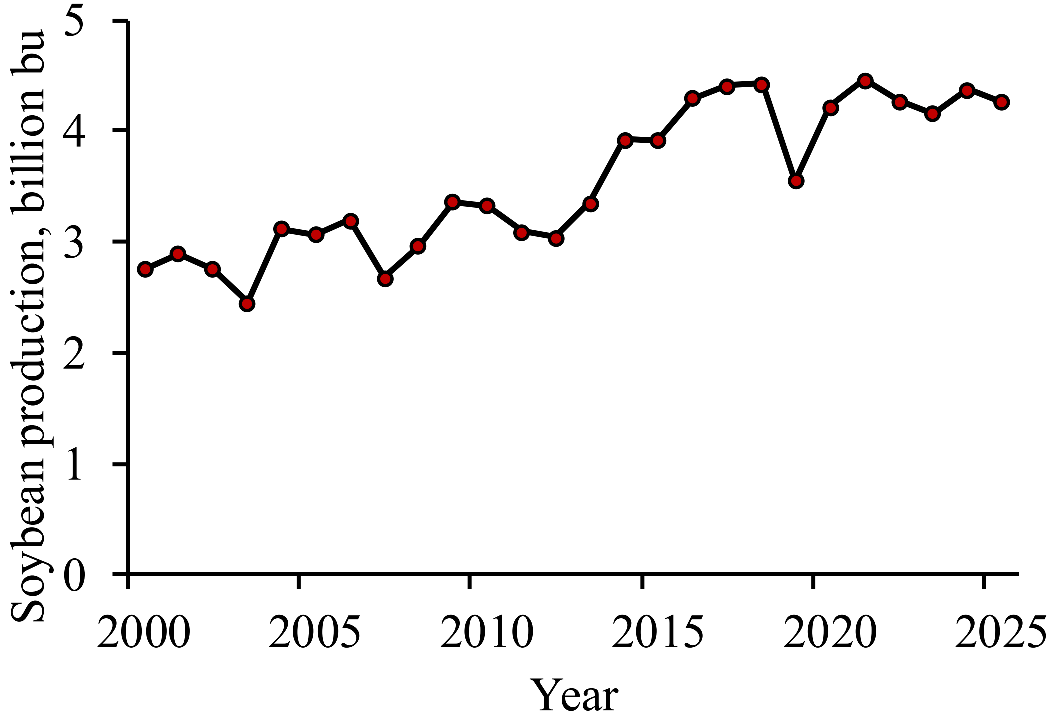
Conventional and High-Oleic Soybeans and Dairy Nutrition Models: Chemistry, Fuel Profile, and Lactation Responses

P. J. Kononoff, PhD
Department of Animal Science, University of Nebraska-Lincoln, Lincoln, NE, 68583-0908

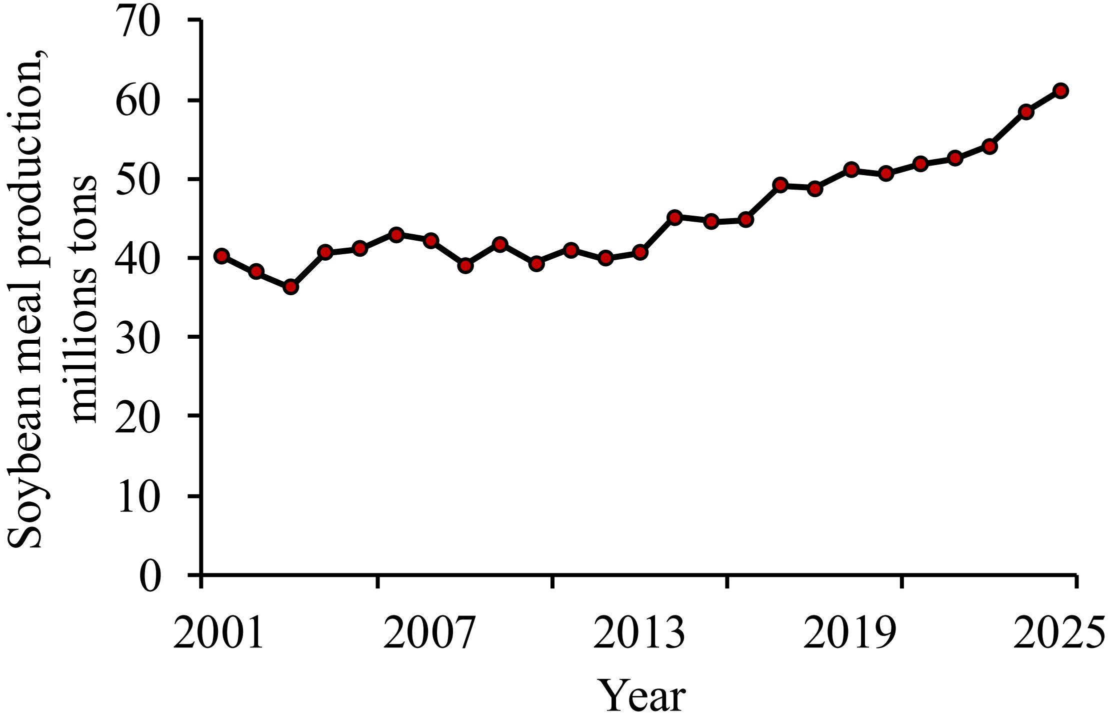
Four State Dairy Nutrition and Management Conference
8:45-9:15 a.m
June 4, 2026
La Crosse Center
La Crosse, WI

US Soybean Snapshot

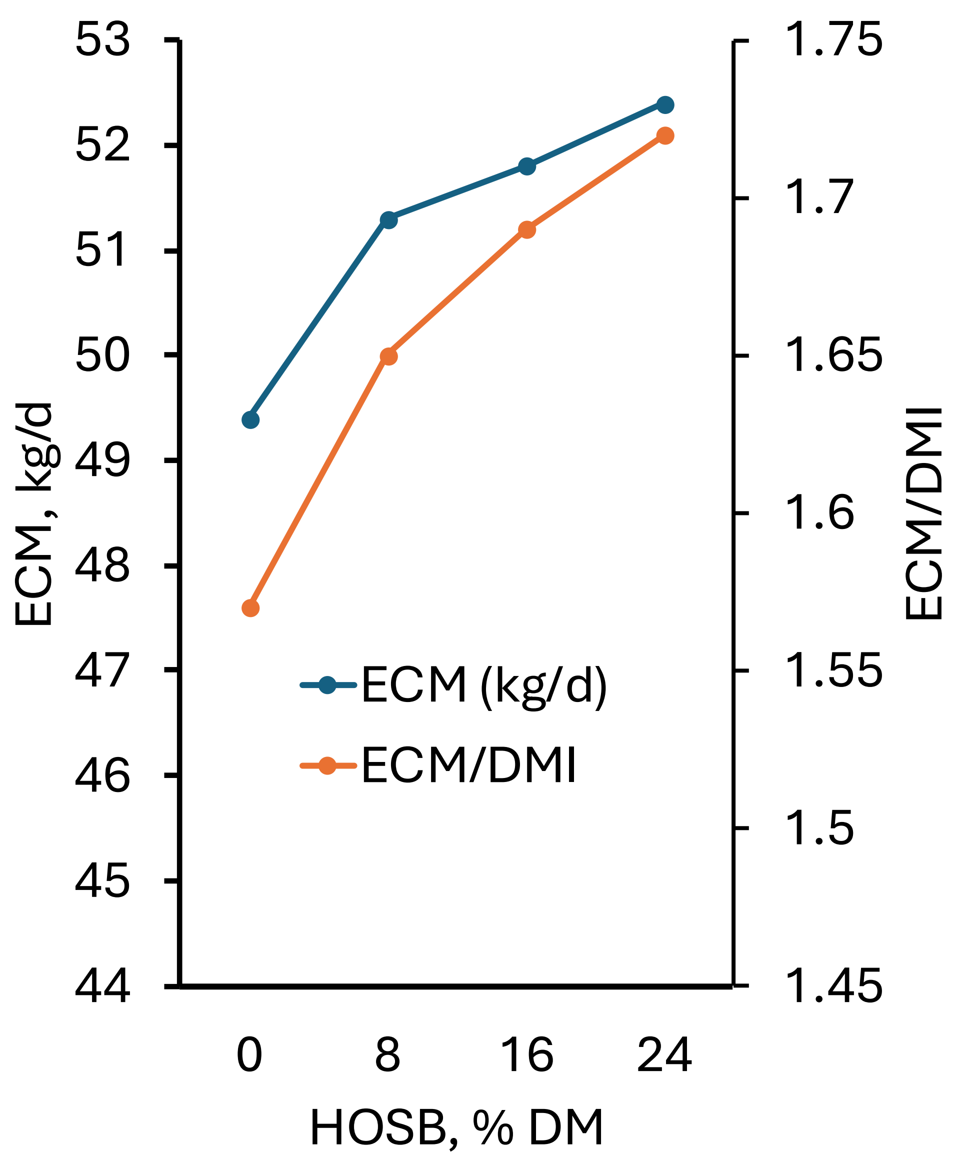
US Soybean production (4.26 Bil BU in 2025)



