UNIVERSITY OF SASKATCHEWAN

Getting the best bang for your buck

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Barley and corn as major cereal options

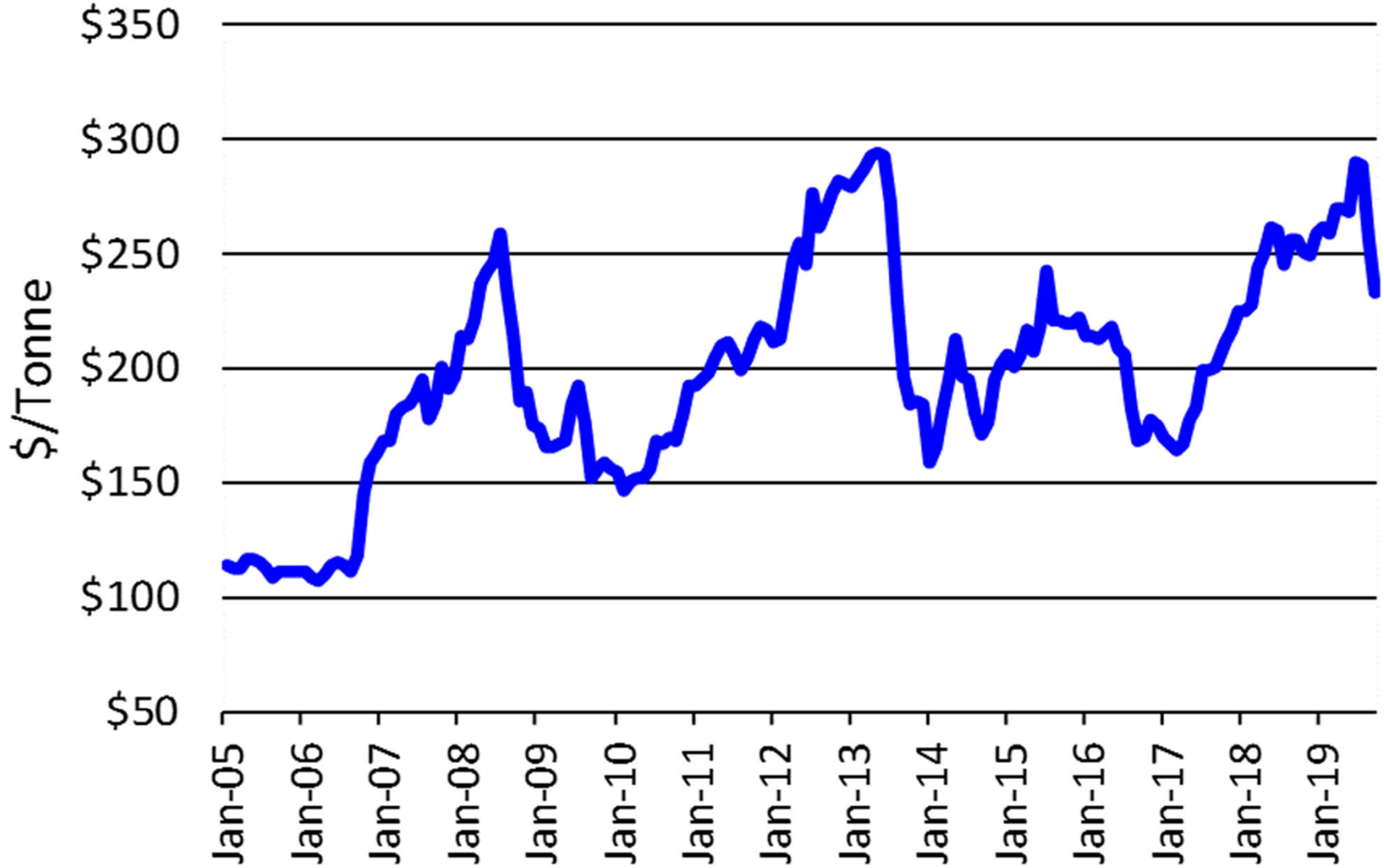
	Western Canada[2]		Upper Midwest US[3]
	Barley grain	Corn grain	Corn grain
DM, %	88.0 ± 6.62	84.1 ± 7.17	76.9 ± 10.1
OM, % DM	97.0 ± 0.75	98.3 ± 0.80	98.6 ± 0.39
CP, % DM	12.4 ± 1.56	9.2 ± 1.49	8.4 ± 1.04
Starch, % DM	59.9 ± 5.84	71.1 ± 7.82	73.2 ± 3.32
ADF, % DM	7.16 ± 2.64	5.7 ± 6.29	4.5 ± 1.45
NDF, % DM	17.8 ± 4.23	12.5 ± 9.66	10.6 ± 2.68
Fat, % DM	2.25 ± 0.50	3.7 ± 0.68	3.9 ± 0.61
TDN, % DM	80.4 ± 2.34	85.2 ± 4.72	86.0 ± 1.30
NE_m, Mcal/kg	1.96 ± 0.07	2.09 ± 0.15	2.12 ± 0.04
NE_g, Mcal/kg	1.30 ± 0.07	1.43 ± 0.13	1.46 ± 0.02

[1]Values reported from January 1, 2014 to January 1, 2019.

[2]For Canadian barley grain n ≥ 1,161 ;for corn grain n ≥ 564.

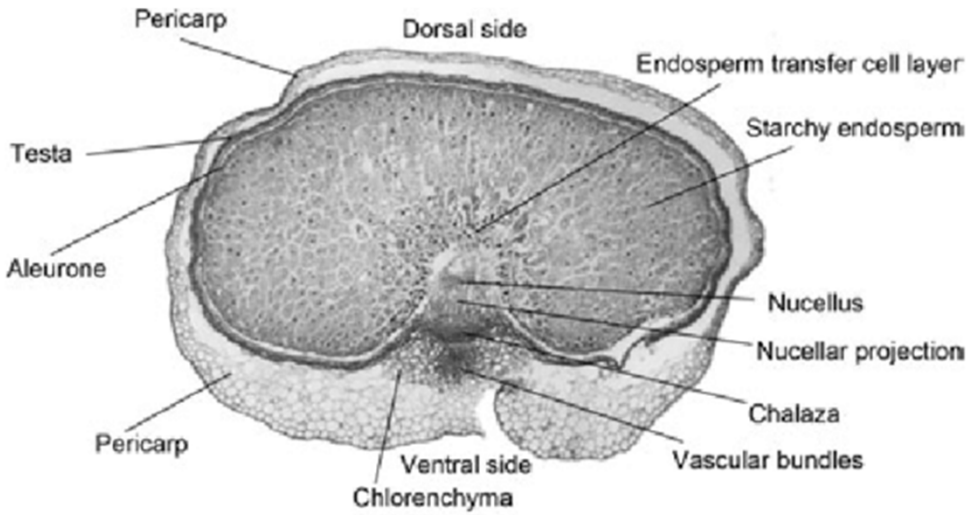
[3]For Upper Midwest US corn grain n ≥ 4,899.

