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

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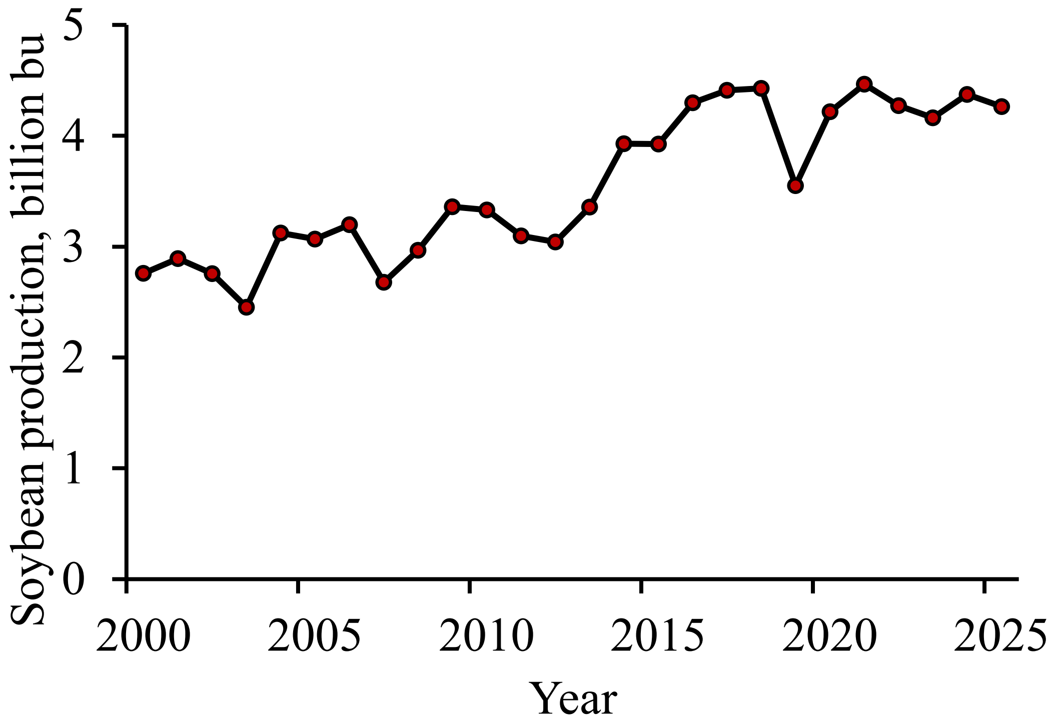
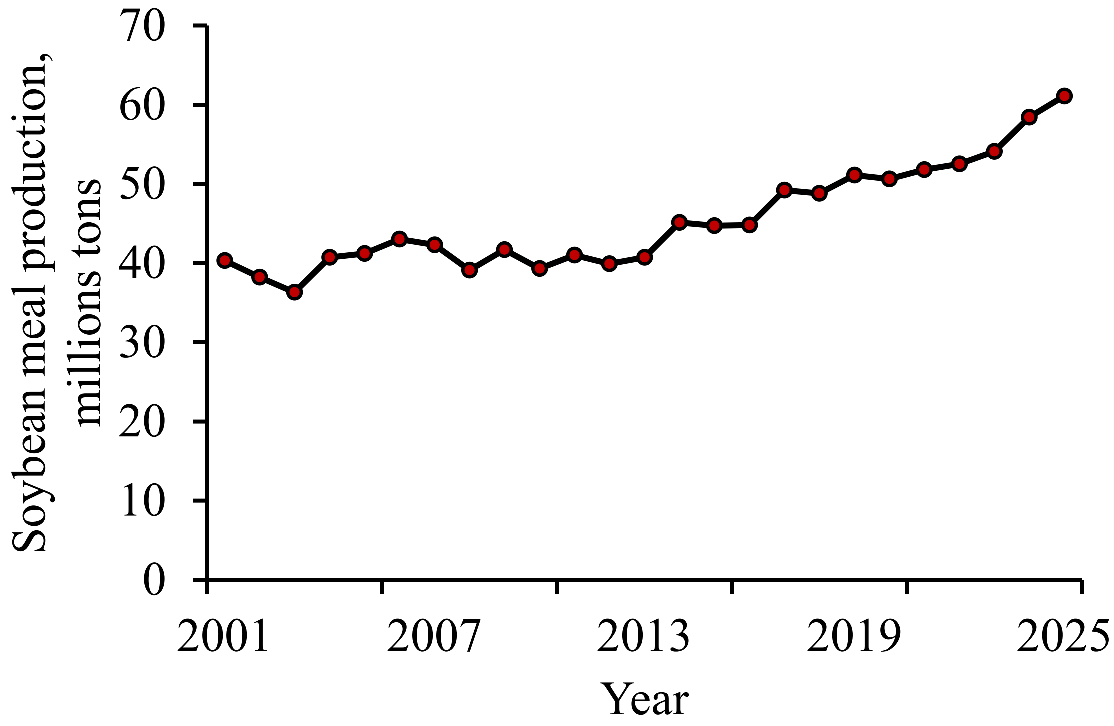
Four State Dairy Nutrition and Management Conference
8:45-9:15 a.m
June 4, 2026
La Crosse Center
La Crosse, WI