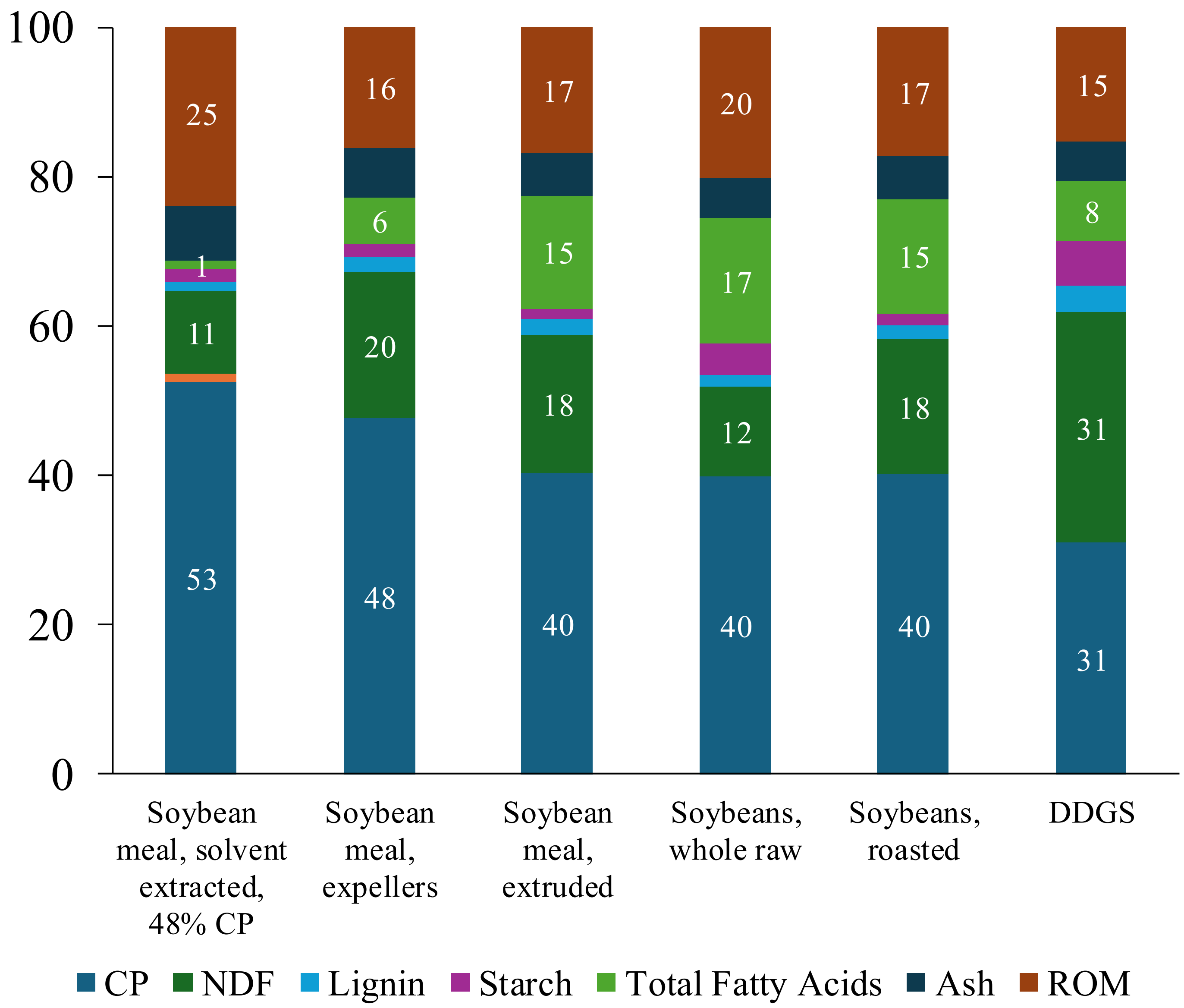
US Soybean meal production (61.1 million tons in 2025/2026)



Bales and Lock (2024)

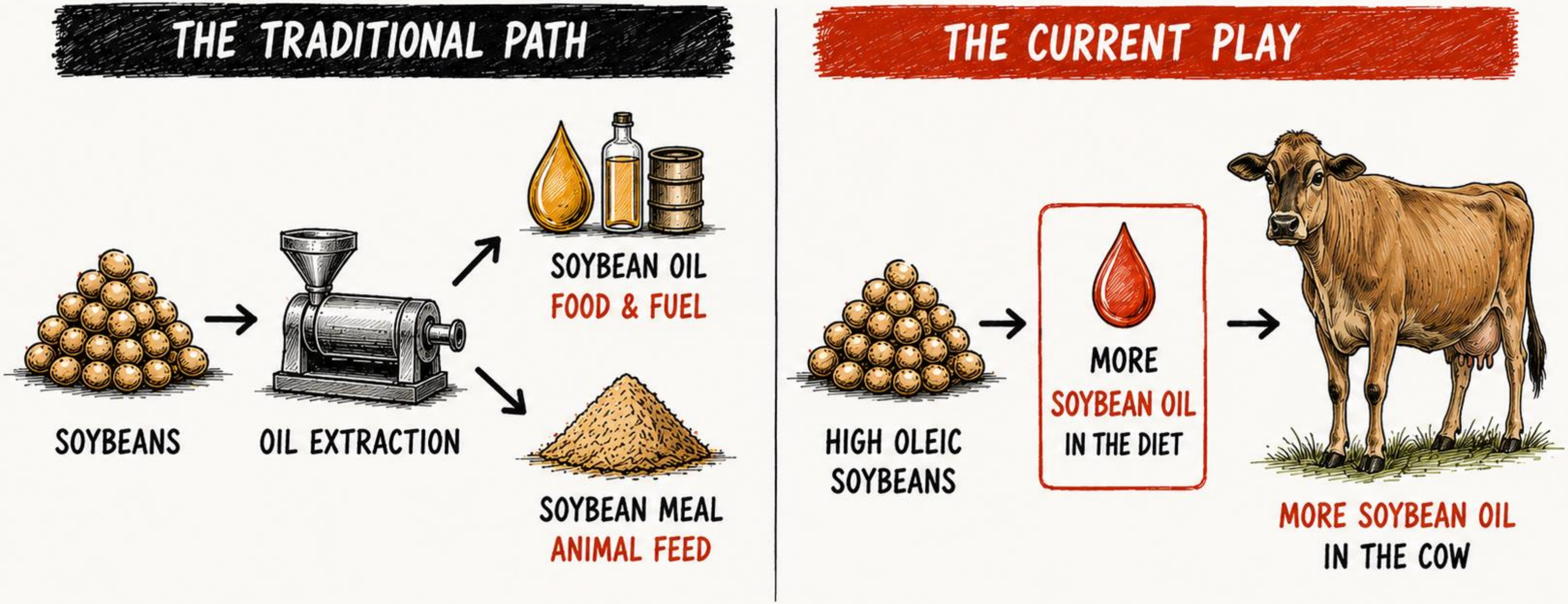


Chemical Composition (NASEM, 2021)

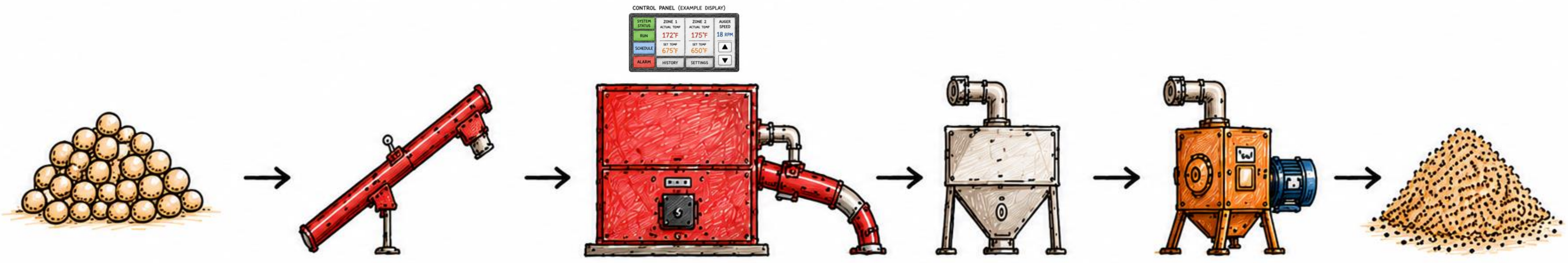


A NEW FOCUS FOR SOYBEANS

FROM OIL EXTRACTION TO MORE SOYBEAN OIL IN THE COW



ON-FARM SOYBEAN ROASTING SYSTEM



① RAW SOYBEANS

Stored and moved into the building.