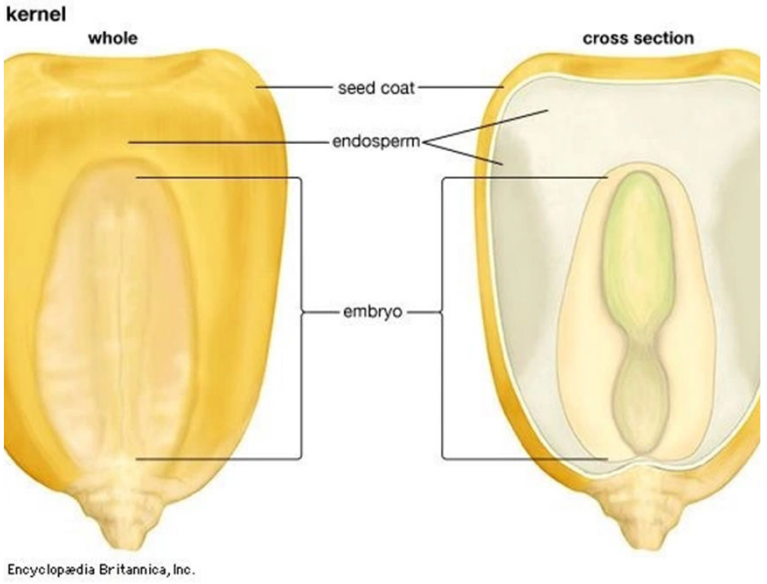
Alberta Barley Price



Source: AB Canola, AG Value, AB Agric

Barley and corn grain anatomy



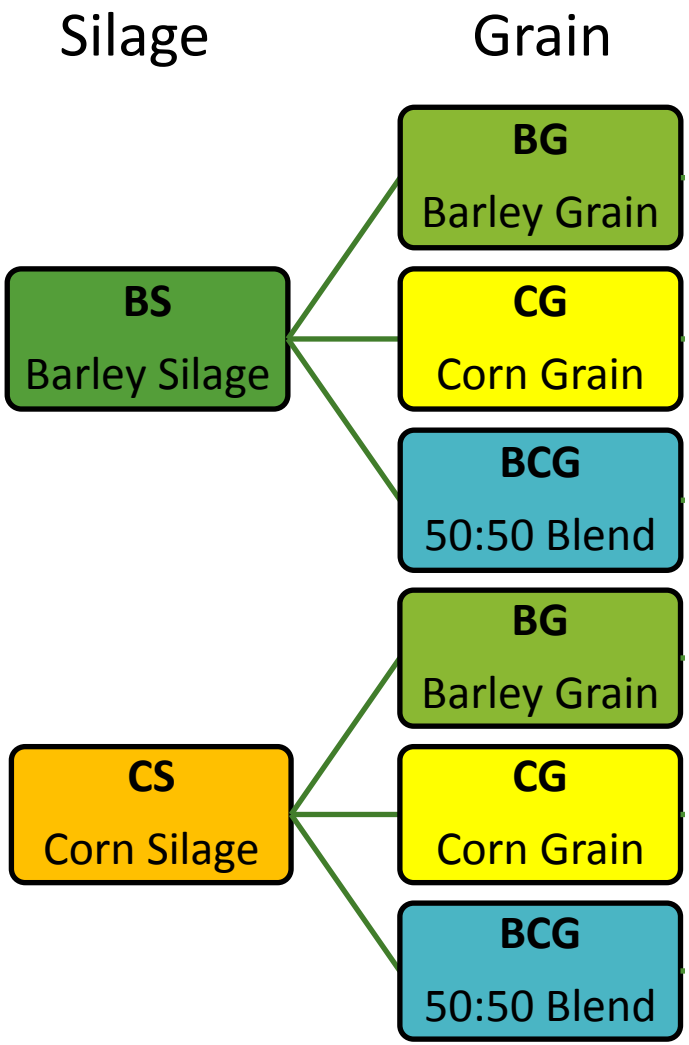


- Inherent barriers to digestion

Hull and pericarp

Seed coat + endosperm

Dietary Treatments

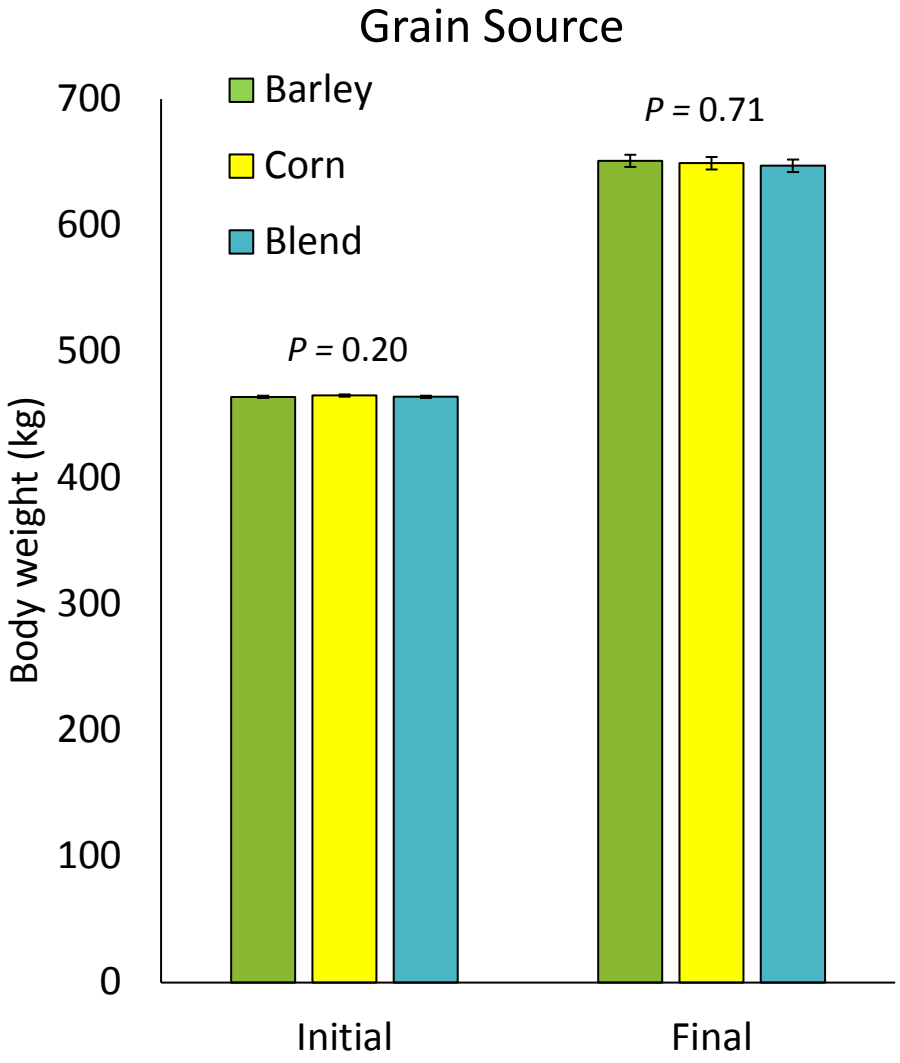


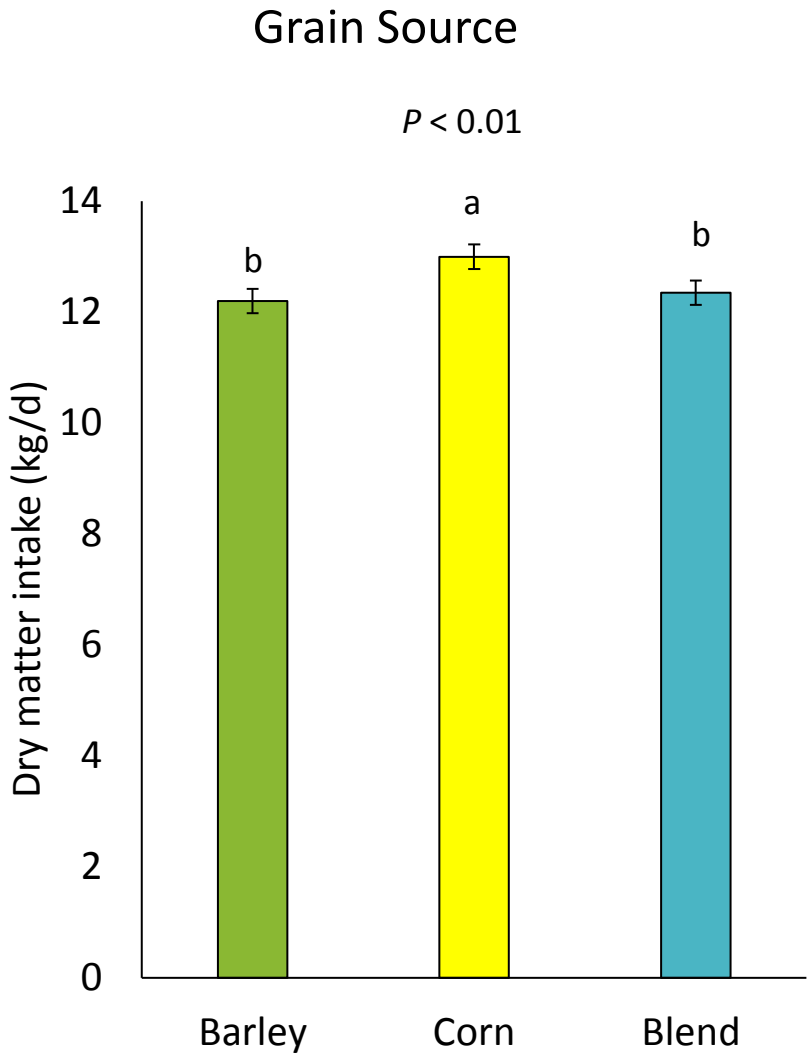
Experimental Design

- 288 steers stratified by BW and randomly assigned to one of 24 pens
  - 4 pens/treatment with 12 steers/pen
- Fecal samples were collected from the pen floor to estimate digestibility
  - Samples were subjected to NIR analysis to estimate fecal starch and digestibility of GE, DM, OM, CP, ADF and NDF as described by Jancewicz et al. (2016)
- Carcass data were obtained from the abattoir at slaughter (Cargill Meat Solutions, High River, AB)

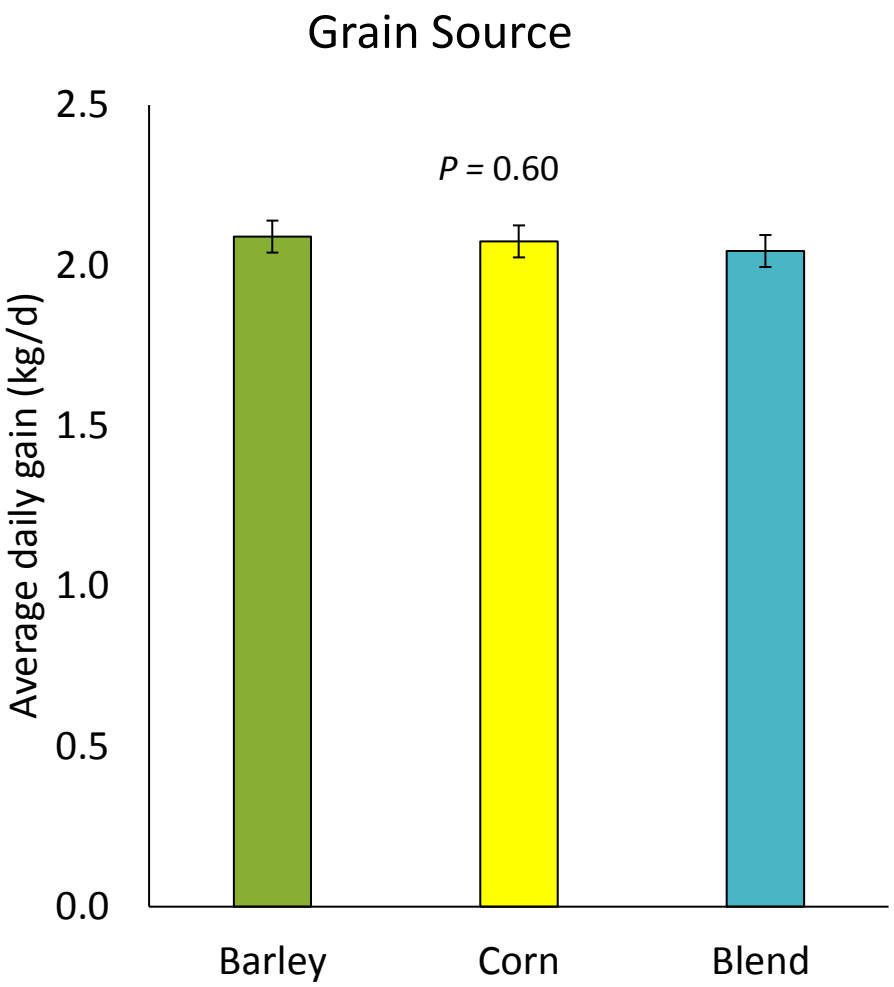
	Barley silage			Corn silage		
	Barley grain	Corn grain	Blend	Barley grain	Corn grain	Blend
Ingredient, % DM						
Barley silage	8.00	8.00	8.00	-	-	-
Corn silage	-	-	-	8.00	8.00	8.00
Barley grain	85.94	-	42.72	85.86	-	42.69
Corn grain	-	84.96	42.72	-	84.89	42.69
Urea	-	0.98	0.50	0.08	1.06	0.57
Mineral pellet[1]	5.56	5.56	5.56	5.56	5.56	5.56
Limestone	0.50	0.50	0.50	0.50	0.50	0.50
Chemical composition, % DM[2]						
DM, %	82.2 ± 1.07	81.7 ± 0.83	82.0 ± 0.81	80.0 ± 0.95	79.9 ± 1.65	80.1 ± 1.28
OM	95.6 ± 0.10	96.0 ± 0.16	95.8 ± 0.03	95.7 ± 0.14	96.1 ± 0.11	95.9 ± 0.02
CP	11.5 ± 0.17	11.3 ± 0.18	11.5 ± 0.14	11.6 ± 0.21	11.4 ± 0.20	11.5 ± 0.17
NDF	21.6 ± 1.57	13.5 ± 0.50	17.5 ± 0.53	21.4 ± 1.82	13.3 ± 0.26	17.3 ± 0.78
ADF	8.4 ± 0.44	5.9 ± 0.34	7.1 ± 0.31	8.3 ± 0.33	5.8 ± 0.24	7.0 ± 0.16
Starch	54.2 ± 1.43	64.5 ± 1.17	59.3 ± 0.27	54.7 ± 1.35	65.1 ± 1.23	59.9 ± 0.15
Ether extract	2.3 ± 0.08	4.0 ± 0.35	3.2 ± 0.22	2.3 ± 0.09	4.0 ± 0.36	3.2 ± 0.23
Ca	0.86 ± 0.03	0.83 ± 0.03	0.84 ± 0.03	0.86 ± 0.03	0.82 ± 0.02	0.84 ± 0.03
P	0.35 ± 0.02	0.32 ± 0.02	0.34 ± 0.01	0.35 ± 0.02	0.32 ± 0.02	0.34 ± 0.01
NE_m, Mcal/kg[3]	1.85	2.00	1.93	1.86	2.00	1.93
NE_g, Mcal/kg[3]	1.23	1.35	1.29	1.23	1.36	1.30