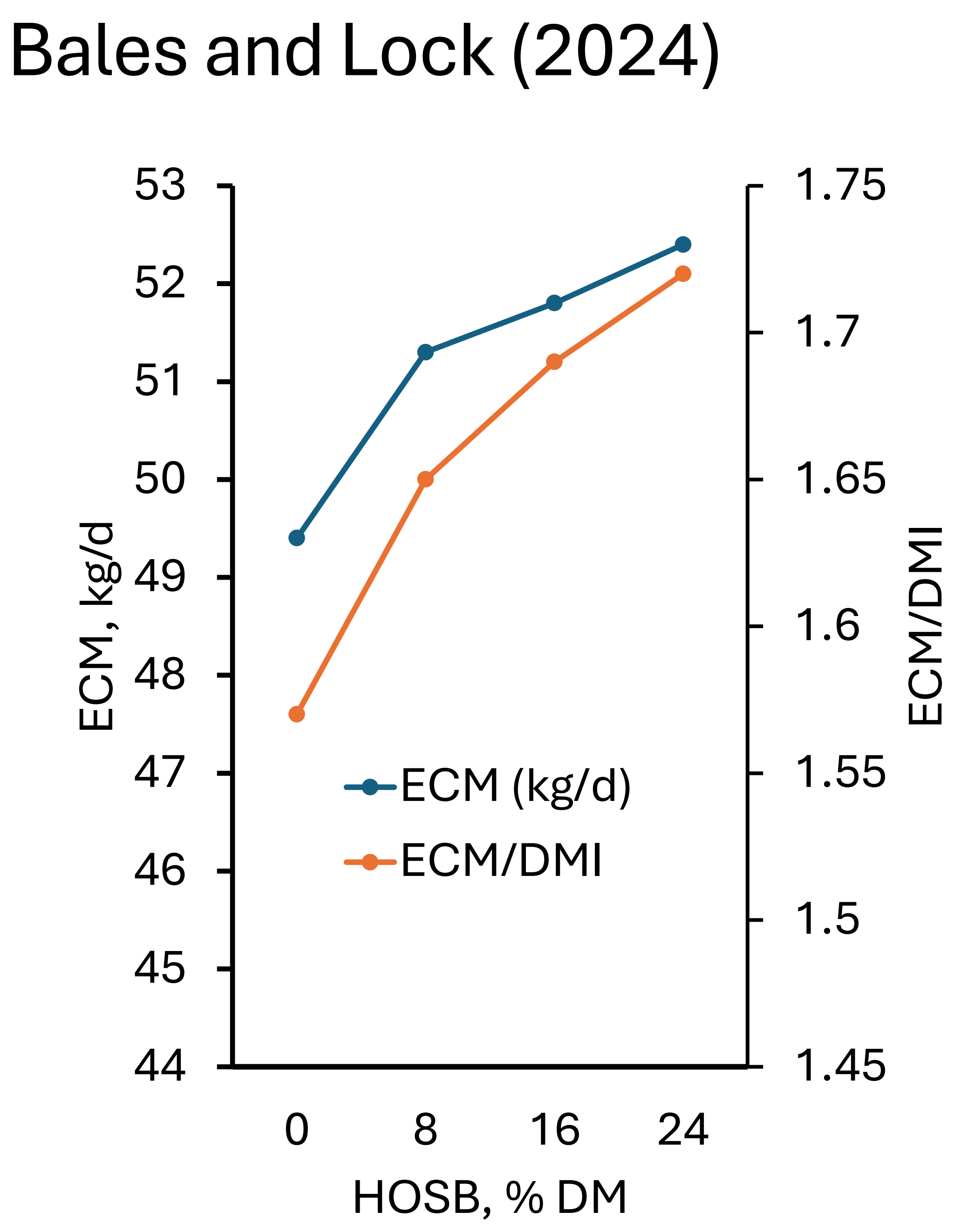
US Soybean Snapshot

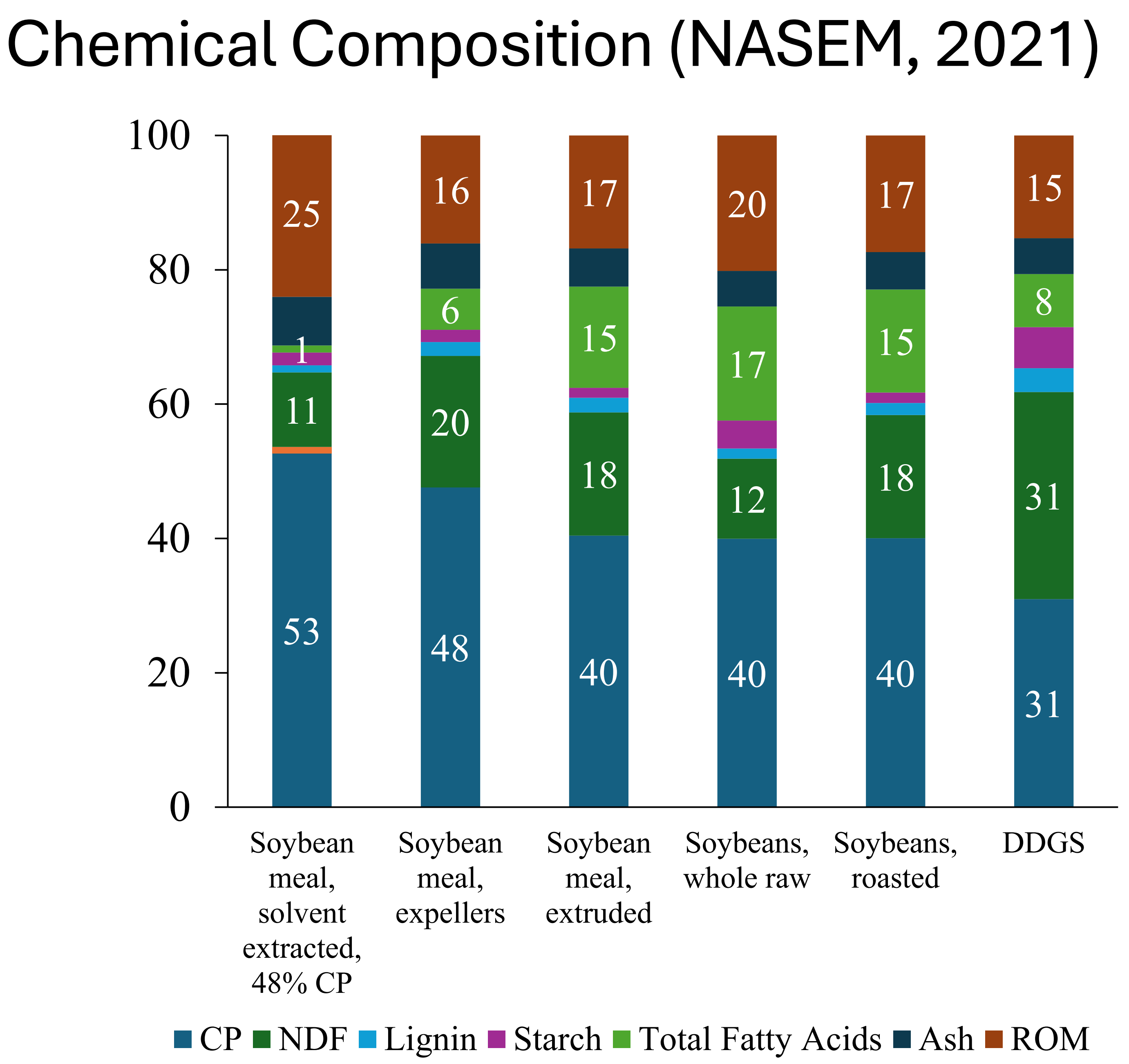
US Soybean production (4.26 Bil BU in 2025)



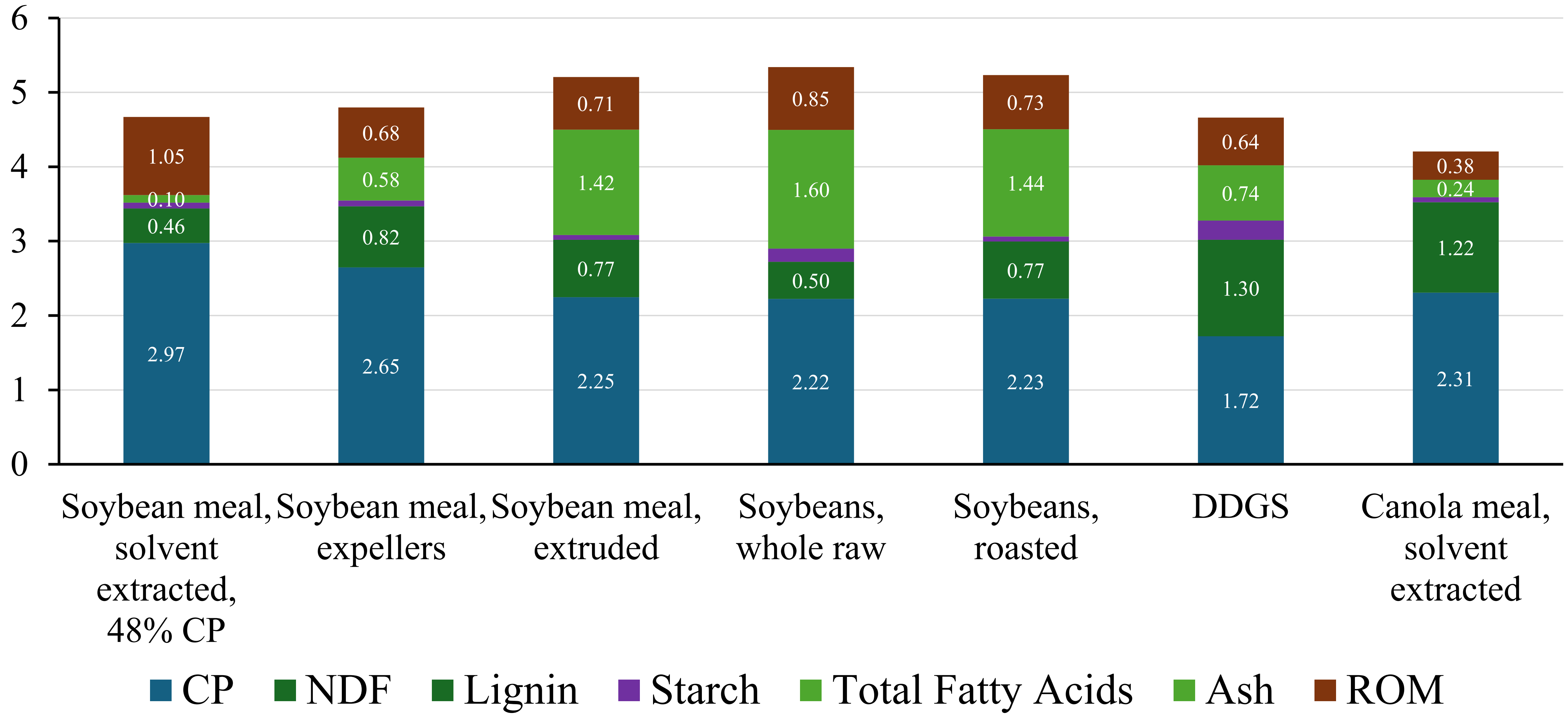
US Soybean meal production (61.1 million short tons in 2025/2026)

