein (g/kg seed meal)
Brooks 2005	217.8
Bow Island 2005	184
Goodale 2005	176.9
Davidson 2005	154.7
Kyle 2004	190
Kyle 2005	197.4
Swift Current 2005	212.7
Elrose 2005	155.5
Scott 2004	245.6
Scott 2005	216.5

Kabuli Chickpea	Protein (g/kg seed meal)
Bow Island 2005	192.3
Elrose 2005	172
Kyle 2005	194.2
Davidson 2005	158.4
Goodale 2005	198.2
Swift Current 2005	209.7
Hodgeville 2005	180.3

Frimpong, et al. *J. Sci Food Agric* 2009; **89**: 2052–2063

Genetics

Desi Chickpea	Protein (g/kg seed meal)
ICC - 12512-9	191
ICC-12512-1	192
CDC Vanguard	185
CDC Cabri	196
316B-42	201
CDC Anna	188
Myles	212

Kabuli Chickpea	Protein (g/kg seed meal)
CDC Frontier	188
FLIP97-133C	171
Amit	192
FLIP97-45C	190
FLIP98-135C	186
FLIP98-134C	184
97-Indian2-1	187
CDC Xena	182
Sanford	198

Faba Bean	Protein (g/kg DM)
CDC Fatima	307
Disco	285
Dixie	297
Florent	282
Gloria	324
Imposa	275
NPZ4-7460	283
NPZ4-7540	297
NPZ5-7530	287
Snowbird	284
SSNS-1	302

Pea	Protein (g/kg DM)
Bluebird	250
CanStar	242
CDC Striker	275
CDC Tucker	271
Cooper	255
Cutlass	250
Fusion	244
Reward	255
SW Marquee	253
Tamora	253

Chickpea data: Frimpong, et al. *J. Sci Food Agric* 2009; **89**: 2052–2063
Pea and faba bean data: Hood-Niefer et al, *J Sci Food Agric* 2012; **92**: 141–150

Protein Digestibility-Corrected Amino Acid Score (PDCAAS)[1]

- Proposed by FAO/WHO in 1991
  - Adopted by USA in 1993
- Amino Acid Score (AAS)
  - AA in food/AA in reference pattern
    - mg/g protein
    - Reference pattern of 2-5 yr old school children (1991)
- True Fecal Protein Digestibility (TFPD)
  - Fecal N output/Dietary N input
    - Corrected for endogenous losses
- Additive
  - Can use existing PDCAAS data to predict new values

Reference Values (mg/g protein)	
	PDCAAS (1991)
THR	34
VAL	35
MET+CYS	25
ILE	28
LEU	66
PHE+TYR	63
HIS	19
LYS	58
TRP	11

1)Joint FAO/WHO. In Joint FAO/WHO expert consultation on protein quality evaluation. Food and Agriculture Organization of the United Nations; Rome, Italy, 1990.

Protein Quality

- Protein digestibility-corrected amino acid score (PDCAAS)[1]
  - Amino Acid Score (AAS)
  - Protein Digestibility
- AAS
  - Ratio between amino acid composition of the protein to a reference pattern based on human nutritional requirements
  - AAS ≥ 1 : Not limiting
  - AAS ≤ 1 : Limiting
  - Lowest AAS – first limiting amino acid

1)Joint FAO/WHO. In Joint FAO/WHO expert consultation on protein quality evaluation. Food and Agriculture Organization of the United Nations; Rome, Italy, 1990.