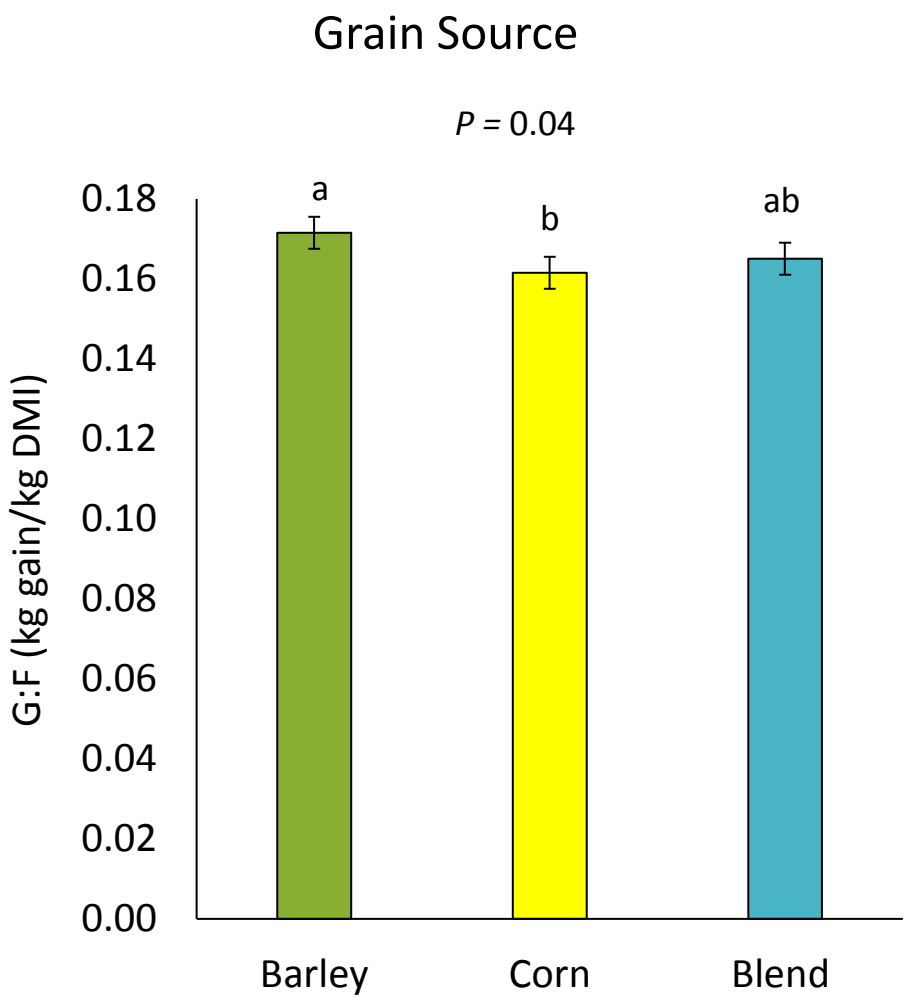
Grain source effects on BW and DMI



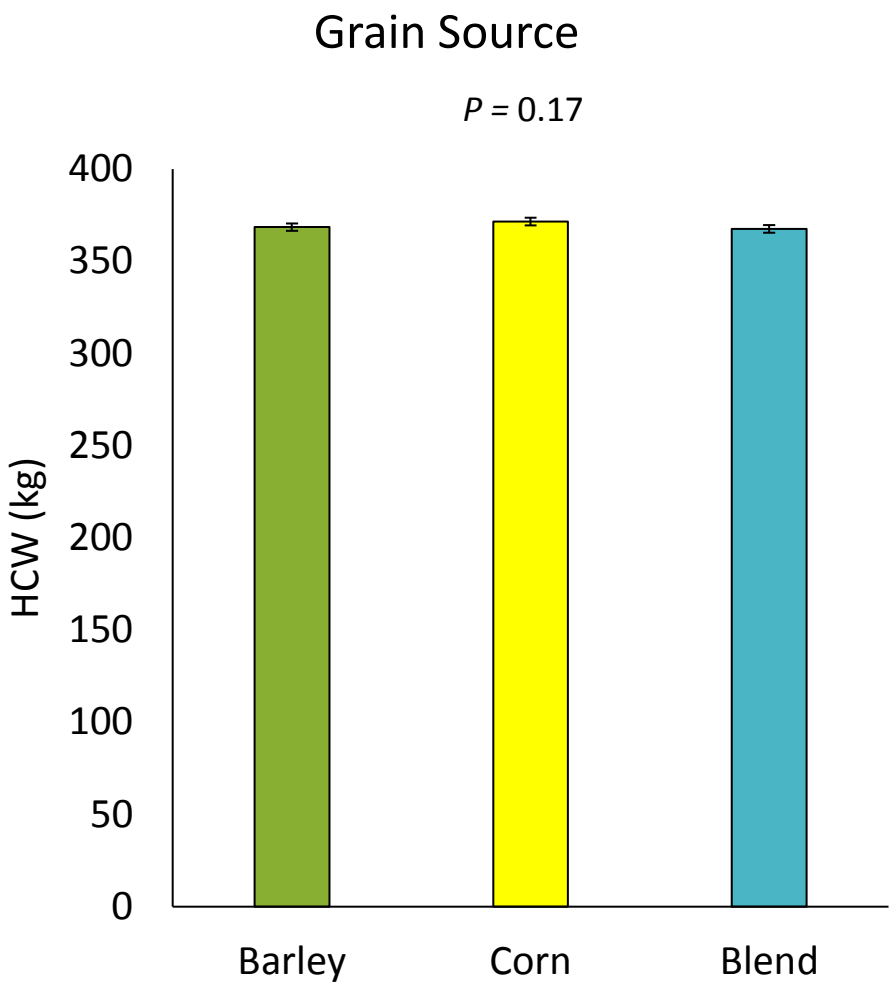


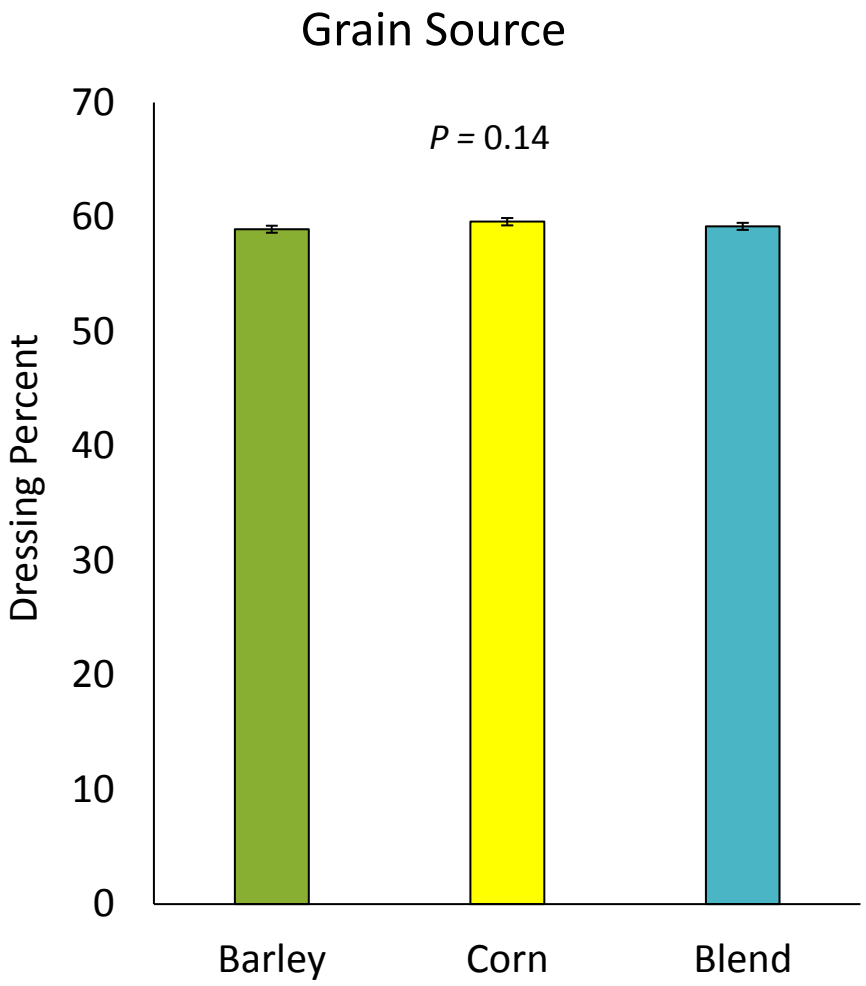
Grain source effects on ADG and G:F



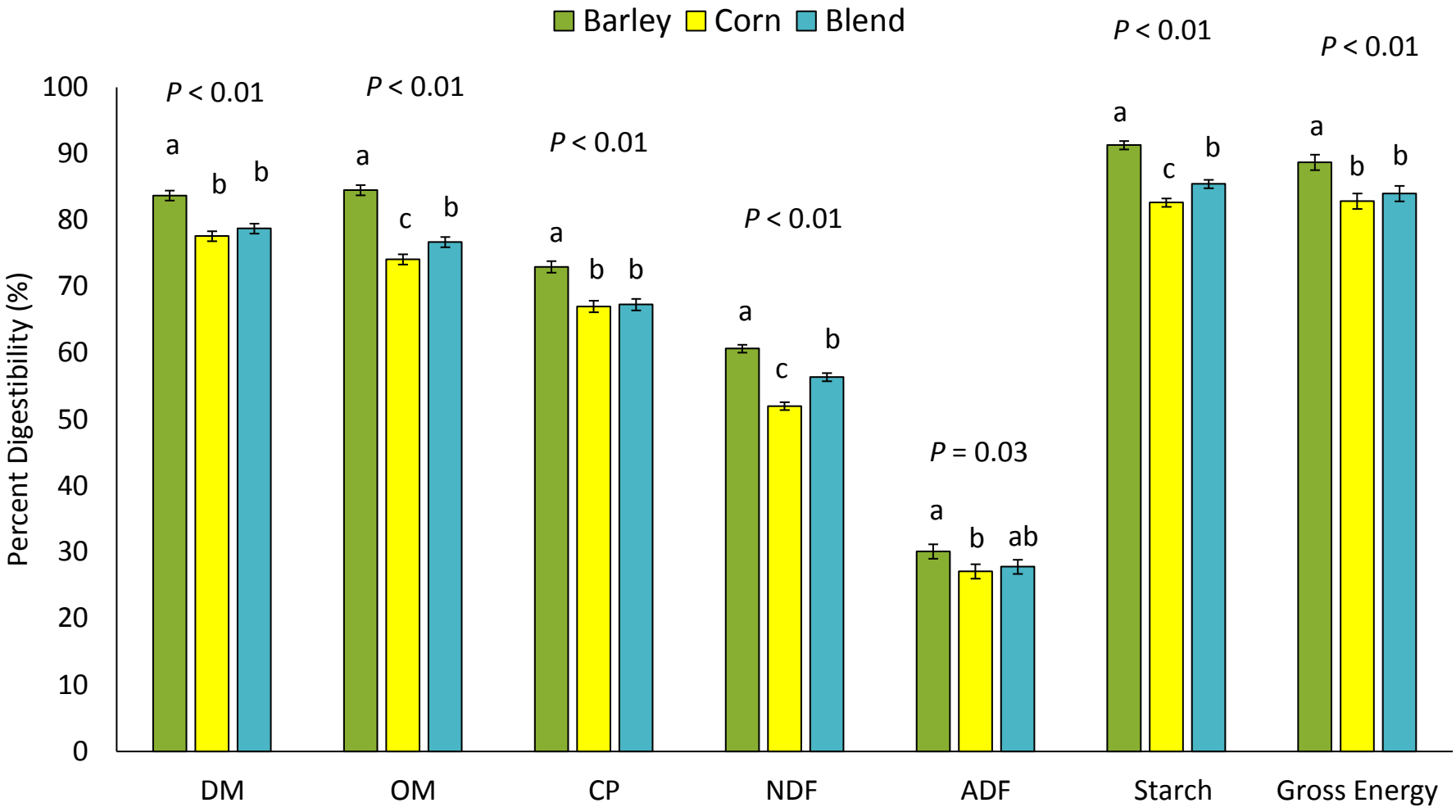


Grain source effects on the carcass

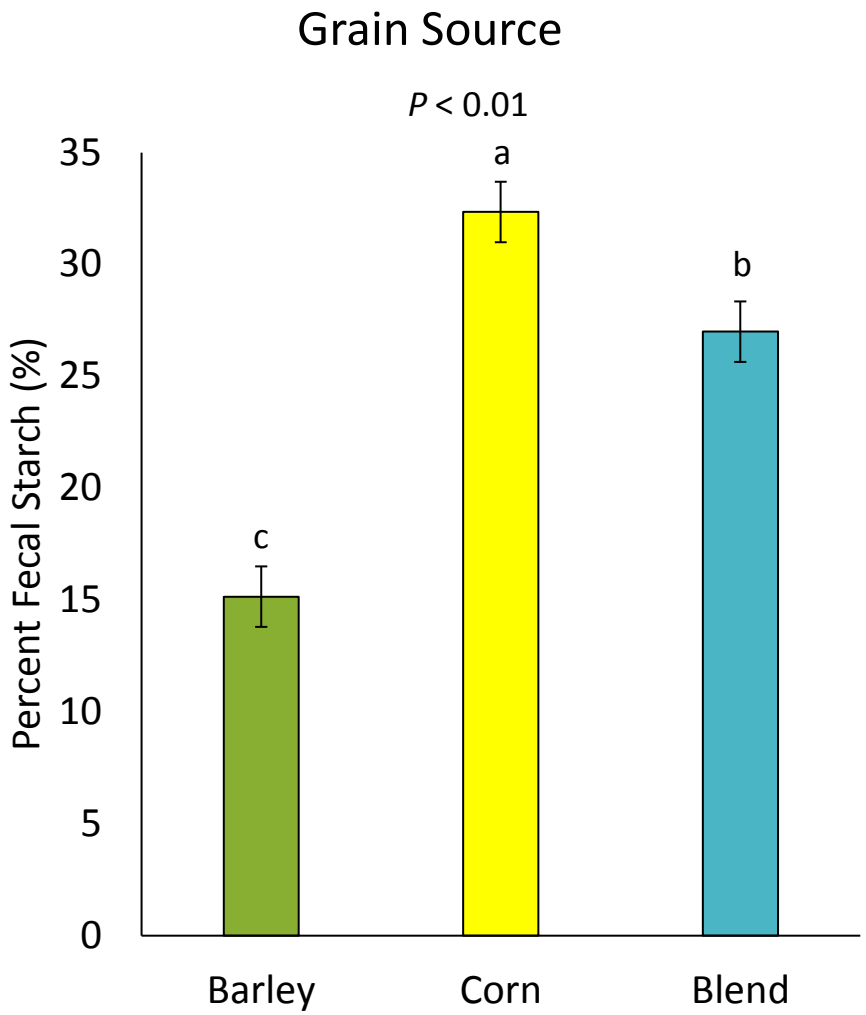




Grain source and predicted digestibility



Grain source effects



Summary

- Feeding BG resulted in improved growth performance and digestibility compared to either CG or BCG