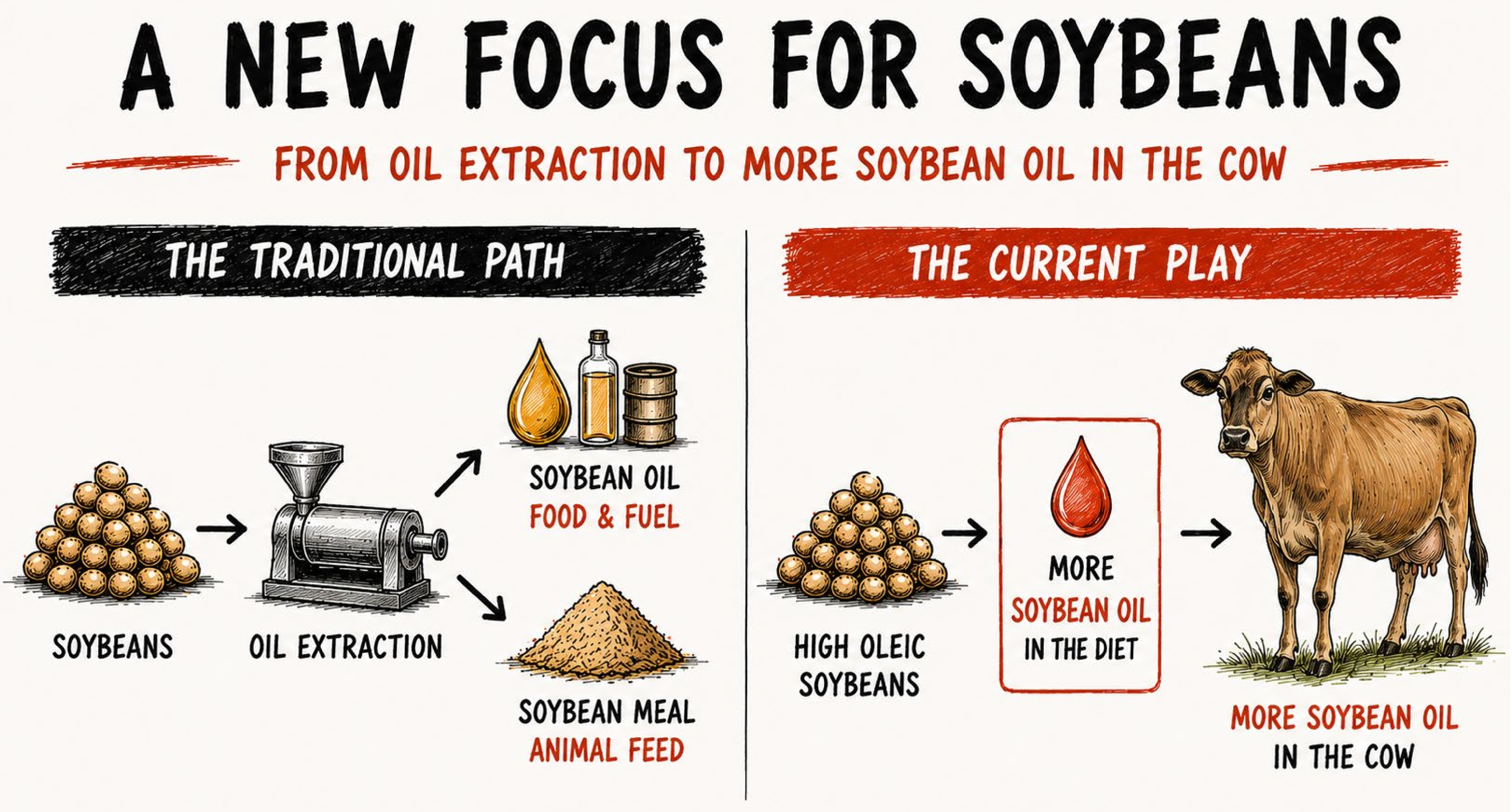



Bales and Lock (2024)
53
52
51
50
49
48
47
46
45
44
1.75
1.7
1.65
1.6
1.55
1.5
1.45
ECM, kg/d
ECM/DMI
ECM (kg/d)
ECM/DMI
0
8
16
24
HOSB, % DM

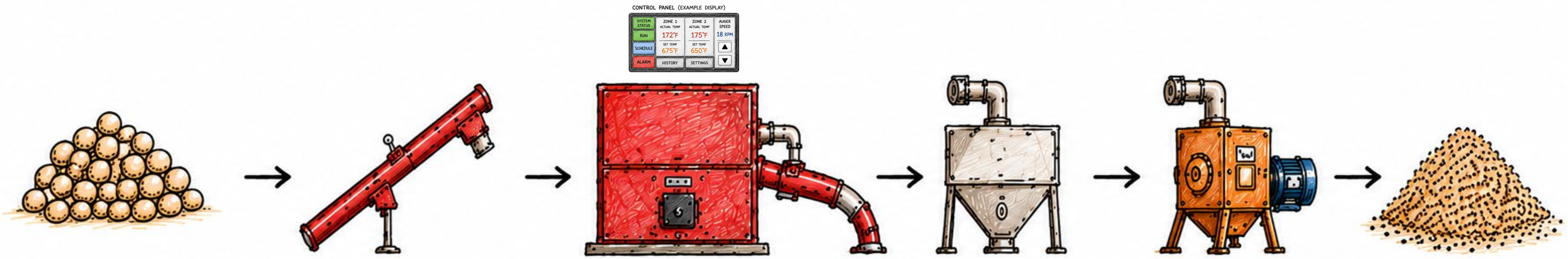

Chemical Composition (NASEM, 2021)
100
80
60
40
20
0
25
1
11
53
16
6
20
48
17
15
18
40
20
17
12
40
17
15
18
40
15
8
31
31
Soybean meal, solvent extracted, 48% CP
Soybean meal, expellers
Soybean meal, extruded
Soybeans, whole raw
Soybeans, roasted
DDGS
CP
NDF
Lignin
Starch
Total Fatty Acids
Ash
ROM

Fuel (Energy) in common dairy feeds, Mcal




A NEW FOCUS FOR SOYBEANS
FROM OIL EXTRACTION TO MORE SOYBEAN OIL IN THE COW
THE TRADITIONAL PATH
SOYBEAN OIL
FOOD & FUEL
SOYBEANS
OIL EXTRACTION
SOYBEAN MEAL
ANIMAL FEED
THE CURRENT PLAY
MORE
SOYBEAN OIL
IN THE DIET
HIGH OLEIC
SOYBEANS
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)	Nitrogen measured by Kjeldahl and multiplied by 6.25 to convert to CPE
Acid detergent-insoluble protein	ADICP	% CP	Residual N measured ADF residue
Neutral detergent insoluble protein	NDICP	% CP	Residual N measured on NDF residue

(Higgs, 2015)