② AUGER FEEDS BEANS TO ROASTER

An auger conveys beans from storage into the roaster.

③ ROASTER HEATS BEANS IN TWO ZONES

Beans are heated in two zones with dry heat to improve protein value and reduce anti-nutritional factors.

④ EXIT & COOLING / TEMPERING

Hot beans exit the roaster and move to a cooling / tempering hopper where carryover heat is removed and beans cool evenly.

⑤ HAMMERMILL / CRACKER

Beans are ground or cracked to the desired particle size for optimal performance and palatability.

⑥ TO MIXER OR STORAGE BINS FOR FEEDING

Processed beans are moved into storage bins or directly to the mixer for feeding.

Protein analysis for CNCPS v6.5

Analyte	Abbreviation	Unit	
Crude protein	CP	% DM	Nitrogen measured using a combustion N analyzer and multiplied by a factor of 6.25
Soluble protein	SP	% CP	CP soluble in borate-phosphate buffer including sodium azide NPN is not subtracted but corrected within the model
Ammonia	-	CPE (% SP)	AOAC 941.04; Nitrogen measured by Kjeldahl and multiplied by 6.25 to convert to CPE
Acid detergent insoluble protein	ADIP	% CP	Residual N measured ADF residue
Neutral detergent insoluble protein	NDIP	% CP	Residual N measured on NDF residue

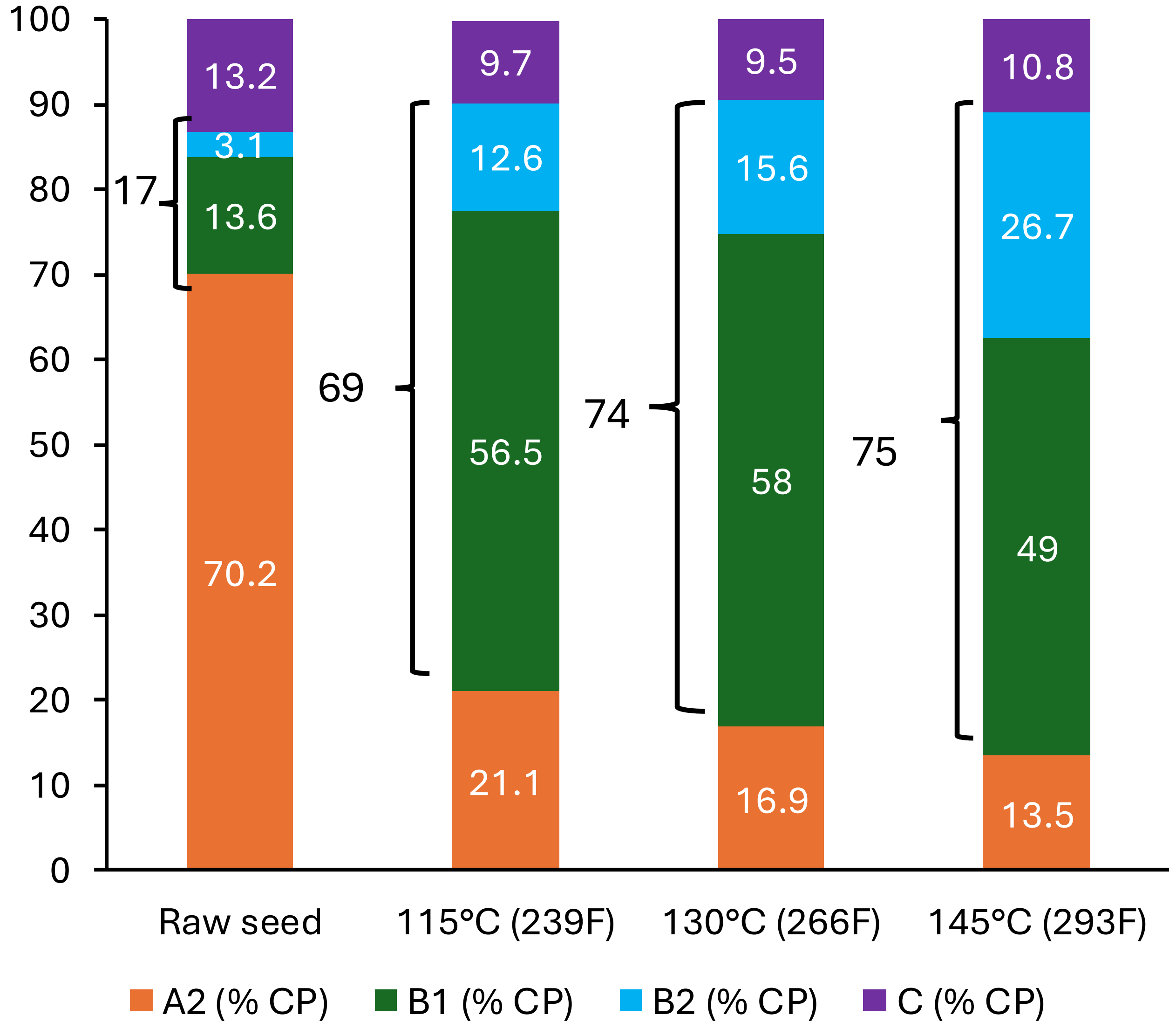
(Higgs, 2015)

Protein fractions for CNCPS v6.5

Fraction	Description	Equation	Rates	Intestinal True Digestibility
PA1*j*[3]	Ammonia	Ammoniaj × (SPj/100) × (CPj/100)	200	100
PA2*j*	Soluble true protein, % DM	SPj/100 × CPj − PA1j	10-40	100
PB1*j*	Insoluble true protein	CPj − (PA1j+PA2j + PB2j + PCj)	3-20	100
PB2*j*	Fiber-bound protein	(NDICPj − ADICPj) × CPj / 100	1-18	80
PCj	Indigestible protein	ADICPj × CPj / 100	0	0

(Van Amburgh et al, 2015; Higgs et al., 2015)