- Generally, no benefit to feeding BCG

Owens et al., 1997; JAS

Breaking down barriers to digestion

- Processing methods and feed-to-gain ratio

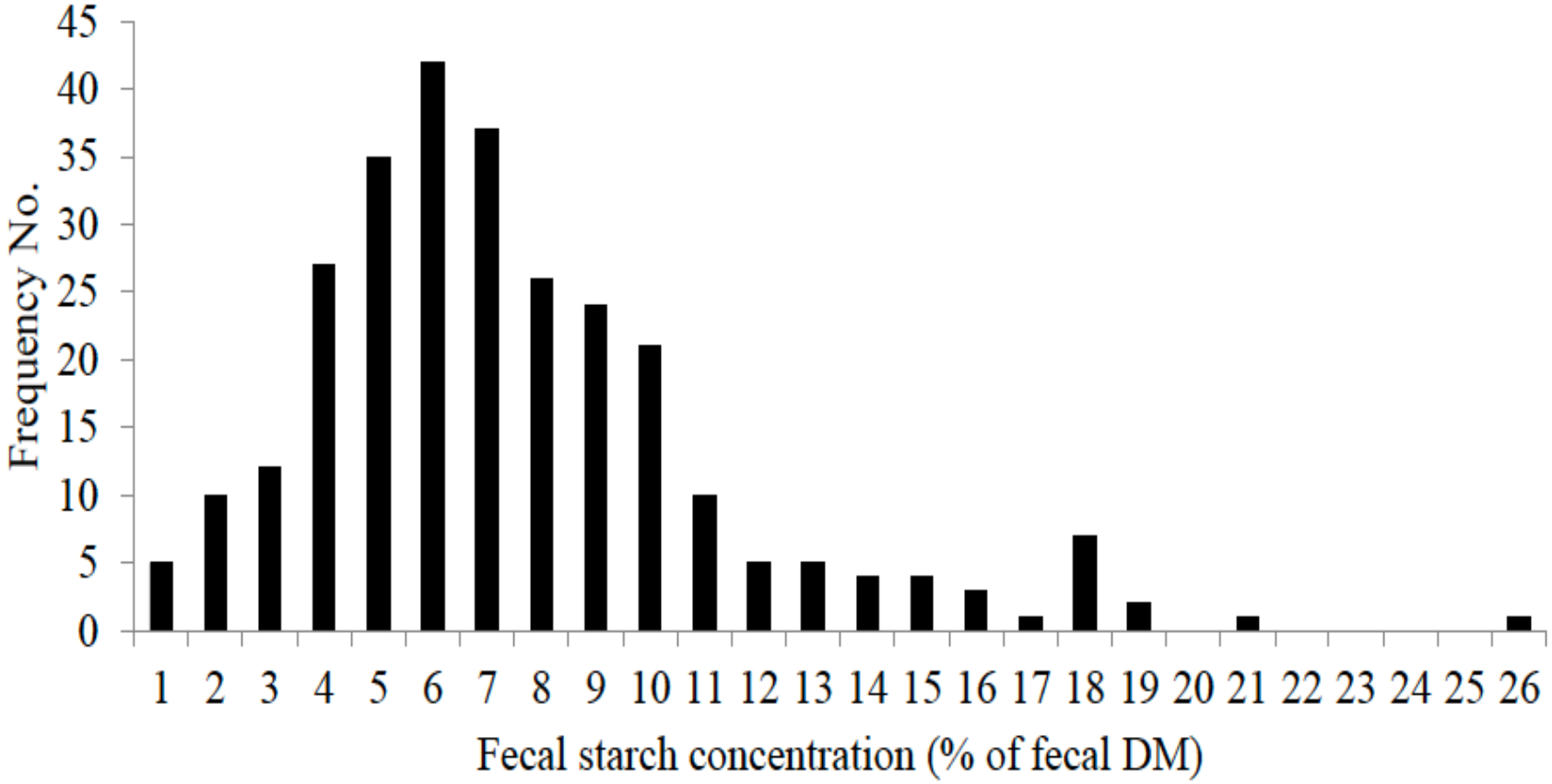
Processing method	Barley	Corn	Milo	Oats	Wheat
Dry roll	6.25	6.57[a]	7.43[a]	6.01	6.59[a]
High moisture	—	6.43[a]	7.12[ab]	—	—
Steam roll	6.19	5.87[b]	6.33[c]	6.18	5.92[b]
Whole	6.66	5.95[b]	—	—	—
Reconstituted	—	—	6.75[bc]	—	—
MSE[d]	48.06	21.91	34.37	5.07	14.87

[a,b,c]Means within a column with different superscripts differ ($P < .05$).