Protein fractions for CNCPS v6.5

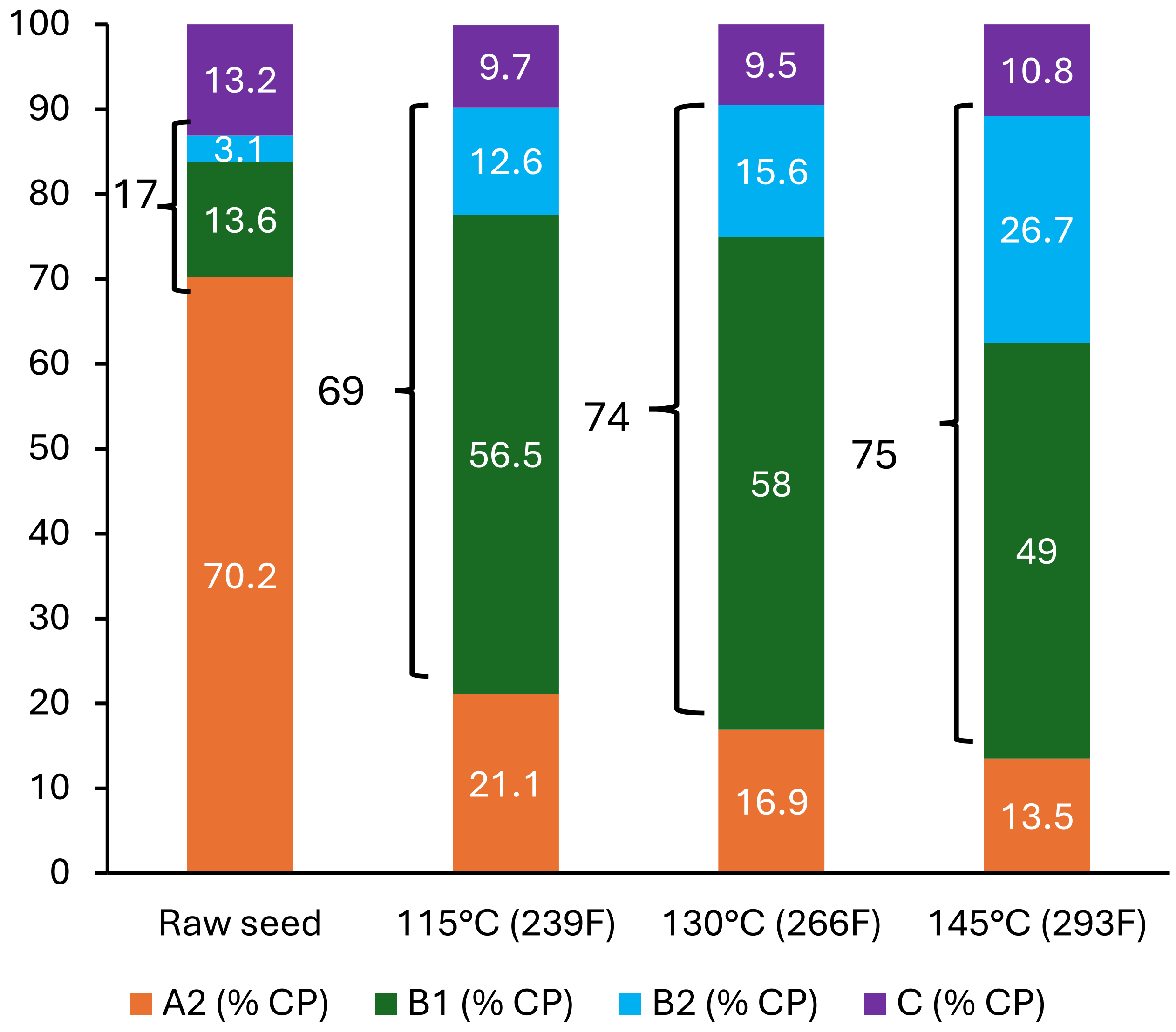
Fraction [1]	**Description**	**Equation**	**Rates**	**Intestinal True Digestibility[1, 2]**
PA1*j*[3]	Ammonia	Ammoniaj	200	100
PA2*j*	Soluble true protein, % DM	SPj/100 × CPj − PA1j	15.2	100
PB1*j*	Insoluble true protein	CPj − (PA1j − PA2j − PB2j − PCj)	5.4	100
PB2*j*	Fiber-bound protein	(NDICPj − ADICPj) × CPj / 100	10.6	80
PCj	Indigestible protein	ADICPj × CPj / 100	0	0

[2] Intestinal total tract digestibility of bacterial protein is assumed to be 100%

[3] Previous versions of the CNCPS feed library use NPN for the PA1 fraction; this has been replaced with ammonia

(Higgs, 2015)

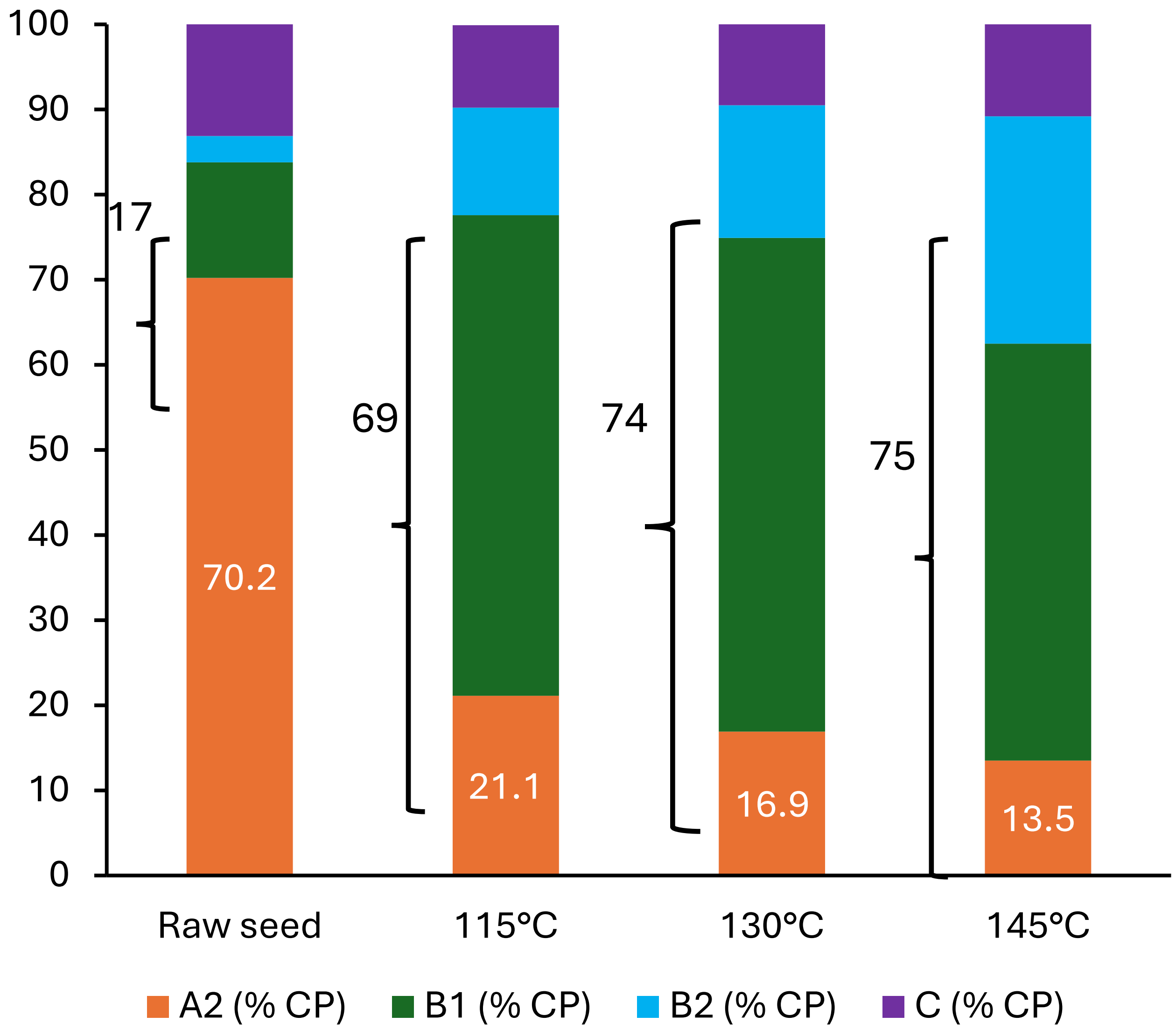
What does roasting do to CNCPS fractions?