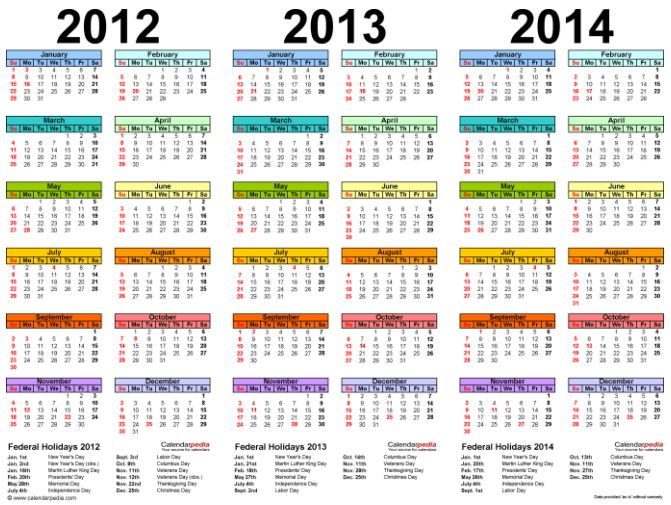
Objective

What is the effect of:

1) Cropping Year

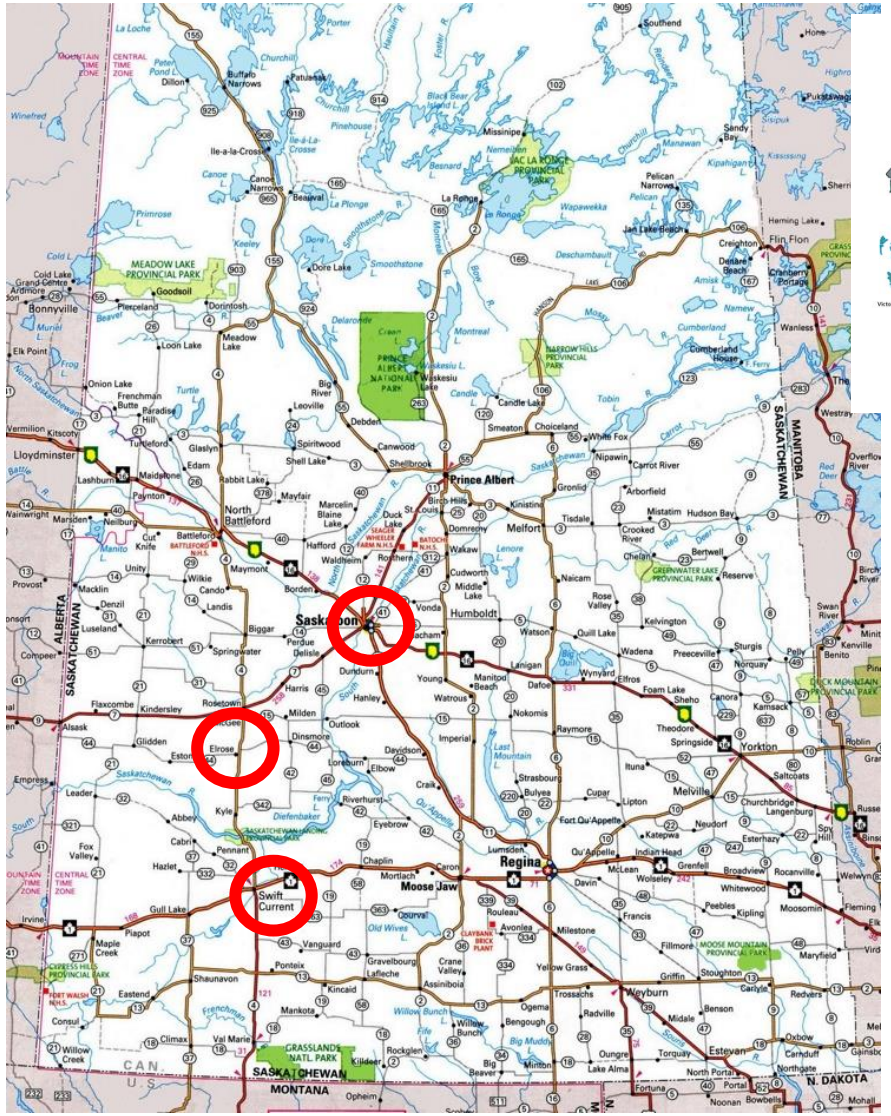
2) Cropping Location

On protein content and amino acid composition of different varietals of red and green lentils.