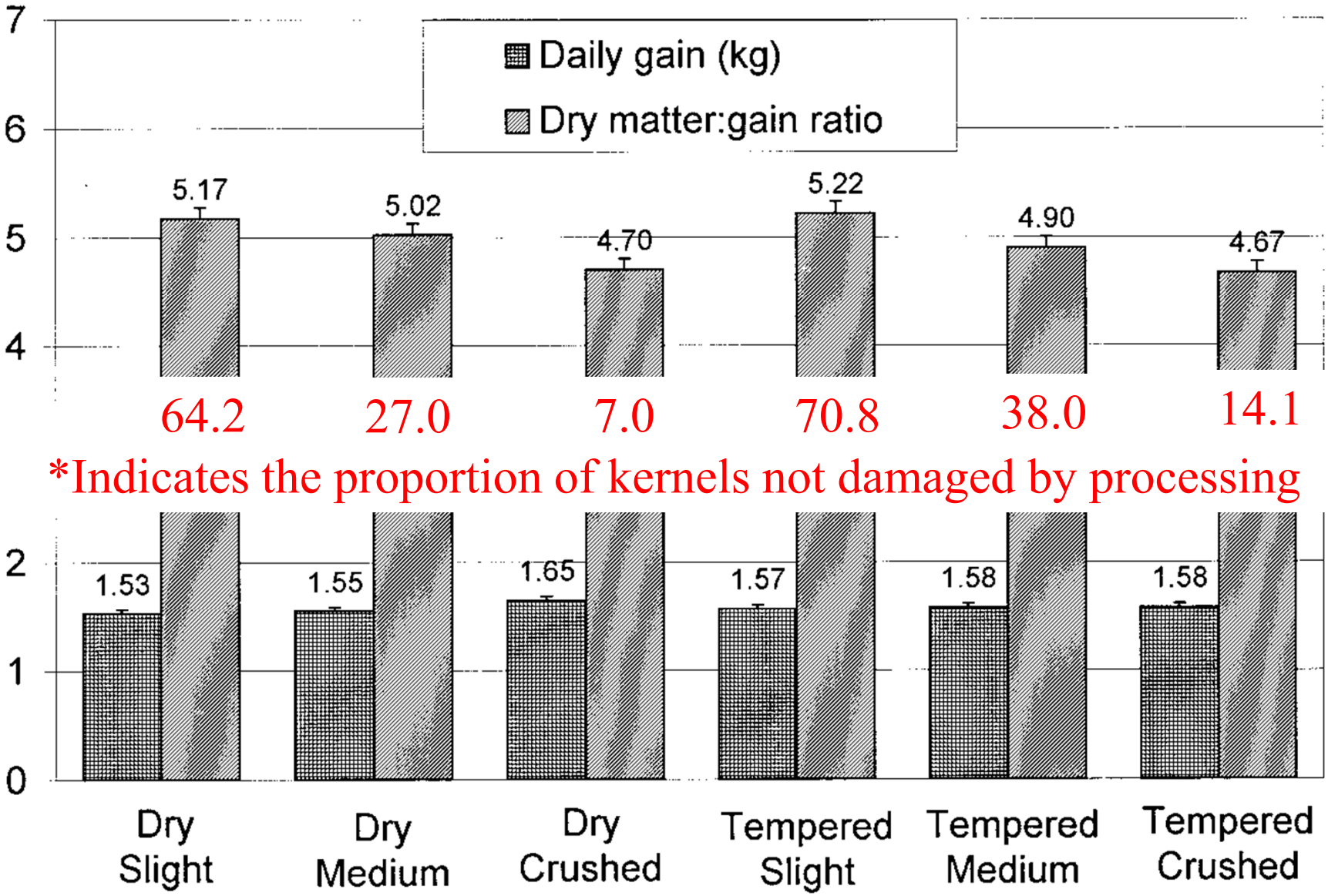
[d]Standard error for each mean in a column equals the square root of the error mean square for that column divided by the number of observations in each mean as listed in Table 1.

Jancewicz et al., 2017; CJAS

High fecal starch is a lost opportunity!



Mathison et al., 1997; CJAS



*Indicates the proportion of kernels not damaged by processing

Ahmad et al., 2010; CJAS

Precision processing improves digestibility

Item	MRS	SRS	SEM	*P* value
In situ starch digestibility (%)				
0 h	22.8	14.9	1.1	<0.01
3-h	55.0	38.6	1.8	<0.01
6-h	62.6	54.4	1.9	<0.01
12-h	78.9	69.7	1.2	<0.01
24-h	85.3	83.0	0.7	<0.05
48-h	93.1	93.4	0.5	0.76
Rate of starch disappearance (% h^{-1})	18.6	11.9	0.8	<0.01
Effective disappearance (%)[z]	74.7	65.5	0.01	<0.01

- **But, segregation of barley grain on farm is impractical!**

Other strategies?

- Steam flaking
- Most studies do not report flaking conditions

	Barley			Corn		
Dry density, kg/L[a]	<.28	.28 to .37	>.37	<.28	.28 to .37	>.37
ADG, kg	1.35	1.62	1.36	1.45	1.39	1.39
DMI, kg	7.31	8.40	7.71	7.85	7.31	7.40
Feed/gain	5.4[cd]	5.2[d]	5.6[c]	5.4	5.2	5.3
ME,[b] Mcal/kg DM	3.83	3.47	3.69	4.01	4.16	4.10

Owens et al., 1997; JAS

University of Saskatchewan

SaskBarley Development Commission

Cargill

SCA Saskatchewan Cattlemen's Association

Evaluating steam-flaking of barley to improve feed efficiency for finishing beef cattle

Feedlot Health Management Services

Students: Leslie Radke and Coleman Nixdorff

Steam-flaking barley grain

- Objective 1: To determine the processing conditions required to improve starch digestibility

Steam-flaking barley grain

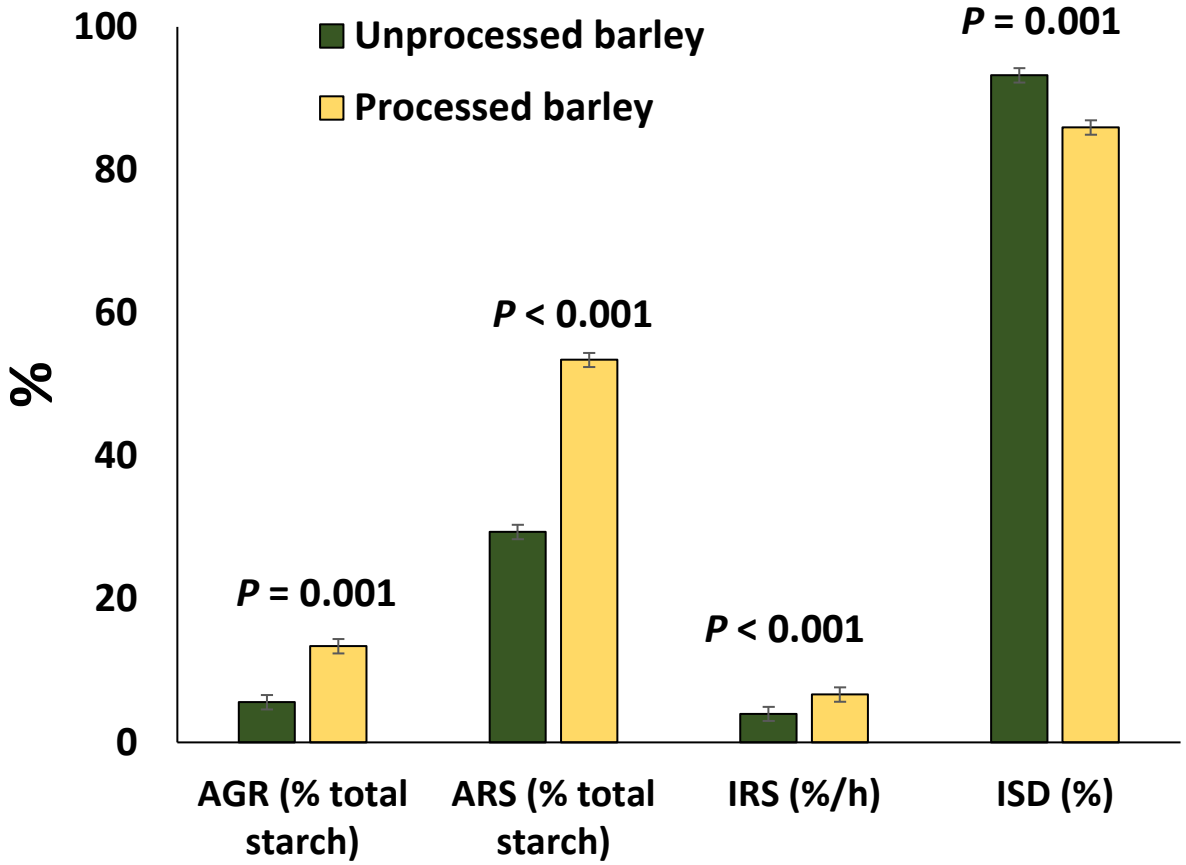
- Five independent sources of barley
- 3 × 3 + 1 factorial design
  - Unprocessed barley (**CON**)
  - Steam conditioning duration: **5**, **20** or **35** min
  - Flaking density: 0.43 (**HIGH**), 0.34 (**MID**) and 0.25 kg/L (**LOW**)
    - **LOW** = 0.323 ± 0.010 kg/L
    - **MID** = 0.373 ± 0.021 kg/L
    - **HIGH** = 0.474 ± 0.031 kg/L

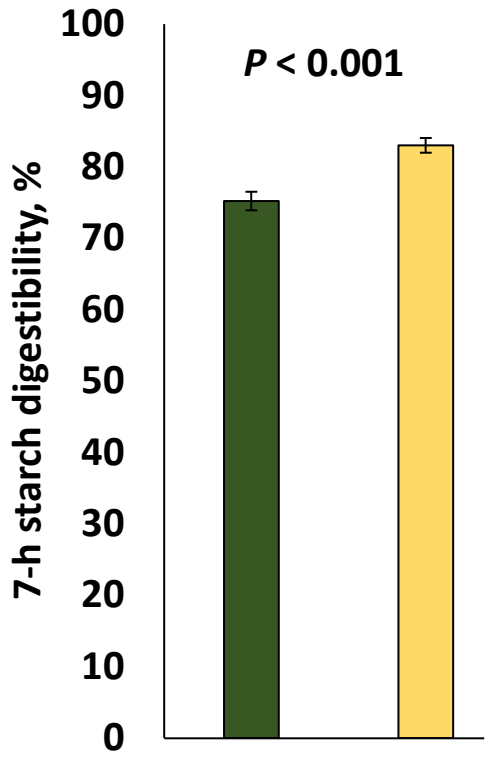
Processing does not change composition

Chemical composition of unprocessed (**CON**) and barley when steam conditioned for **5**, **20**, or **35** min and flaked to densities of 0.474 ± 0.031 for **HIGH**, 0.373 ± 0.021 for **MID** and 0.323 ± 0.010 kg/L for **LOW**.

Variable (% DM)	CON	Flaking duration			Flaking density		
		5 min	20 min	35 min	HIGH	MID	LOW
DM (%)	90.9	88.5	88.8	88.8	87.8	88.8	89.4
CP	11.2	11.3	11.2	11.3	11.3	11.2	11.3
NDF	16.5	19.5	19.0	18.3	19.0	18.9	18.8
Starch	61.5	60.9	61.6	61.6	61.0	61.8	61.2