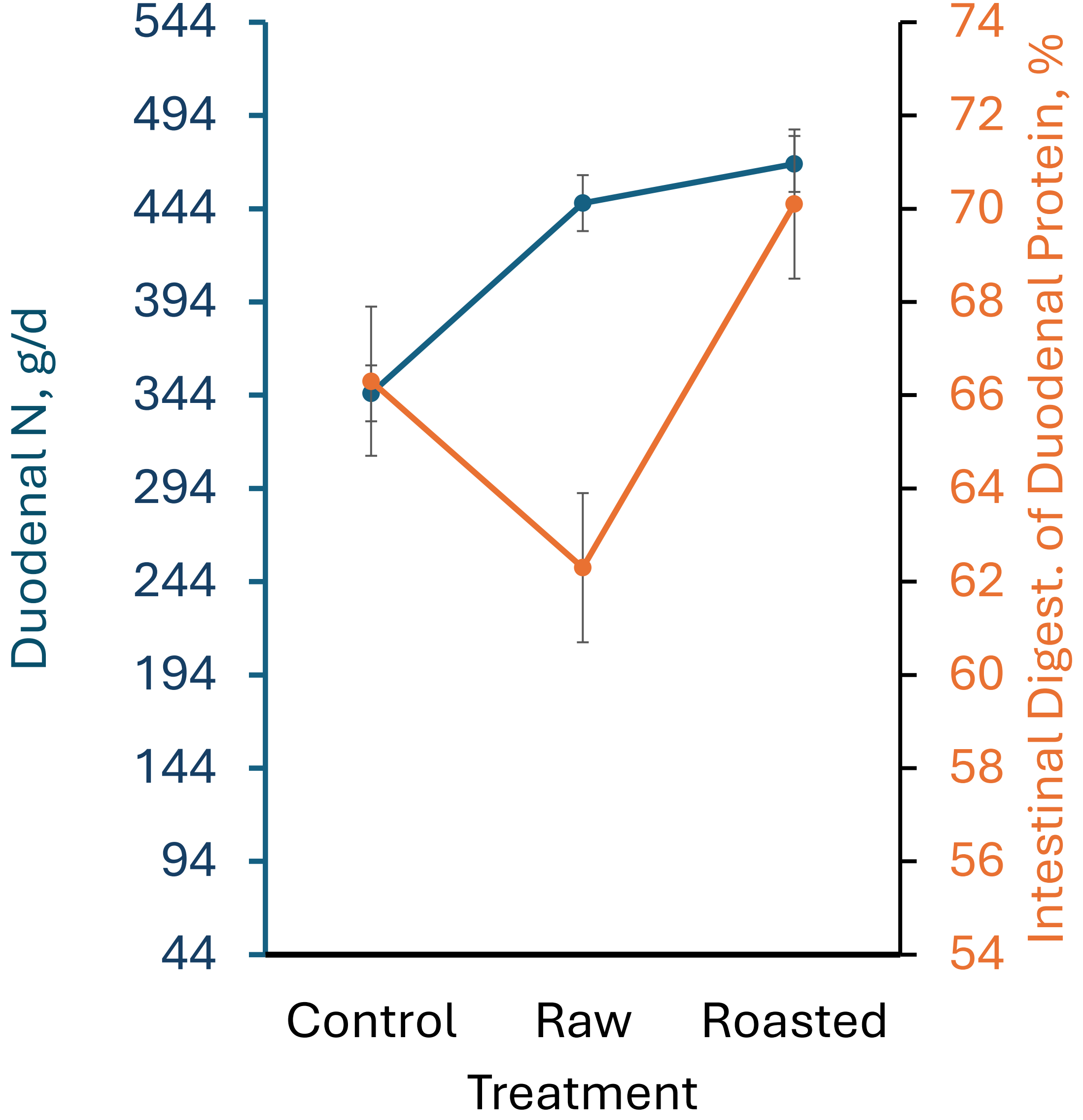
- Decreases soluble/rapid protein,
- Increases bypass protein
- High heat begins shifting protein into slower and potentially less digestible fractions.

Rafiee-Yarandi et al., 2016

What does roasting do?