Sample Procurement

- Cropping locations:
  - Elrose
  - Sutherland
  - Swift Current
- Red Lentil
  - Maxim
  - Imax
  - KR-1
- Green Lentil
  - Greenstar
  - Invincible
  - Impower
- Collected in 2012, 2013, 2014



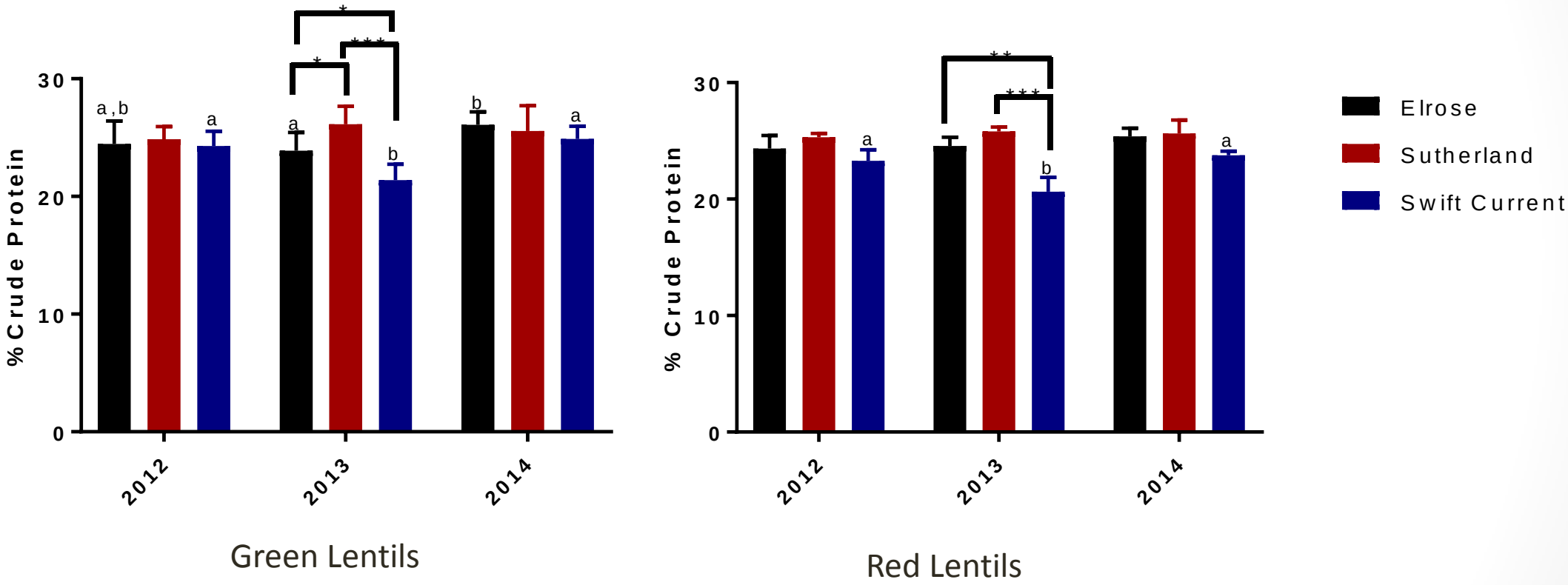
Sample analysis

- Nitrogen
  - Dumas Combustion, conversion to protein using N x 6.25

- Amino acid composition
  - Acid hydrolysis[2]
  - Sulfur amino acids were determined by performic acid oxidized hydrolysis[2]
    - Both acid hydrolysis and SAA were quantified via UPLC (AccQ Tag Ultra)
  - Tryptophan isolated via alkaline hydrolysis and quantified using HPLC[3]