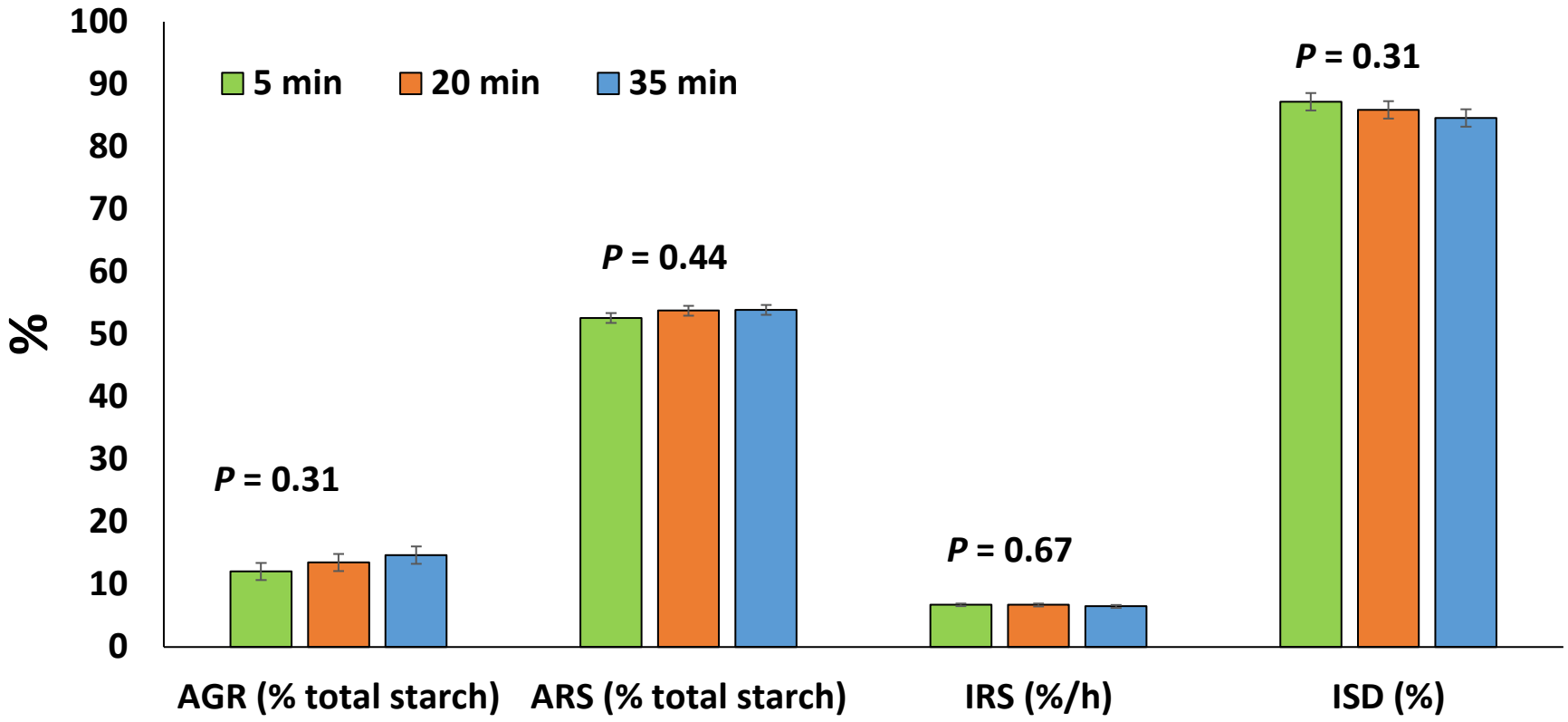
Impact of flaking



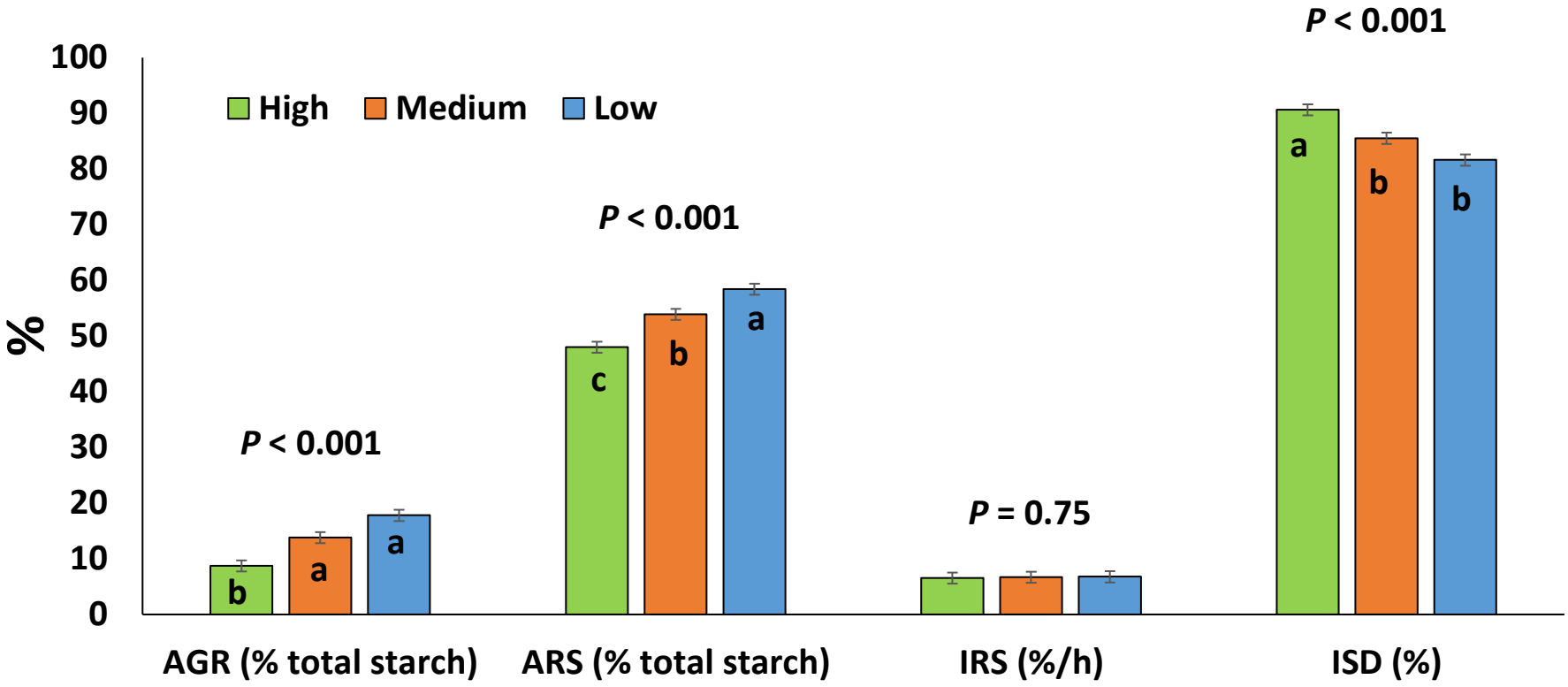


AGR = amyloglucosidase reactive soluble starch
ARS = 6-h amylase reactive insoluble starch
IRS = insoluble reactive starch
ISD = Digestive insoluble starch

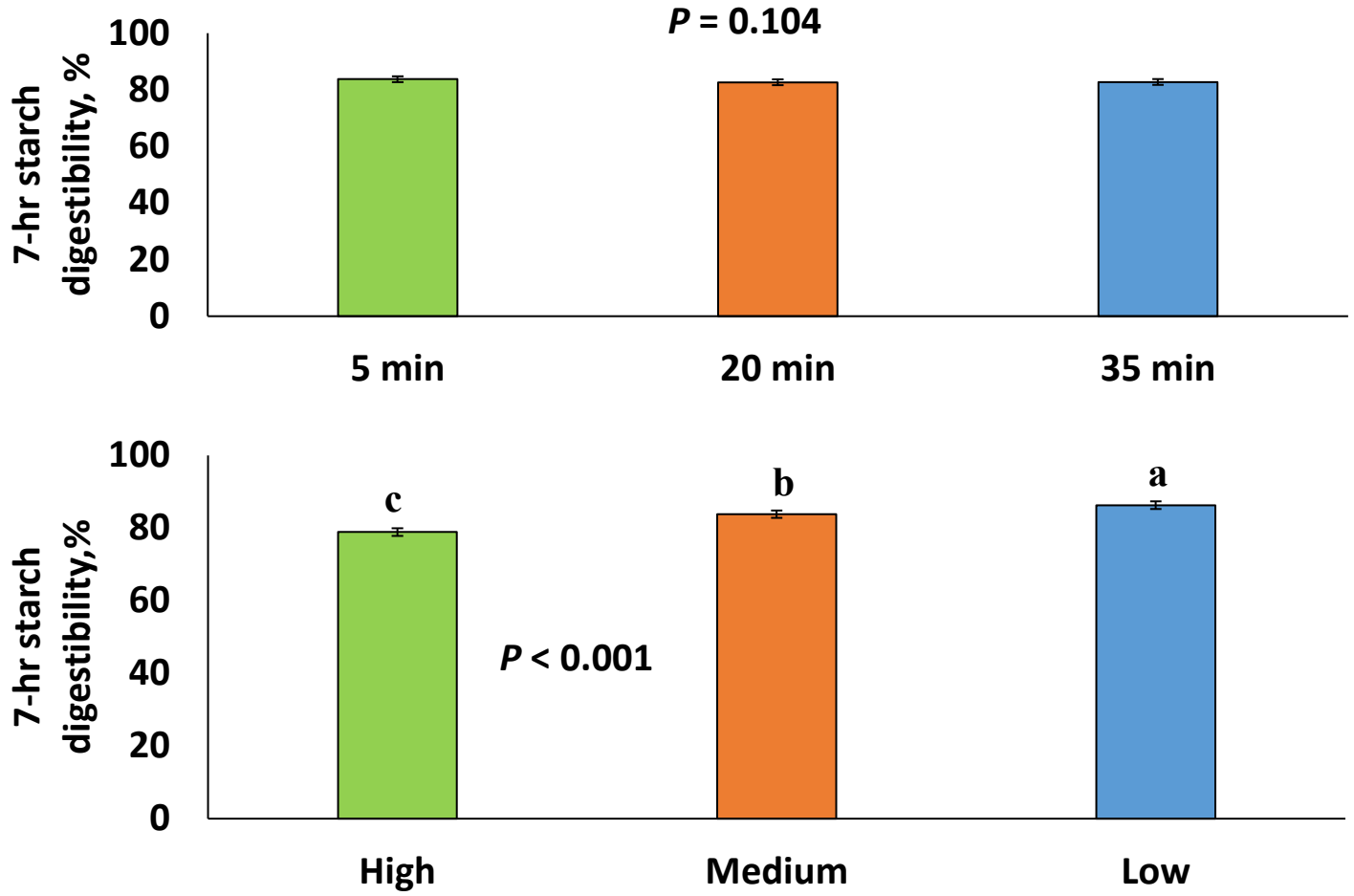
Flaking conditions: conditioning time



Steam-flaking conditions: flaking density



Only flaking density impacts the response



Steam-flaking conditions

- Exposure to 5 min of steam was sufficient to increase starch availability
- Decreasing flaking density (increasing the severity of processing) increased starch availability
- But, how will cattle respond?