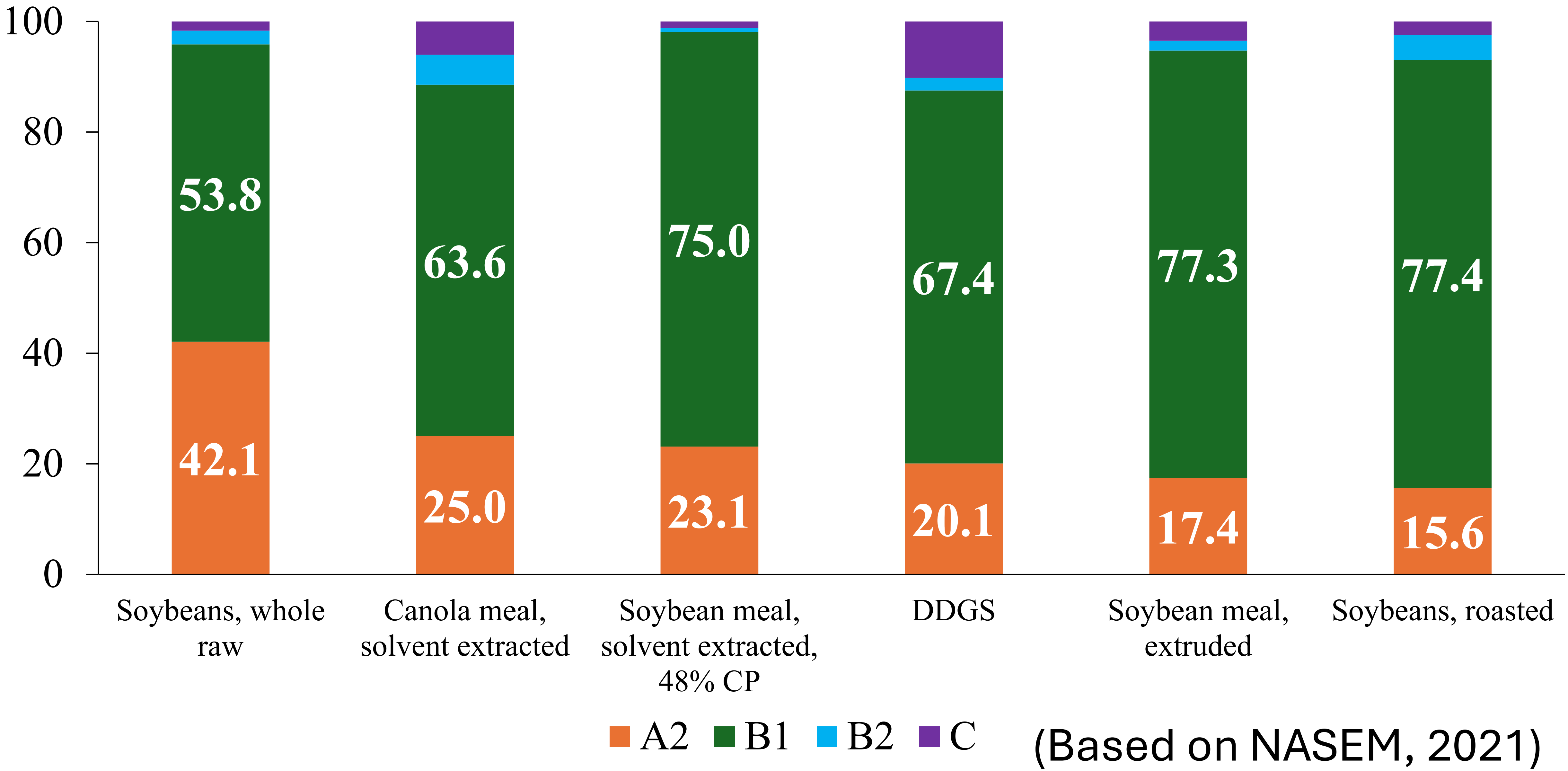


Rafiee-Yarandi et al., 2016



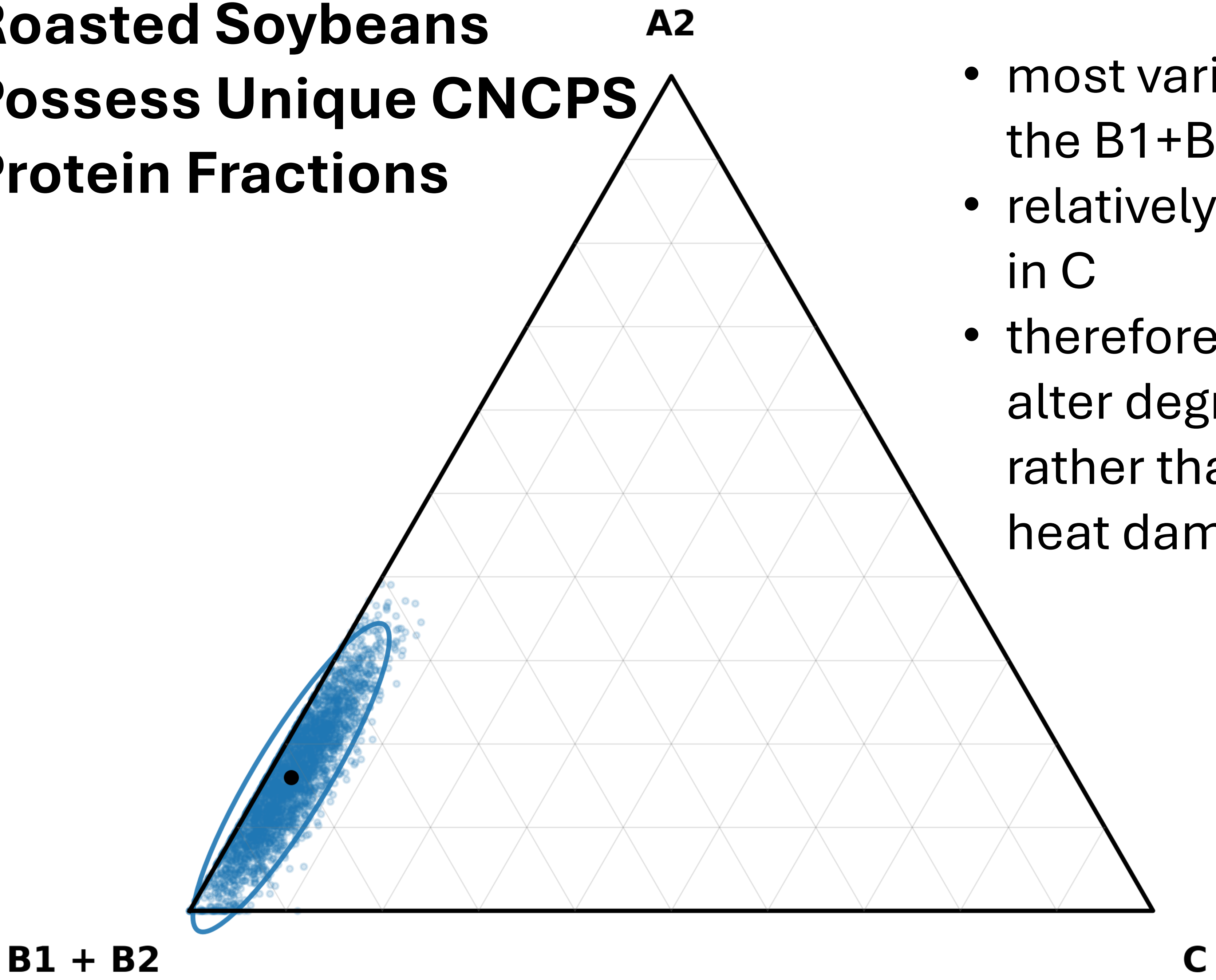
Tice et al., 1993

CNCPS Protein Fractions, % CP



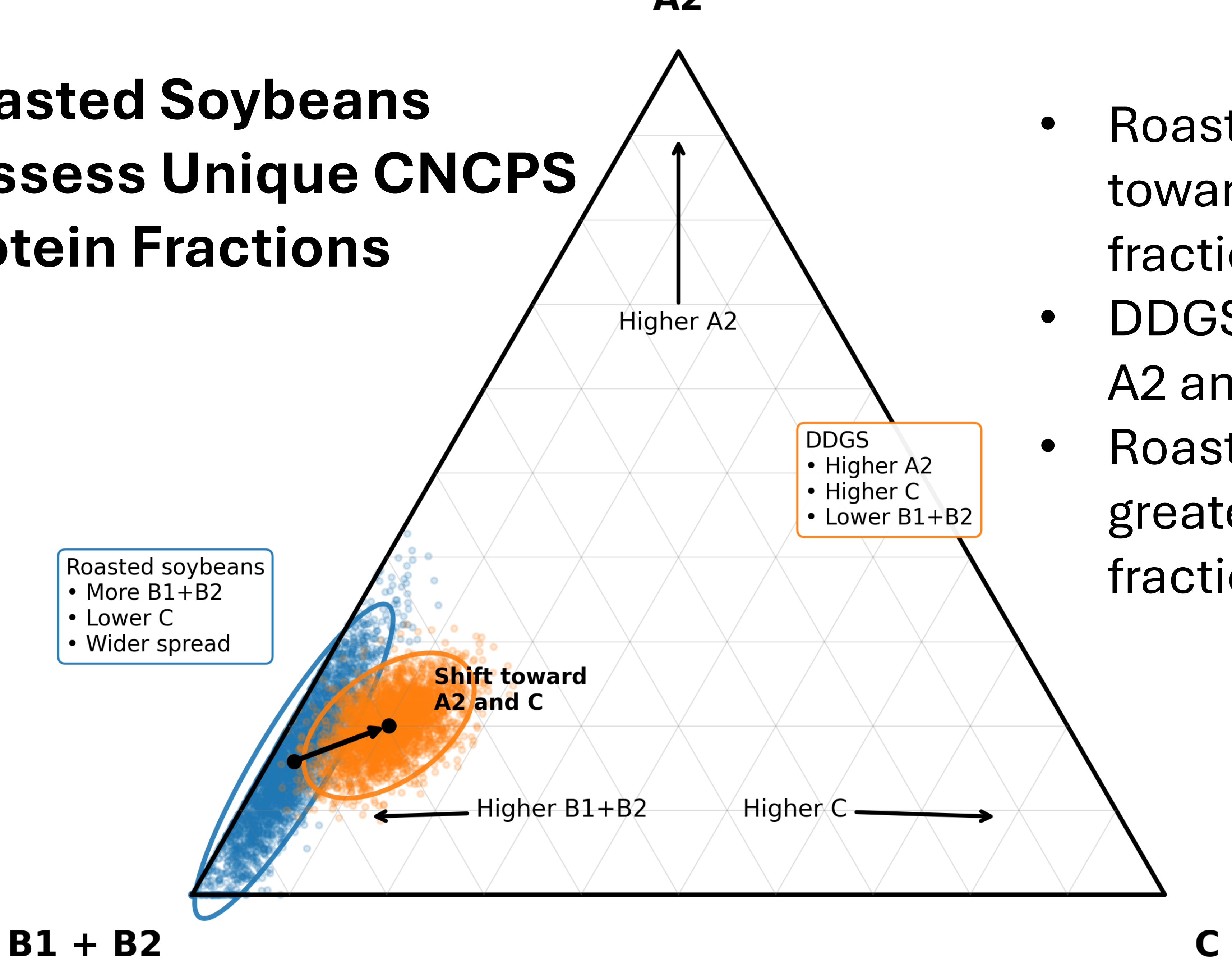
(Based on NASEM, 2021)