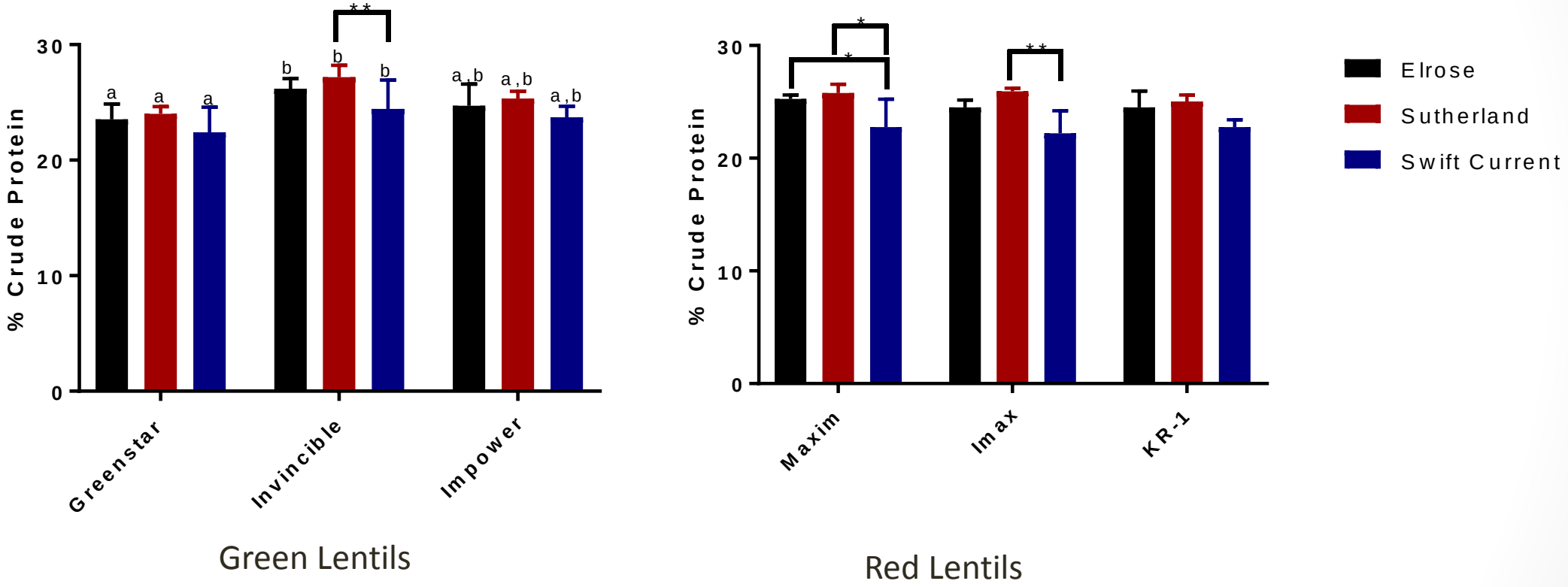
2)AOAC International. In *Official Methods of Analysis of AOAC International,* 16th ed.; AOAC International: Arlington, VA, 1995
3) Nosworthy et al. 2017 JAFC 65:3919-25

Annual Crude Protein Content



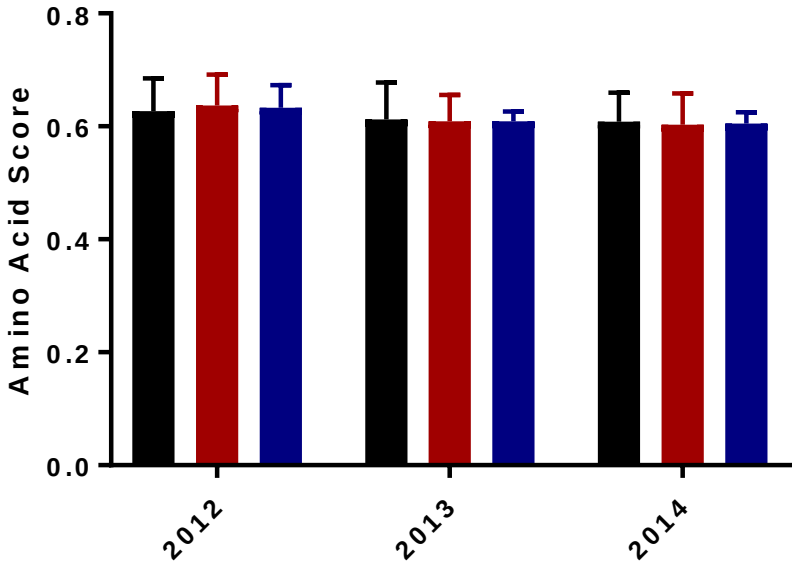
Data were analyzed via Two-Way ANOVA with Tukey's post-hoc test. Comparisons within year are designated by lines where * = $p < 0.05$, ** = $p < 0.01$, **** = $p < 0.0001$. Significant differences between years, but within location, are designated by different letters, $p < 0.05$.