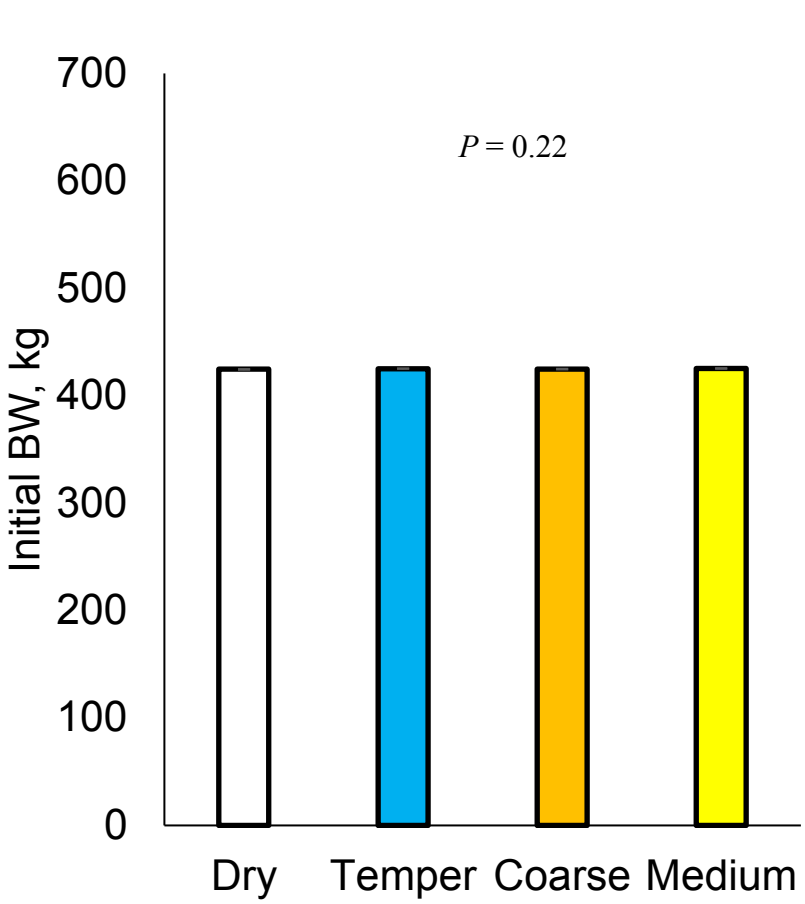
Growth performance study

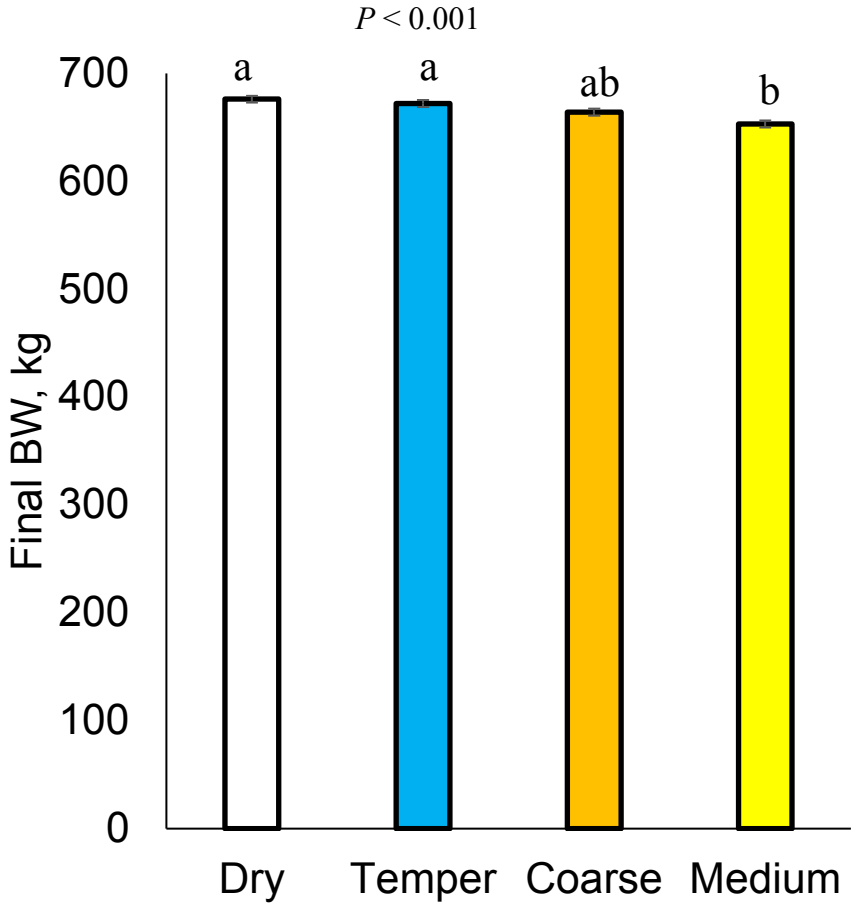
- 28 pens at LFCE
- 4 treatments
  - Dry rolled
  - Temper rolled
  - Mid-flake
  - Coarse-flake

Growth performance study

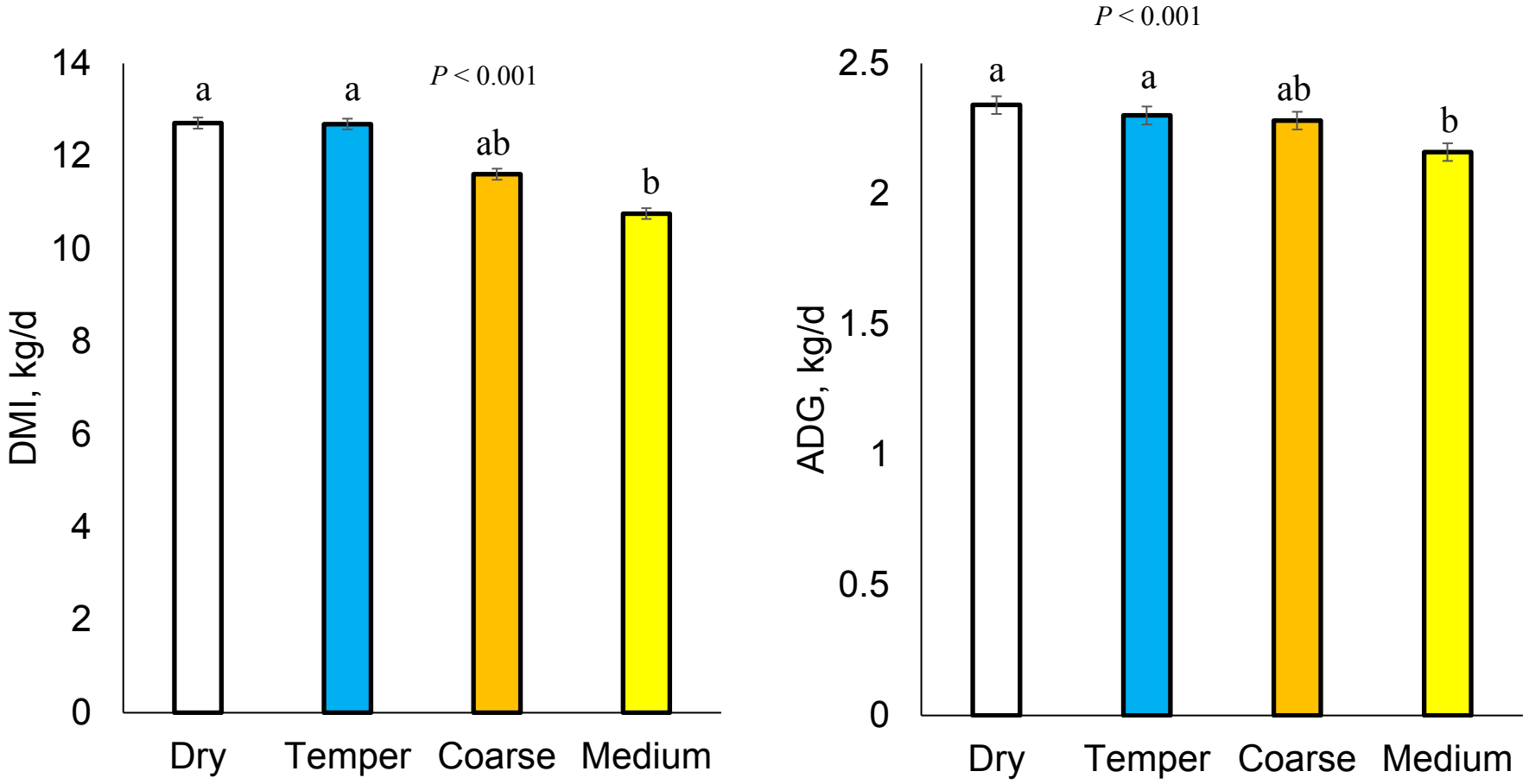
Item[1]	Treatments				
	Unprocessed	Dry rolled	Temper rolled	Mid flake	Coarse flake
Dry matter, %	89.2 ± 1.00	88.2 ± 2.16	80.3 ± 1.92	86.4 ± 1.64	86.4 ± 1.75
Post processing bulk density (g/L)	671 ± 11.47	522 ± 42.11	540 ± 26.68	361 ± 12.75	450 ± 14.79
Processing index, %	-	77.4 ± 6.59	79.7 ± 5.08	54.1 ± 1.74	67.5 ± 2.31