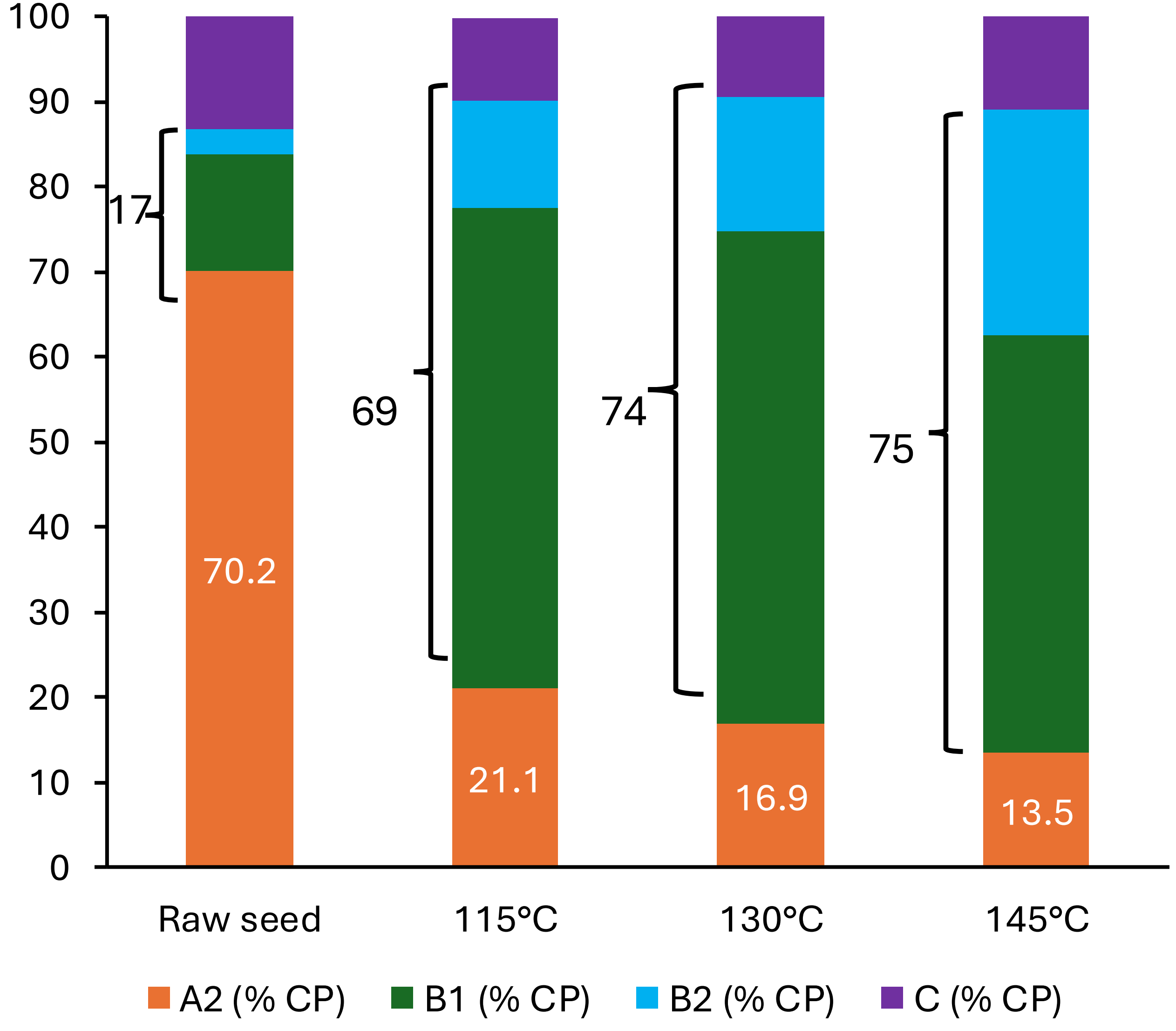
What does roasting do to CNCPS fractions?



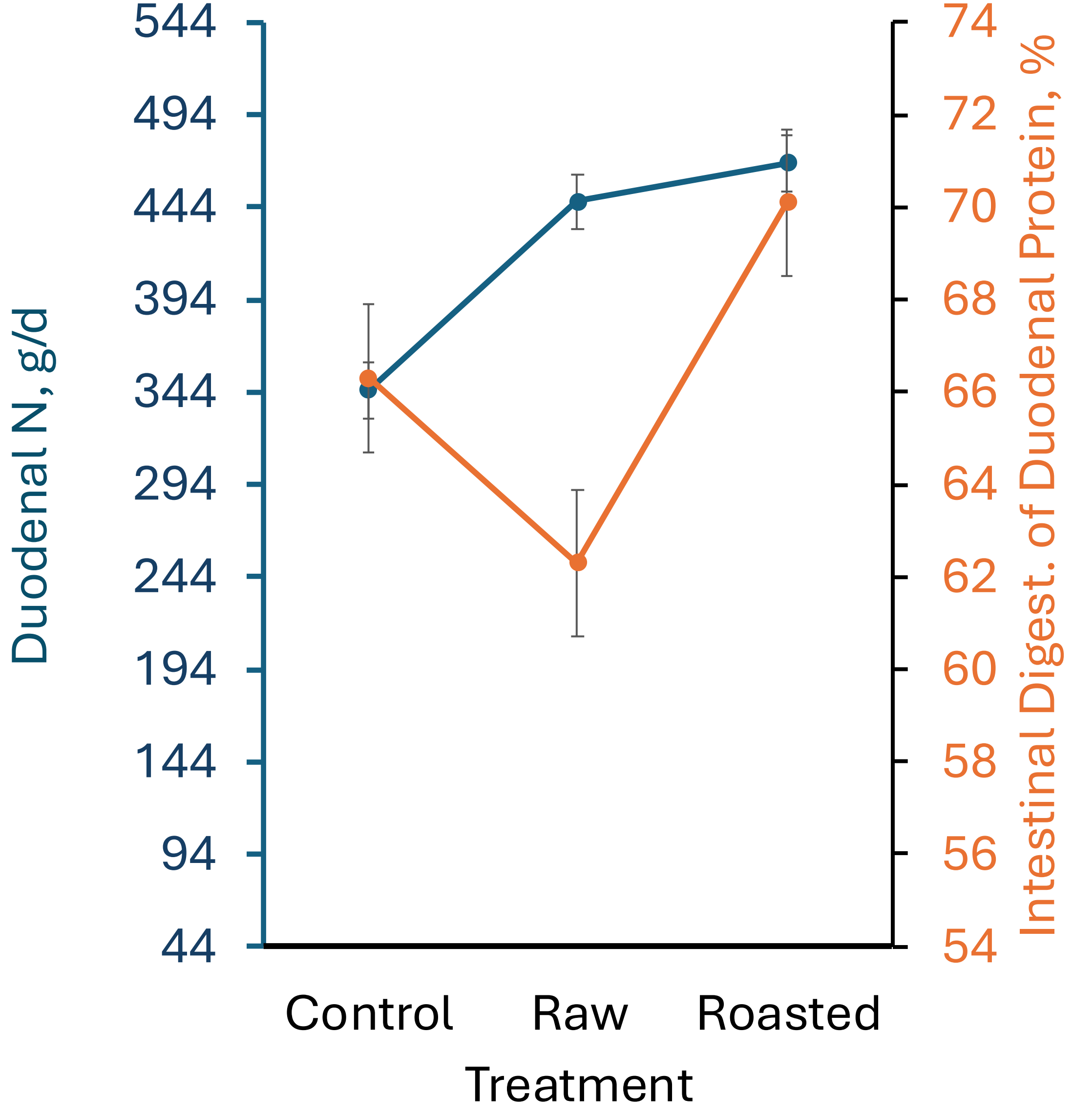
- Decreases soluble/rapid protein,
- Increases bypass protein
- High heat begins shifting protein into slower and potentially less digestible fractions.

Rafiee-Yarandi et al., 2016

What does roasting do?