Roasted Soybeans Possess Unique CNCPS Protein Fractions



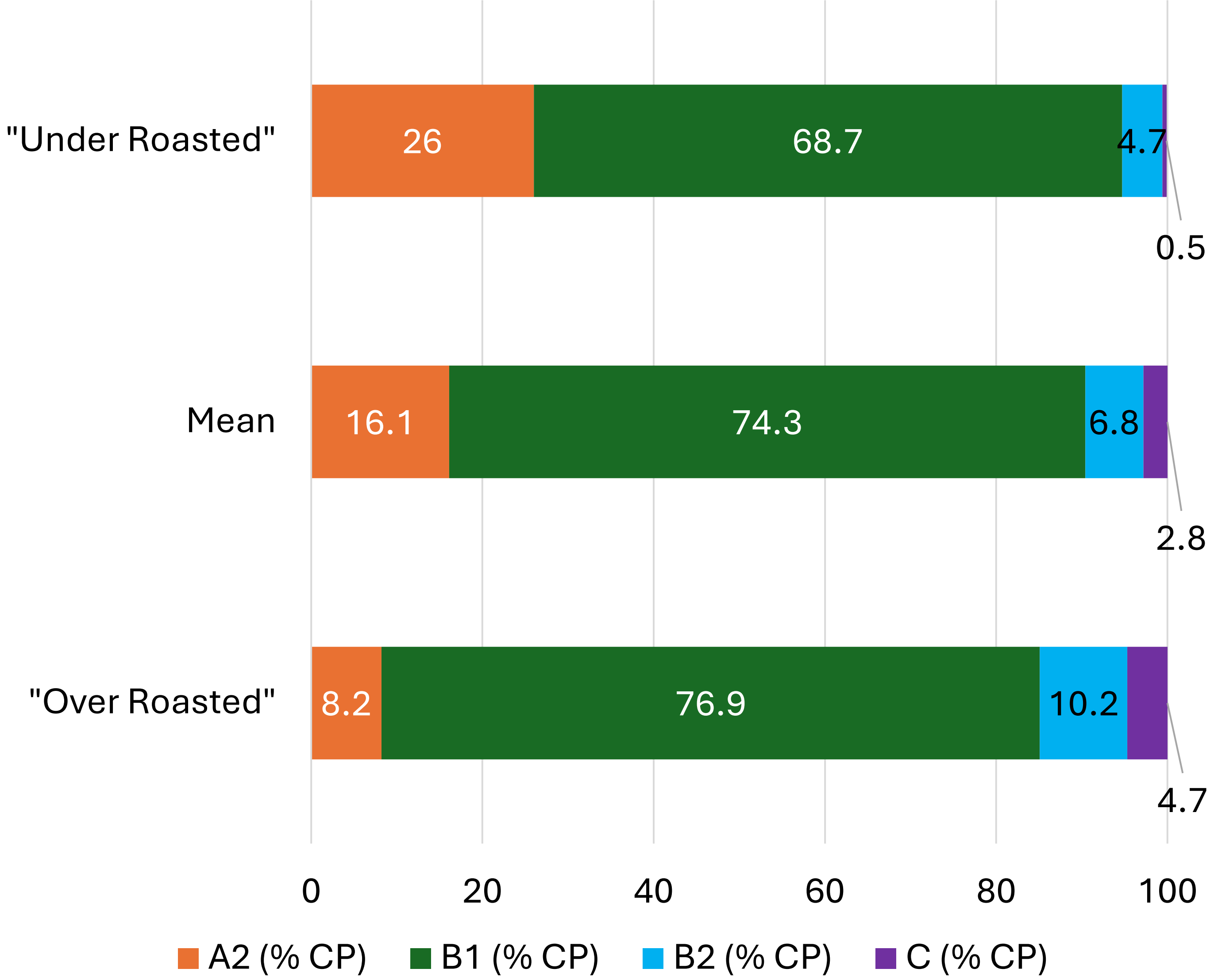
- most variability occurs along the B1+B2 ↔ A2 axis
- relatively little variation exists in C
- therefore processing seems to alter degradability kinetics rather than creating massive heat damage

asted Soybeans ssess Unique CNCPS tein 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

Roasting shifts CNCPS protein fractions



Roasting

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

CNCPS simulation of the 25% HOSB diet

	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

- 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

	"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

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

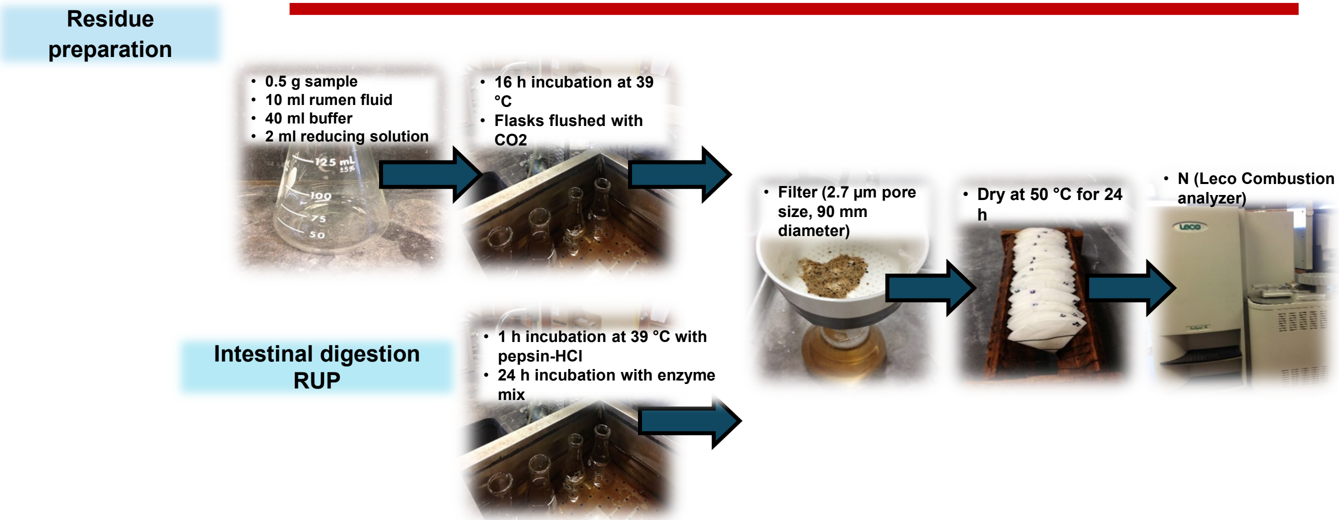
Mix: Trypsin, chymotrypsin, amylase, lipase