Varietal Crude Protein Content

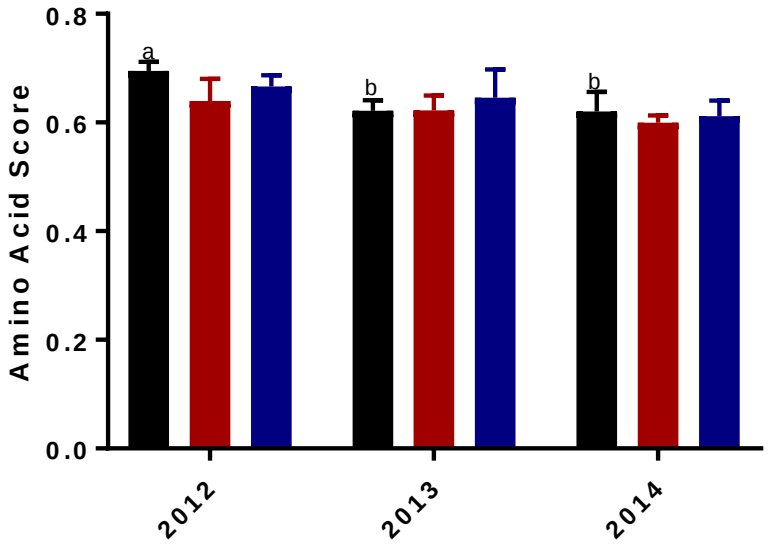


Data were analyzed via Two-Way ANOVA with Tukey's post-hoc test. Comparisons within year are designated by lines where * = $p < 0.05$, ** = $p < 0.01$, **** = $p < 0.0001$. Significant differences between years, but within location, are designated by different letters, $p < 0.05$.