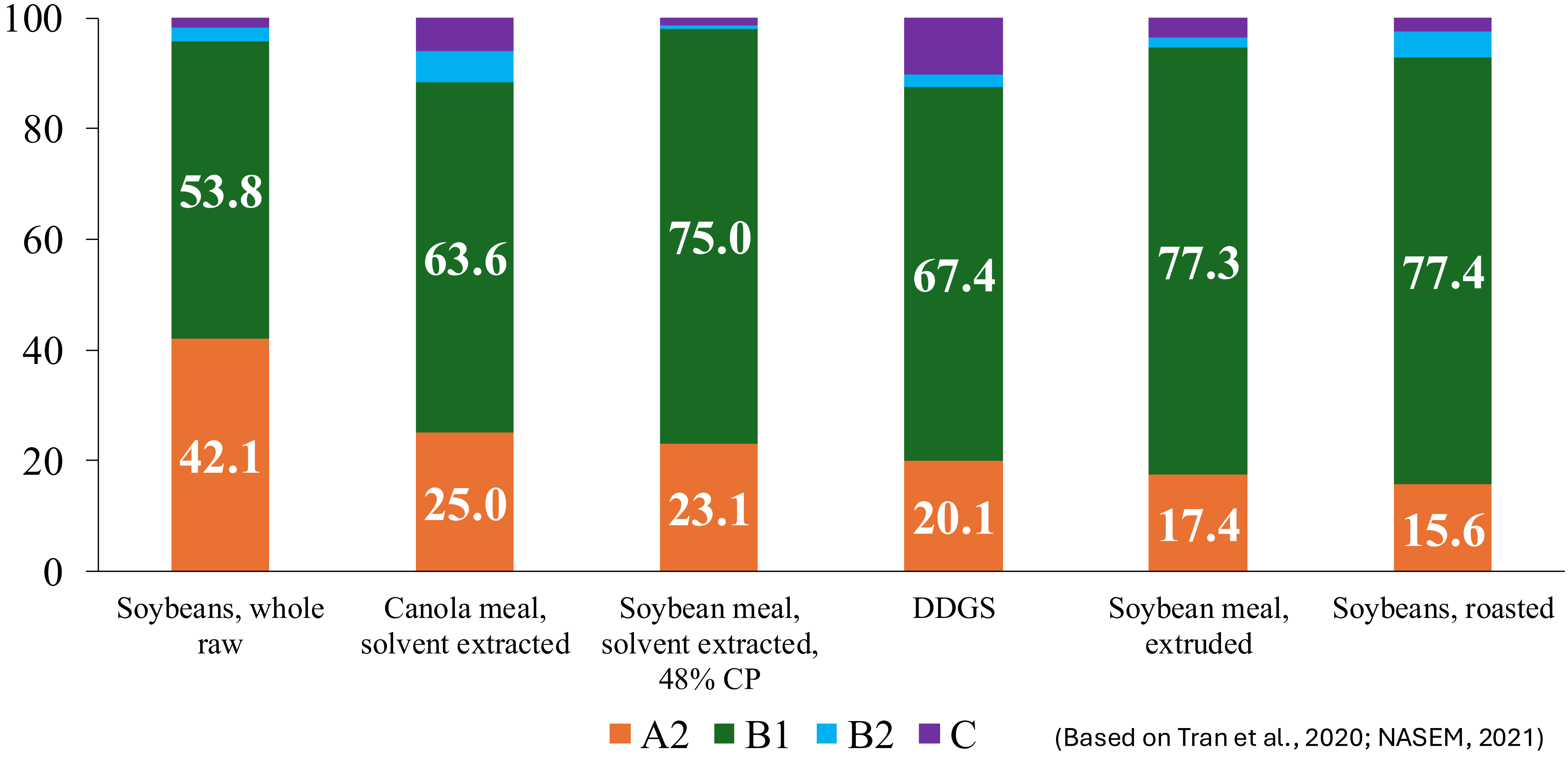


Rafiee-Yarandi et al., 2016



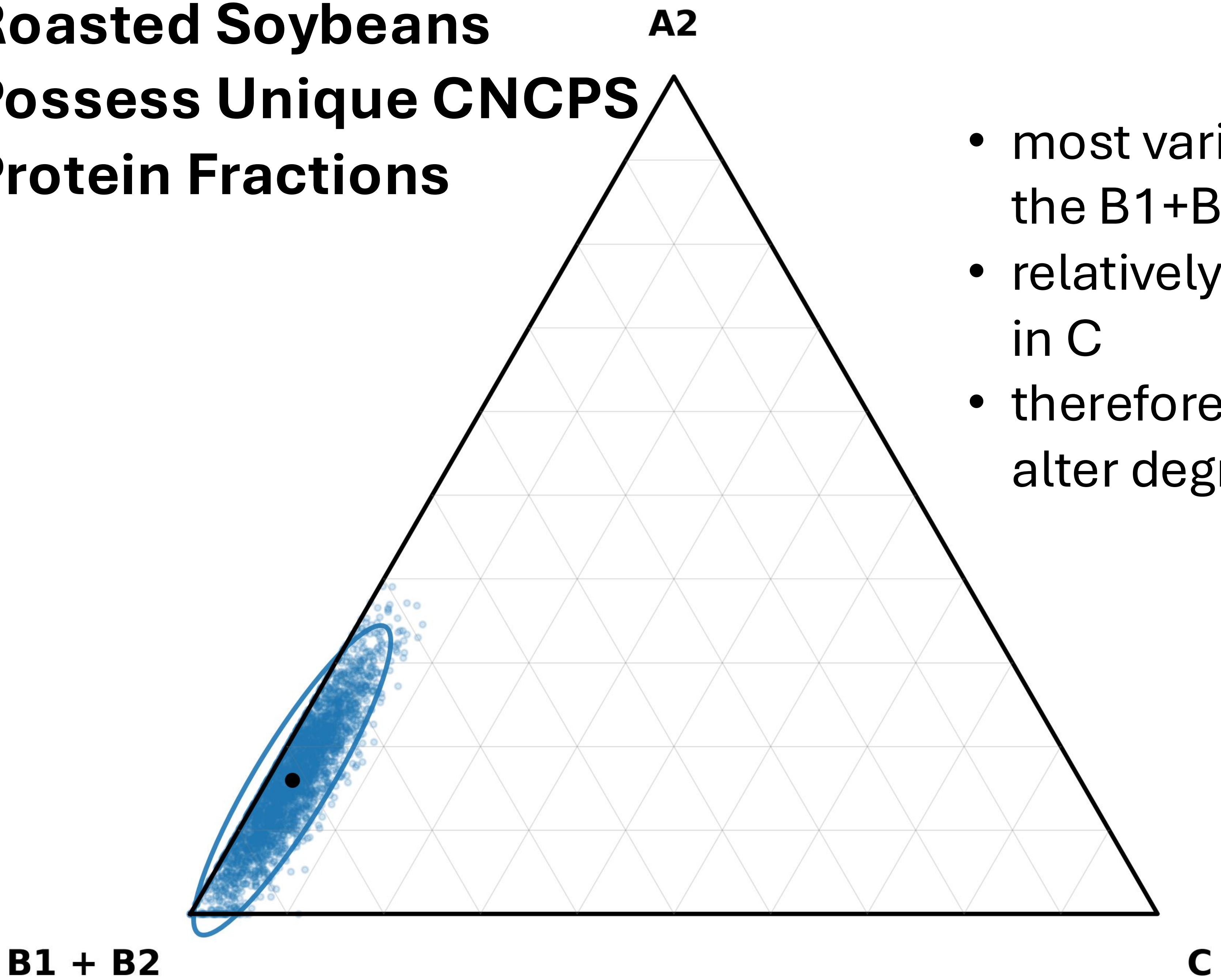
Tice et al., 1993

CNCPS Protein Fractions, % CP



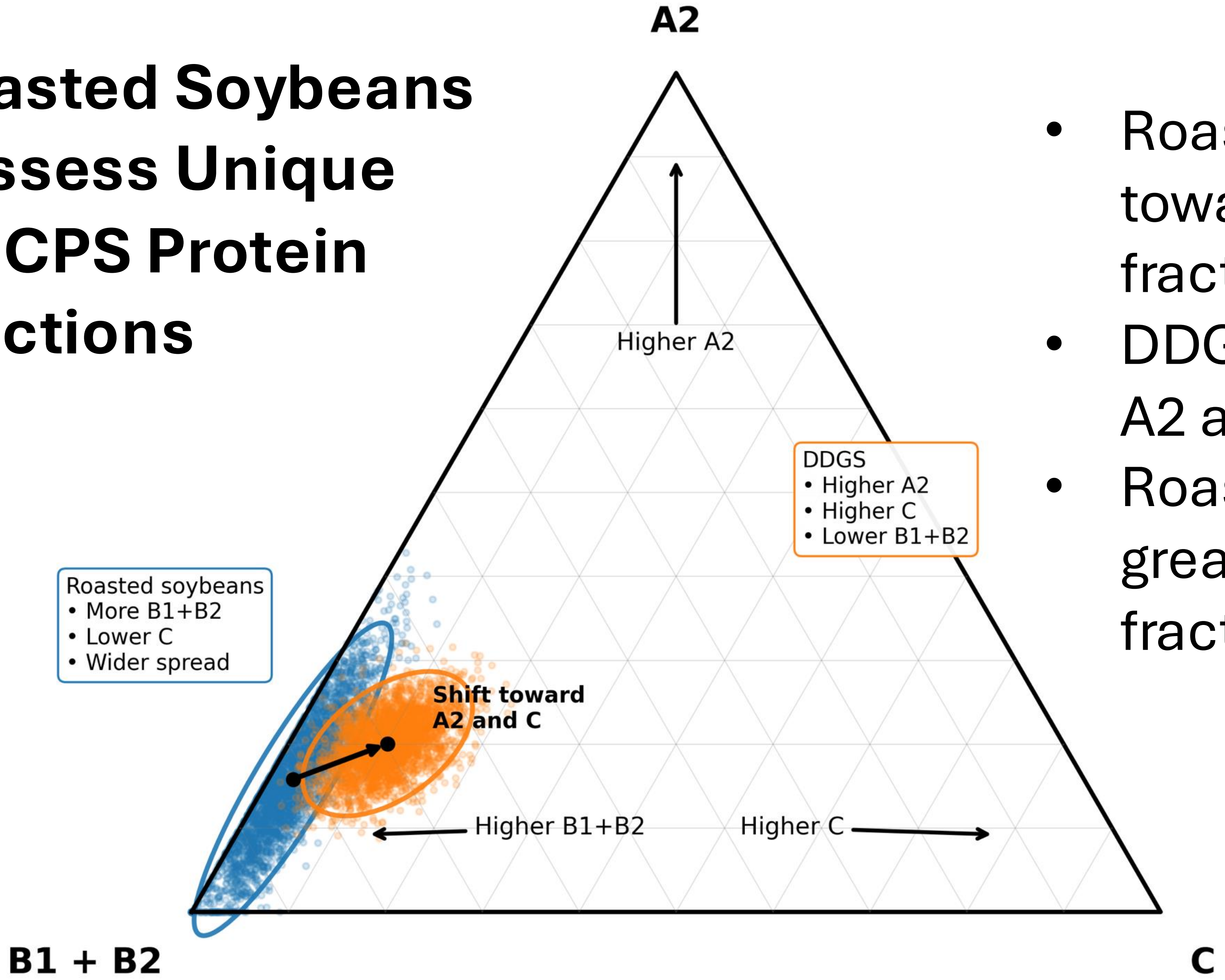
(Based on Tran et al., 2020; NASEM, 2021)