Pancreatin: proteases, amylase, and lipase

Incubation
39 C, 24 h bath

→ Filter → N Analysis

uCP: Ross Assay



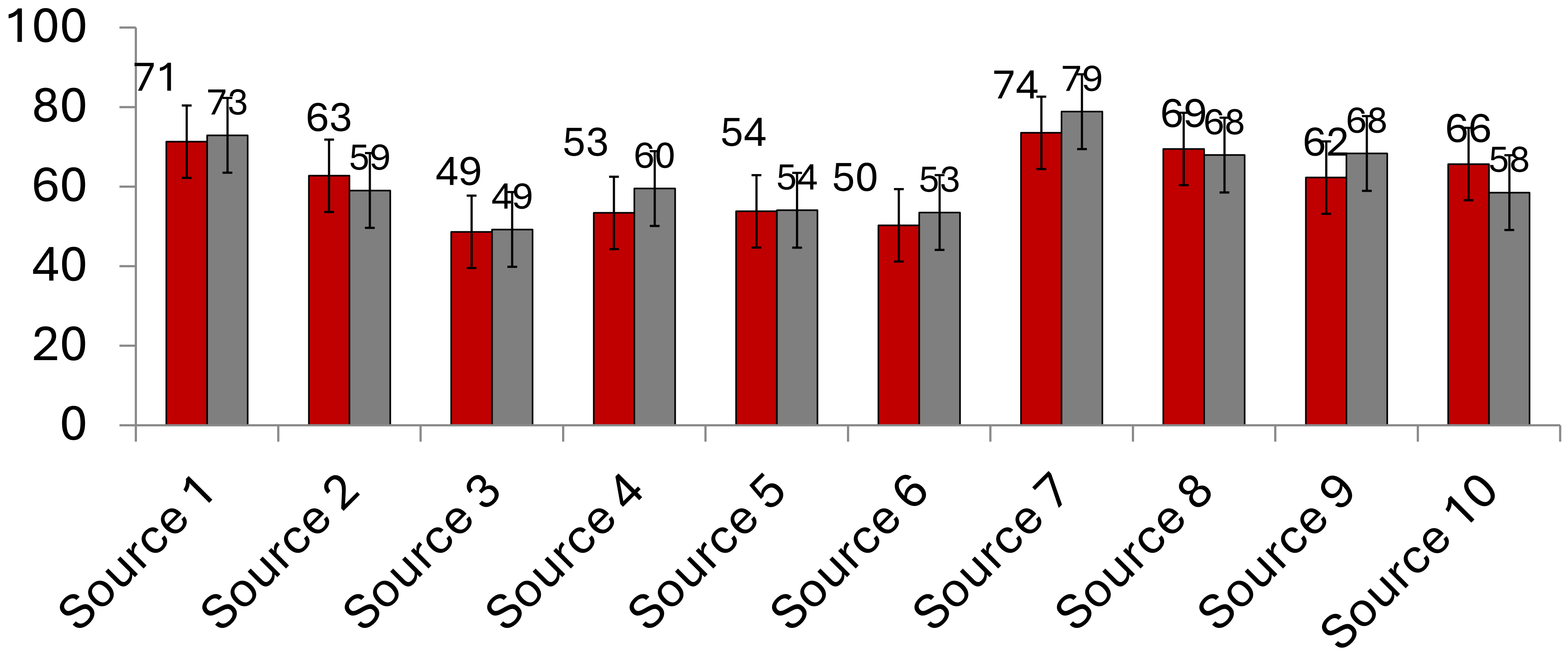
- **RDP** = $\frac{\text{N in sample} - \text{N in residue}}{\text{N in sample}} \times 100$
- **RUP** = 100 - RDP

Ross et al., 2013

(Ross et al., 2013)

Mobile Bag vs Ross, dRUP

Hydrolyzed feathermeal



(Buse et al., 2019)

What if I have Ross Assay data?

	48% Solv Ex. SBM	Expellers SBM	DDGS	Blood meal	Roasted Soybean
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/

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

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

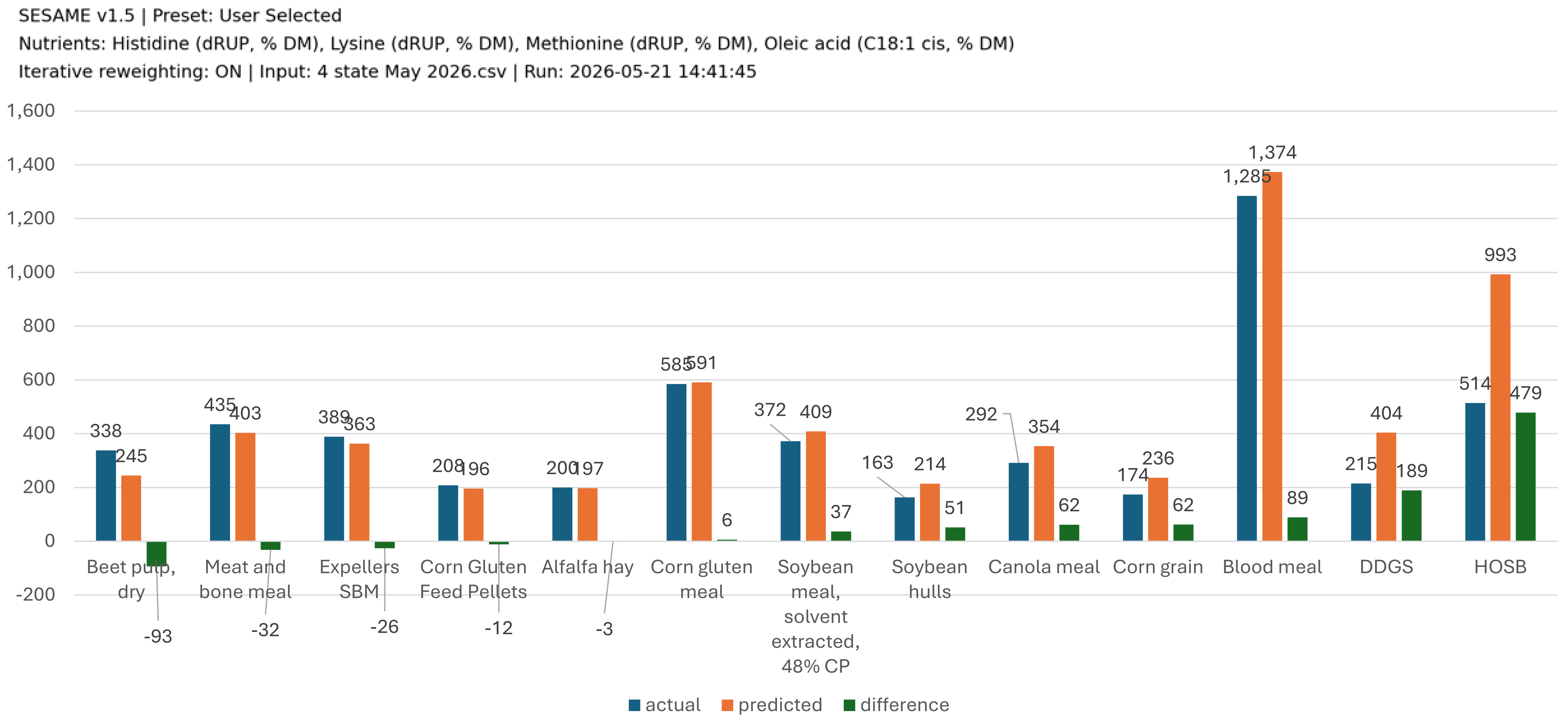
(Weiss et al., 2024)

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

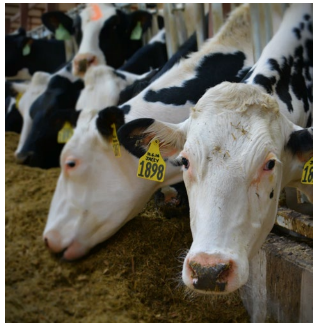
Variable	Mean	SD	10th - 90th percentile	Warning
Chem. Composition[1]				
CP, % DM	40.0	2.07	37.5-42.3	< 36 or > 44
Soluble Protein, % CP	15.6	7.71	6.1-17.1	< 5 or > 25-30
ADIP, % DM	0.97	0.789	0.45-2.35	>2.5-3
NDIP, % DM	2.79	1.975	1.38-8.4	> 8-10
Ross Assay[2]				
RUP, % CP	61.2	13.1	43-82	< 45 or > 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

Midwest: Actual, Predicted and Predicted-Actual Feed Prices



Summary



- Roasting shifts CNCPS protein fractions
  - ↓ soluble protein (PA2)
  - ↑ 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