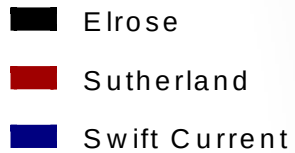
Annual Amino Acid Score



Green Lentils

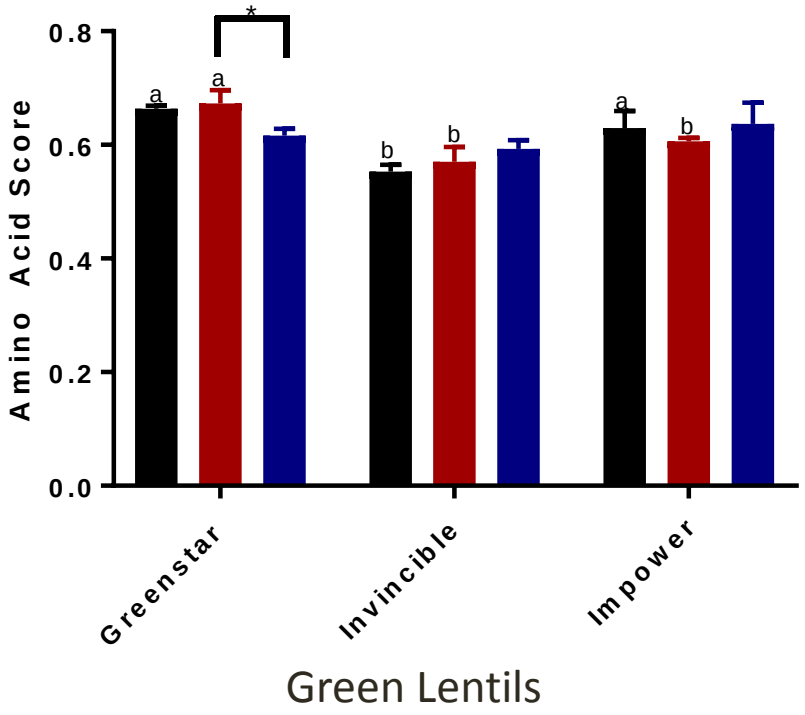


Red Lentils

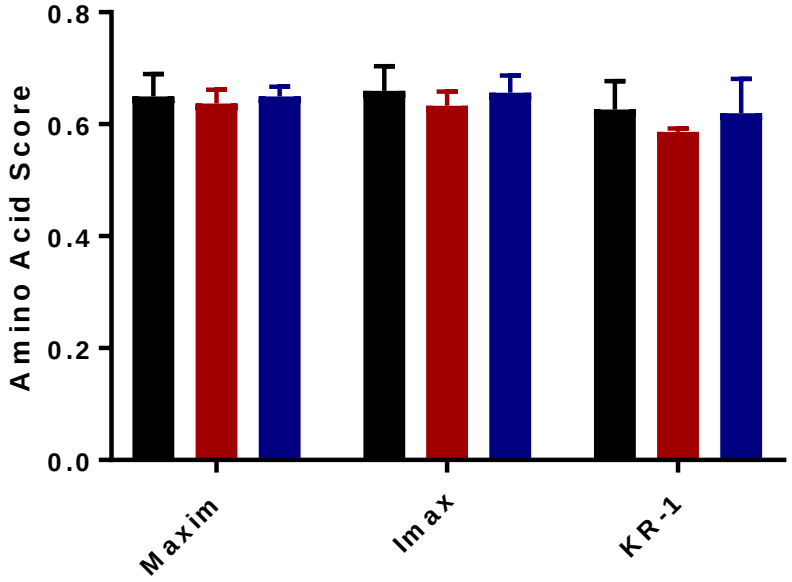


Data were analyzed via Two-Way ANOVA with Tukey's post-hoc test. Comparisons within year are designated by lines where * = $p < 0.05$, ** = $p < 0.01$, **** = $p < 0.0001$. Significant differences between years, but within location, are designated by different letters, $p < 0.05$.

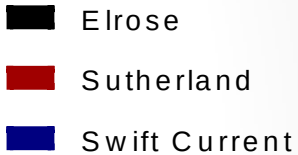
Varietal Amino Acid Score



Green Lentils



Red Lentils



Data were analyzed via Two-Way ANOVA with Tukey's post-hoc test. Comparisons within year are designated by lines where * = $p < 0.05$, ** = $p < 0.01$, **** = $p < 0.0001$. Significant differences between years, but within location, are designated by different letters, $p < 0.05$.

Summary

- Protein Content
  - Change based on year and location for both red and green lentils
  - differs between varietals (Greenstar < Invincible)
  - Selection of varietal and location could be used to optimize protein content

- Amino Acid Score
  - Little annual variation (higher AAS in Elrose 2012 than 2013/2014)
  - Greater variability in green lentils than in red lentils

Future Directions

- Further comparisons
  - Fat content
- Calculation of *in vitro* PDCAAS
  - Requires determination of protein digestibility
  - Good relationship between *in vitro* and *in vivo* PDCAAS
- Investigation of agronomic conditions during 2012-2014
- Analysis of other pulse crops
  - Beans, peas, chickpeas

Growing Forward 2

A federal-provincial-territorial initiative

GIFS

EST. 1877

University of Manitoba