Roasted Soybeans Possess Unique CNCPS Protein Fractions



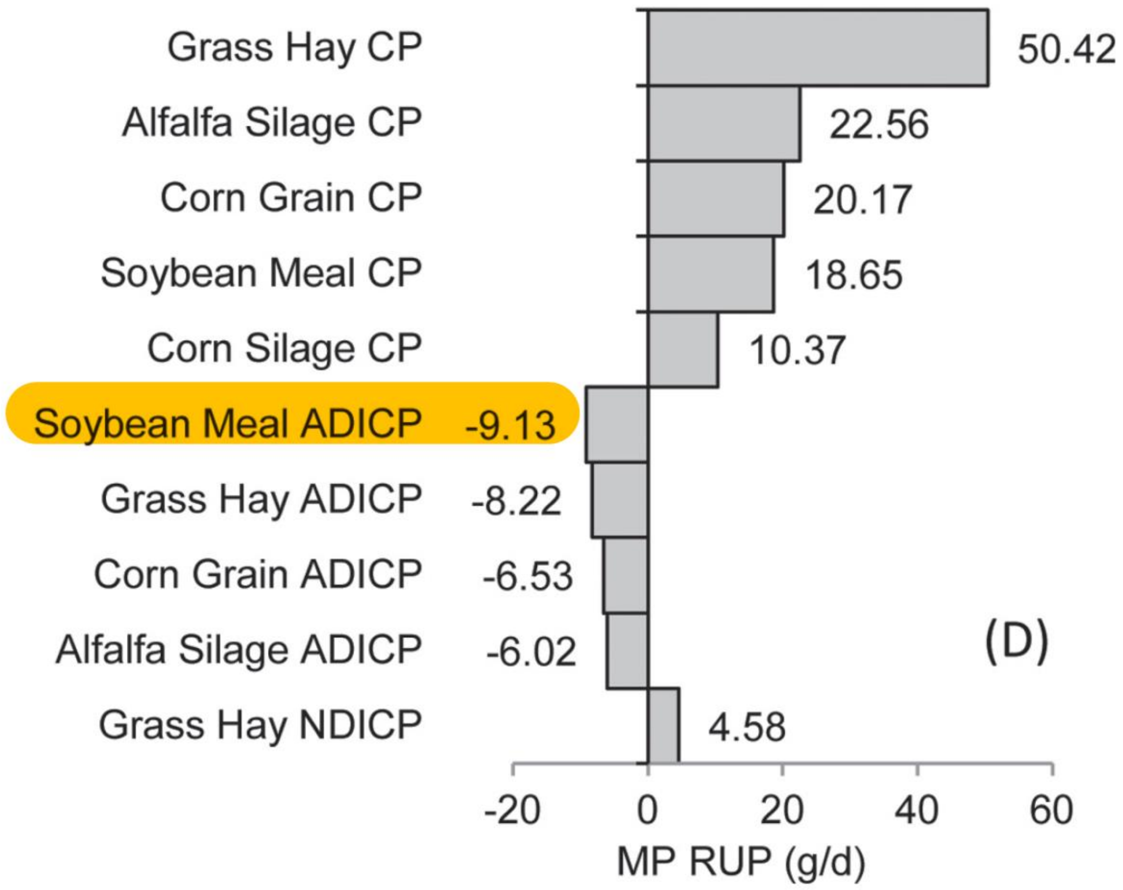
- most variability occurs along the B1+B2 ↔ A2 axis
- relatively little variation exists in C
- therefore processing seems to alter degradability kinetics

Roasted Soybeans Possess Unique CNCPS Protein Fractions



- Roasted soybeans clustered toward higher B1+B2 fractions
- DDGS shifted toward greater A2 and C fractions
- Roasted soybeans exhibited greater dispersion within fraction space

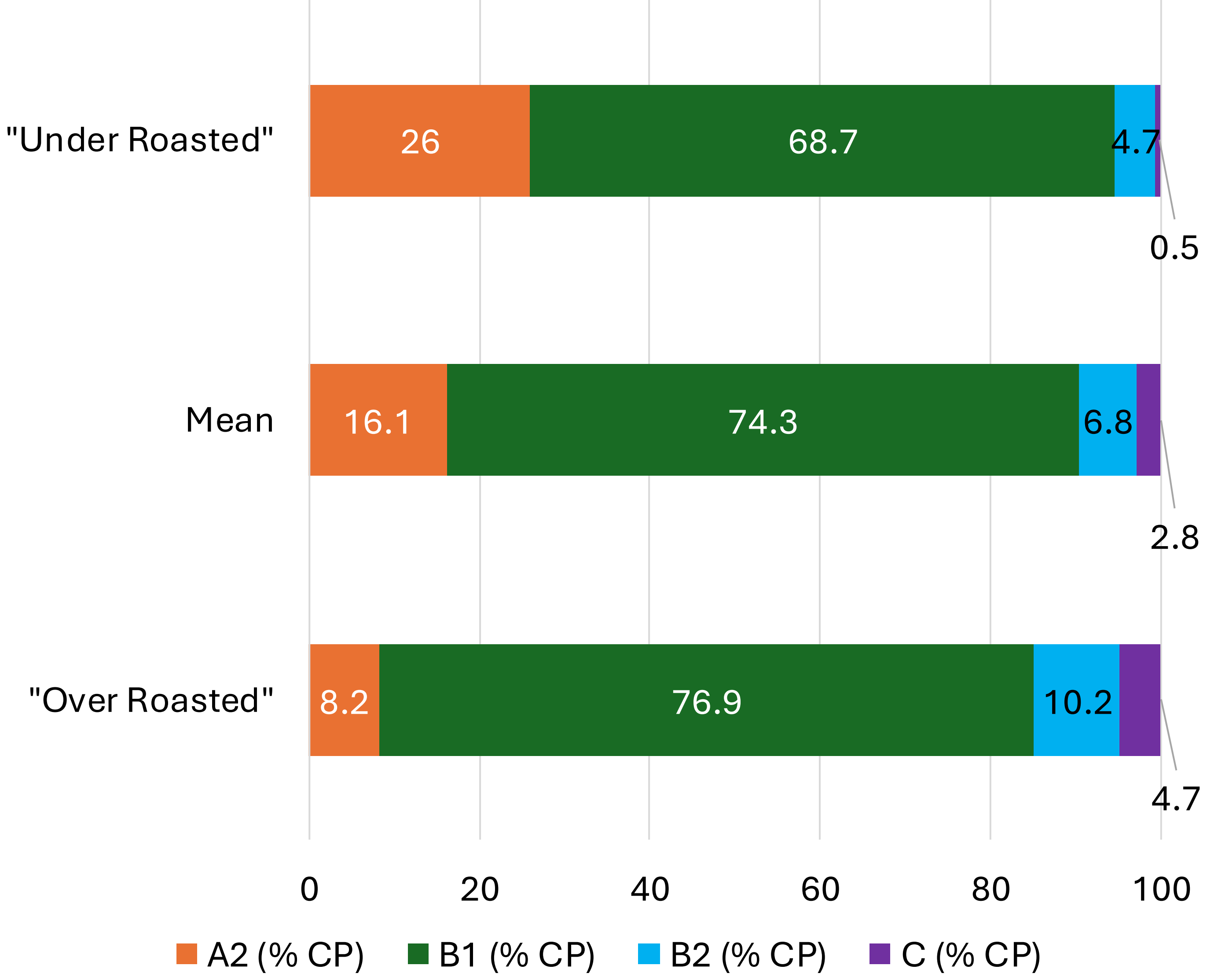
Soybean Meal ADIP Reduces Predicted Digestible RUP Supply



- Sensitivity analysis showing how variation in feed chemistry affects predicted MP from RUP.
- Increasing CP increases predicted MP supplied from RUP.
- Increasing ADIP decreases predicted MP supplied from RUP.
- A 1 SD increase in soybean meal ADIP reduced predicted RUP-derived MP by ~9 g/d.

(Higgs, 2015)

Roasting shifts CNCPS protein fractions



Roasting

- ↓ soluble protein (A2)
- ↑ slowly degradable protein (B1/B2)
- ↑ unavailable protein (C)

(Based on Tran et al., 2020; NASEM, 2021)

CNCPS simulation of the 25% HOSB diet

Predicted	25% HOSB
MP supply, g/d	3,977
MP from RUP, g/d	2,392
MP-allowable milk, kg/d	63
PA2 digested, g/d	540
PB1 digested, g/d	1,759

- NO HOSB specific response unique to HOSB predicted by CNCPS.
- 25% HOSB supplied substantial MP from RUP.
- Most digestible feed protein came from PA2 and PB1.
- Predicted MP-allowable milk was consistent with the high production response reported by Bales and Lock.

J. Dairy Sci. 107:7867–7878
https://doi.org/10.3168/jds.2024-24781

Effects of increasing dietary inclusion of high oleic acid soybeans on milk production of high-producing dairy cows

A. M. Bales and A. L. Lock*
Department of Animal Science, Michigan State University, East Lansing, MI 48824

Proper roasting optimized the balance between ruminally available and digestible bypass protein

Predicted	"Under Roasted"	Typical: 25% HOSB	"Over Roasted"
MP supply, g/d	3, 941	3,977	3,872
MP from RUP, g/d	2,352	2,392	2,291
MP from bacteria, g	1,570	1,567	1,564
MP-allowable milk, kg/d	62	63	60
PA2 digested, g/d	695	540	429
PB1 digested, g/d	1,533	1,759	1,674
NH3-N, g/d	116	109	106

uCP: Ross Assay

Feed Sample

↓

Fermentation
Anaerobic, 16 h, 39 C

← - Rumen Buffer, pH 6.8
- Rumen Fluid

Filter → RUP

↓

Acidify
3 M HCl, pH 1.8 – 2.0

↓

Gastric Digestion
pH 2 HCl + Pepsin

↓

Neutralize
2 M NaOH

↓

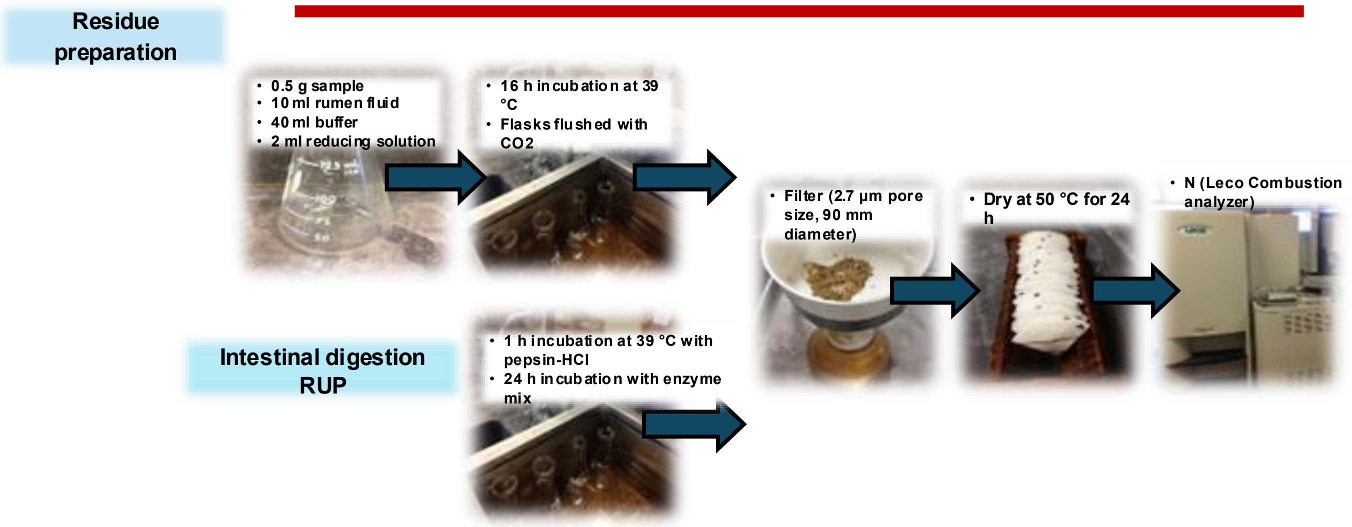
Mix
Trypsin, chymotrypsin, amylase, lipase

Pancreatin
proteases, amylase, and lipase

↓

Incubation
39 C, 24 h bath

→ Filter → N Analysis



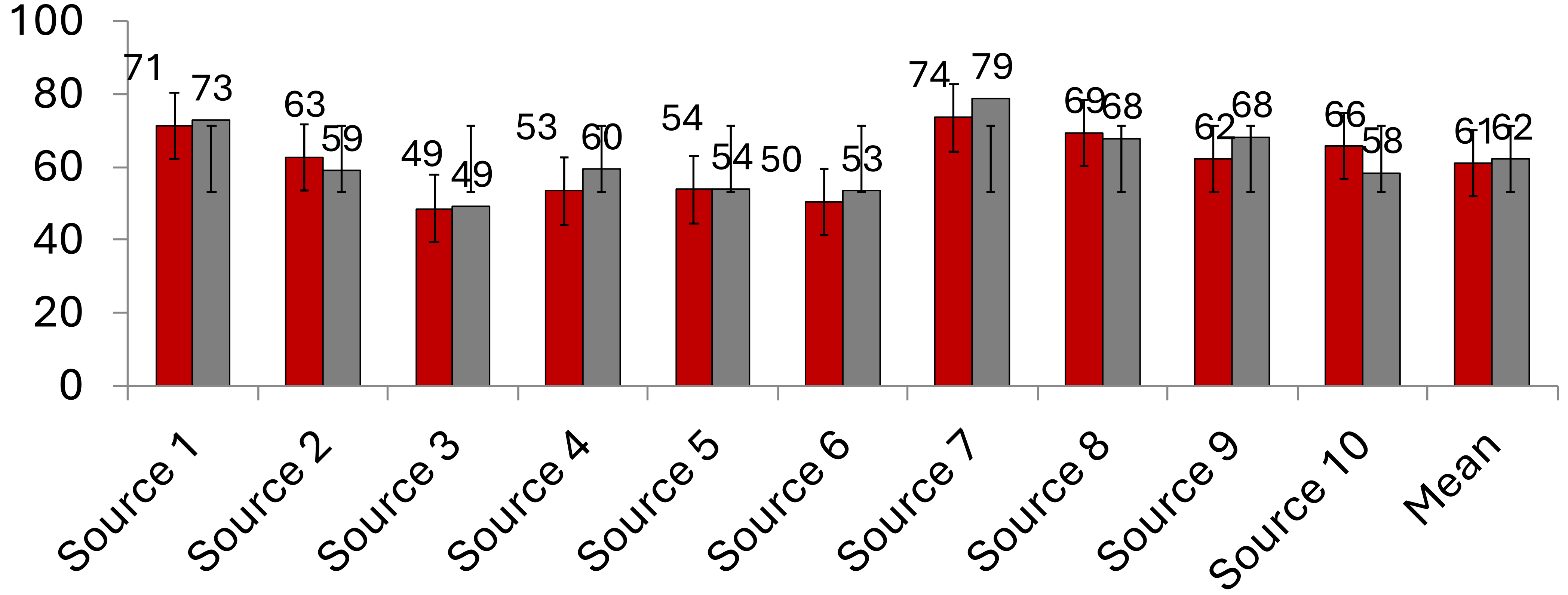
- **RDP** = $\frac{\text{N in sample} - \text{N in residue}}{\text{N in sample}} \times 100$
- **RUP** = 100 - RDP

Ross et al., 2013

(Ross et al., 2013)

Mobile Bag vs Ross ,dRUP

Measures of intestinally digested protein from hydrolyzed feather meal



(Buse et al., 2019)

What if I have Ross Assay data?

	48% Solv Ex. SBM	Expellers SBM	DDGS	Blood meal	Roasted Soybean
N	50	170	368	1124	103
CP, % DM	52.7	50.2	32.0	101.0	39.5
RUP, % CP	40.6	79.7	76.0	87.1	61.2
RUP dig, % DM	80.6	83.4	78.3	75.5	72.8
dRUP, % CP	33.1	66.5	59.6	65.3	44.6
uCP, % CP	7.5	13.1	16.4	21.7	16.5

https://www.perdueanimalnutrition.com/technical_resource/feed-or-fertilizer-determining-the-digestibility-of-high-protein-feedstuffs-logan-morris/

DRAFT: What PJK thinks should roasted soybeans look like analytically? Send comments to pkononoff2@unl.edu or text 402-304-9287

Variable	Mean	SD	10th - 90th percentile	Warning
Chem. Composition[1]				
CP, % DM	40.0	2.07	37.5-42.3	< 36 or > 44
Soluble Protein, % CP	15.6	7.71	6.1-17.1	< 5 or > 25-30
ADIP, % DM	0.97	0.789	0.45-2.35	>2.5-3.0
NDIP, % DM	2.79	1.975	1.38-8.4	> 8-10
Ross Assay[2]				
RUP, % CP	61.2	13.1	43-82	*< 45 or > 80*
RUP Dig, % DM	72.8	10.2	56-87	< 55-60
dRUP, % CP	44.6	12.0	27-69	*< 30 or >65-70*
uCP, % CP	16.5	7.5	7-32	>25-30

[1]NASEM, 2021; [2]Morris, no date

Implications on feeding cows

- Since 1960
  - alfalfa acres decreased about 39%, and alfalfa production ***decreased*** about 19%
  - corn silage acres decreased 12%, corn silage production ***increased*** about 71%
- How do soy-based feed ingredients fit into this scenario?

Applied Animal Science 40:478–486
https://doi.org/10.15232/aas.2024-02563

ARPAS
AMERICAN REGISTRY OF PROFESSIONAL ANIMAL SCIENTISTS

NUTRITION: *Perspective and Commentary*

Perspective and Commentary: Use of soy-based feedstuffs in low-alfalfa, high–corn silage diets for dairy cows

W. P. Weiss,* **PAS**
Department of Animal Science, The Ohio State University, Cincinnati, OH 45202

Scenarios with increased use of soy-based feedstuffs, (58.9 lbs DMI, 100 lbs milk 3.9% fat and 3.1 % protein)

	High Alfalfa Less Soy	No Alfalfa More Soy	++Soy++
Corn silage	30.5	40.0	48.7
Alfalfa hay	24.0	0.0	0.0
Dry corn	27.3	12.7	7.68
Roasted soybeans	10.0	7.0	8.2
Soyhulls	0.0	14.4	19.9
Solvent SBM	0.0	2.5	6.00
Expellers SBM	6.8	7.5	7.51
Cottonseed	.	8.0	.
Wheat Midds	.	6.0	.
Minerals/ Vitamins	2.0	2.0	2.0

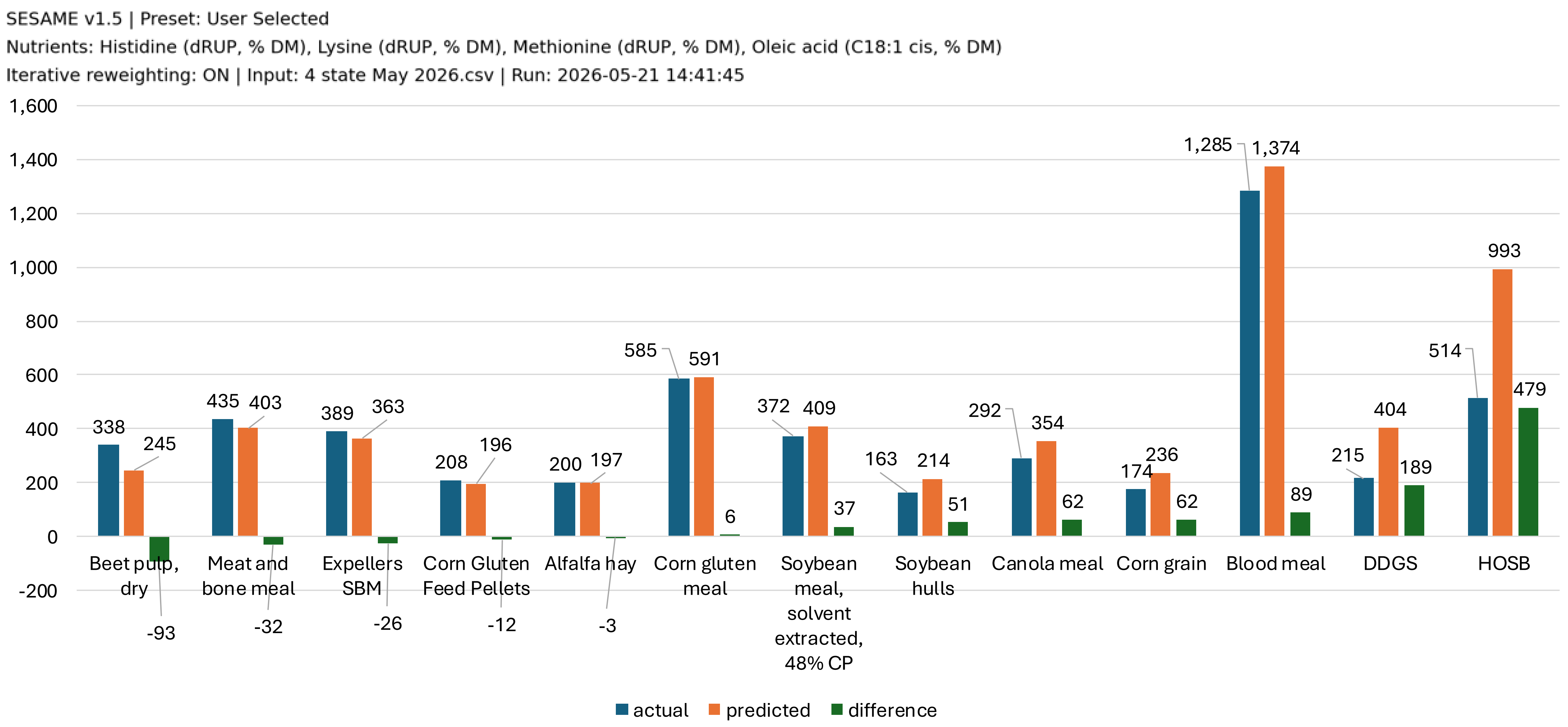
(Weiss et al., 2024)

Scenarios with increased use of soy-based feedstuffs

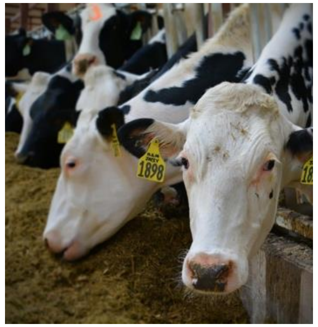
	High Alfalfa Less Soy	No Alfalfa More Soy	++Soy++
CP	17.2	16.6	16.9
NDF	27.6	36.7	37.7
TFA	4.19	4.9	3.55
Starch	30.0	23.6	22.0
fNDF	21.8	16.4	19.9
NEL, Mcal/lb	0.82	0.82	0.81
Metab. Protein, % DM	9.9	9.9	10.3
Met. Histidine, g/d	64	65	68
Met. Methionine, g/d	56	55	56
Met. Lysine, g/d	199	201	210
NEL Allowable milk, lbs/d	100	102	102
MP Allowable milk, lbs/d	96	95	100
“MW” Price, $/d	6.96	6.60	6.22

(Weiss et al., 2024)

Midwest: Actual, Predicted and Predicted-Actual Feed Prices



Summary



- Roasting shifts CNCPS protein fractions
  - ↓ soluble protein (PA2)
  - ↑ rumen degradable/bypass protein (PB1/PB2)

- Proper roasting can improve:
  - digestible RUP supply
  - MP supply
  - milk production

- Most changes reflect altered protein fraction and likely kinetics
  - not simply "heat damage"

- ADIP and NDIP remain useful indicators to monitor processing
  - but they do not fully describe protein value

- Current analytical limitations:
  - Intestinal digestibility
  - Rumen degradation rates
  - Distinguishing "good heat" from excessive heat

Fuel (Energy) in common dairy feeds, Mcal/kg