Growth performance study: BW

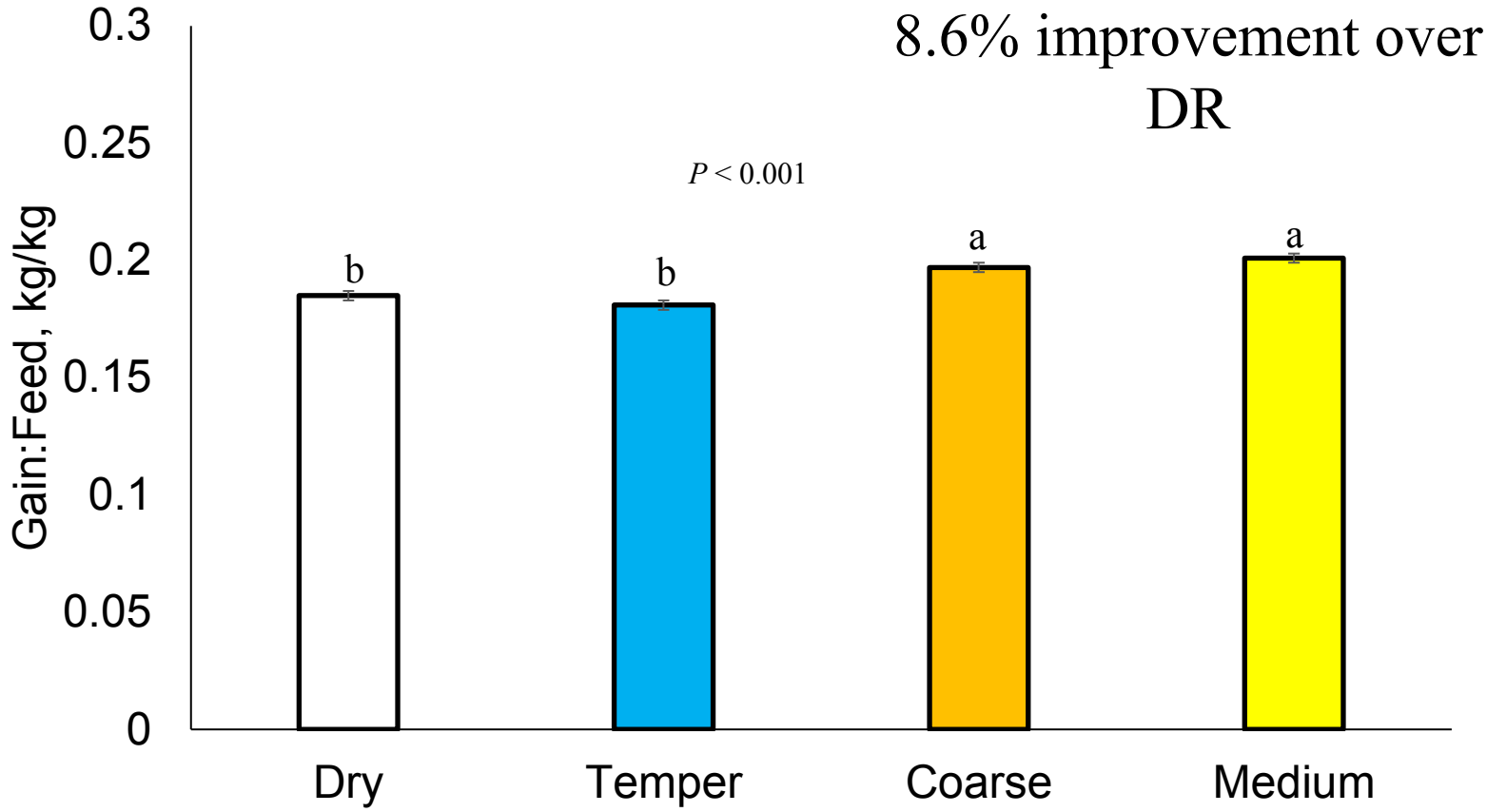




Growth performance study: DMI and ADG

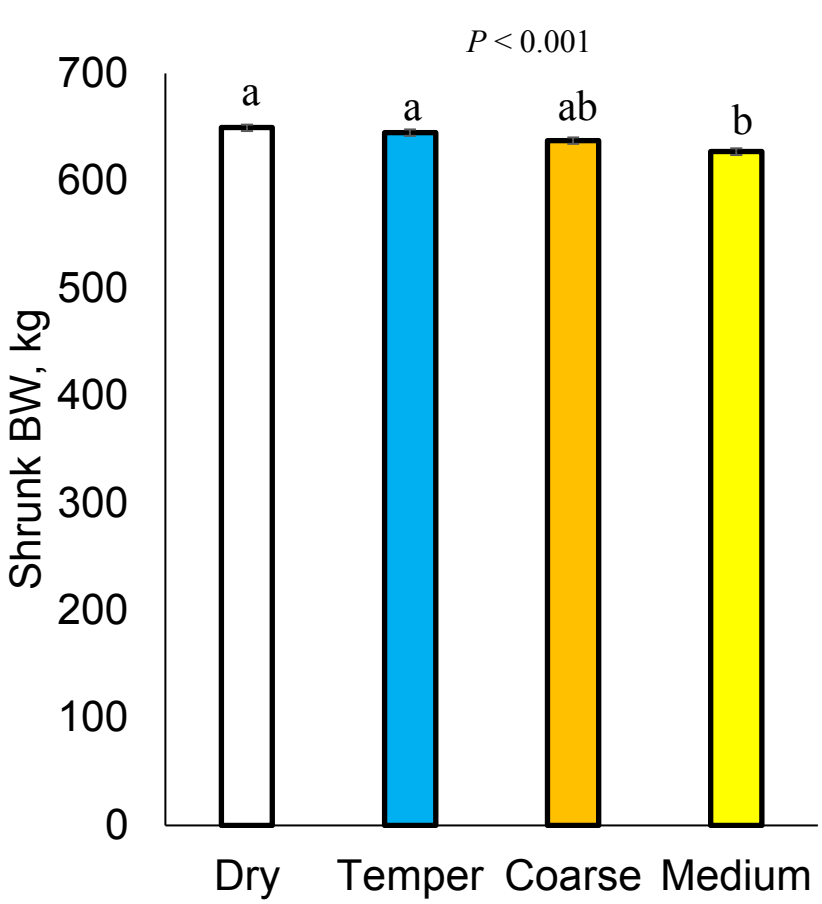


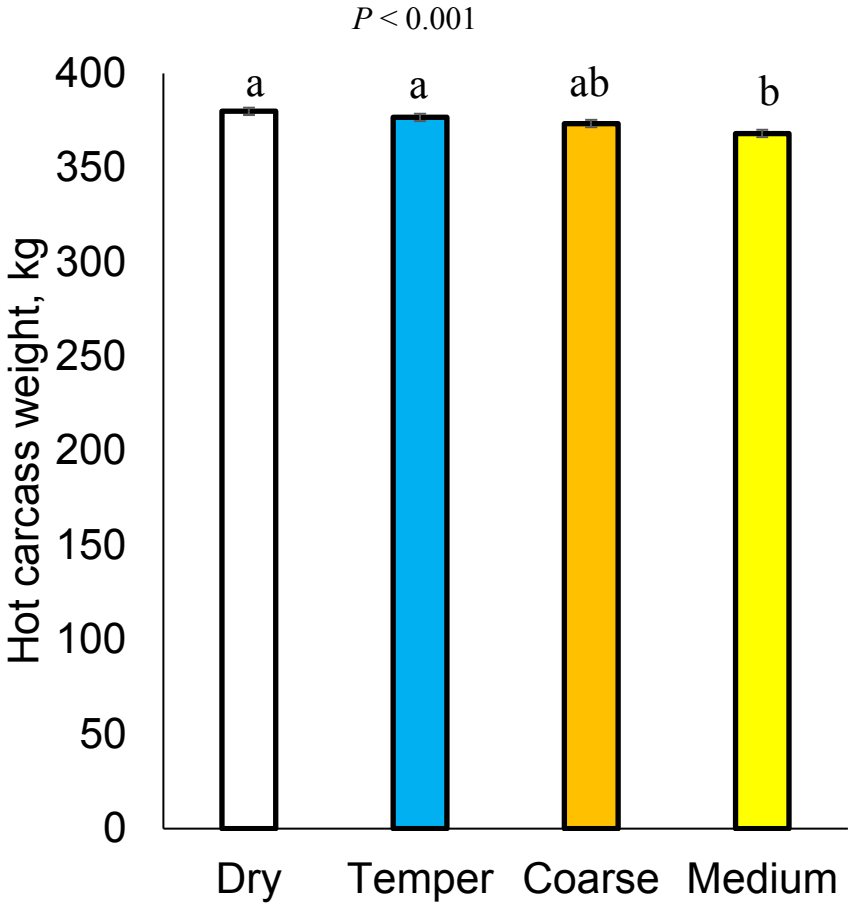
Growth performance study: G:F



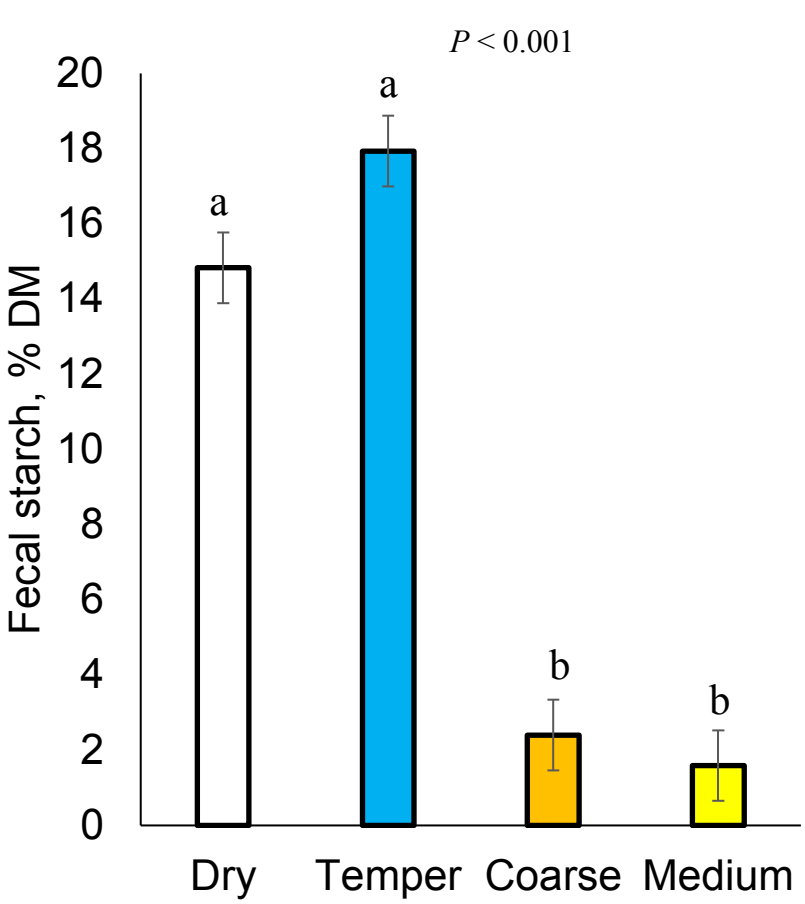
No effect on yield or quality grades!

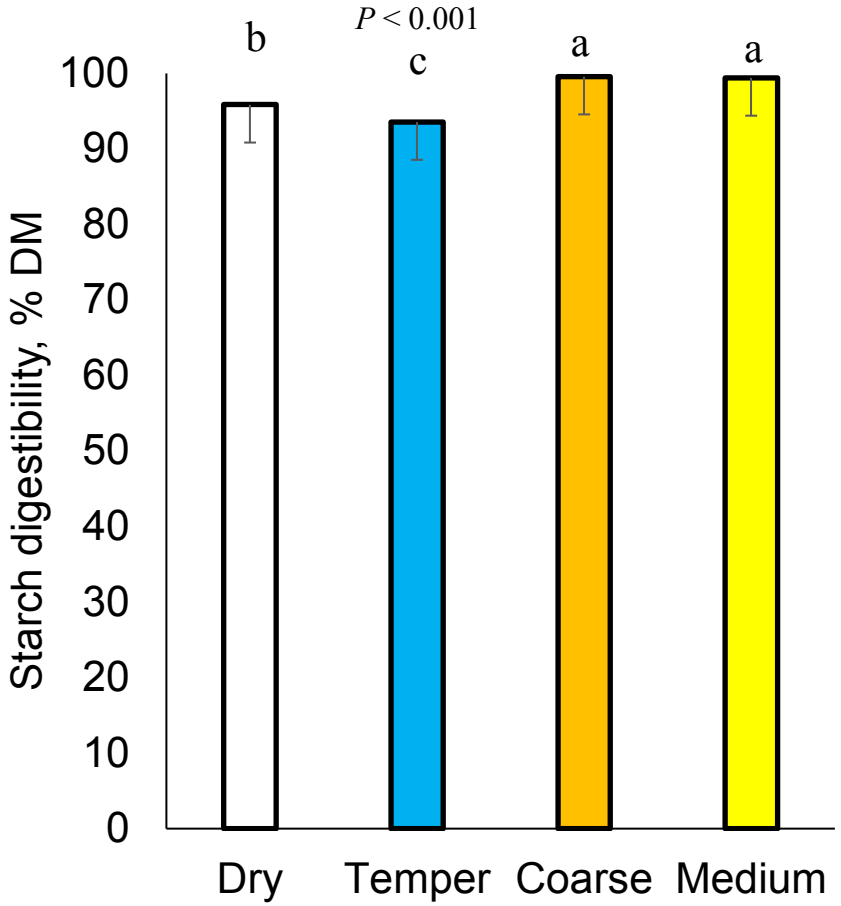
Growth performance study: carcass





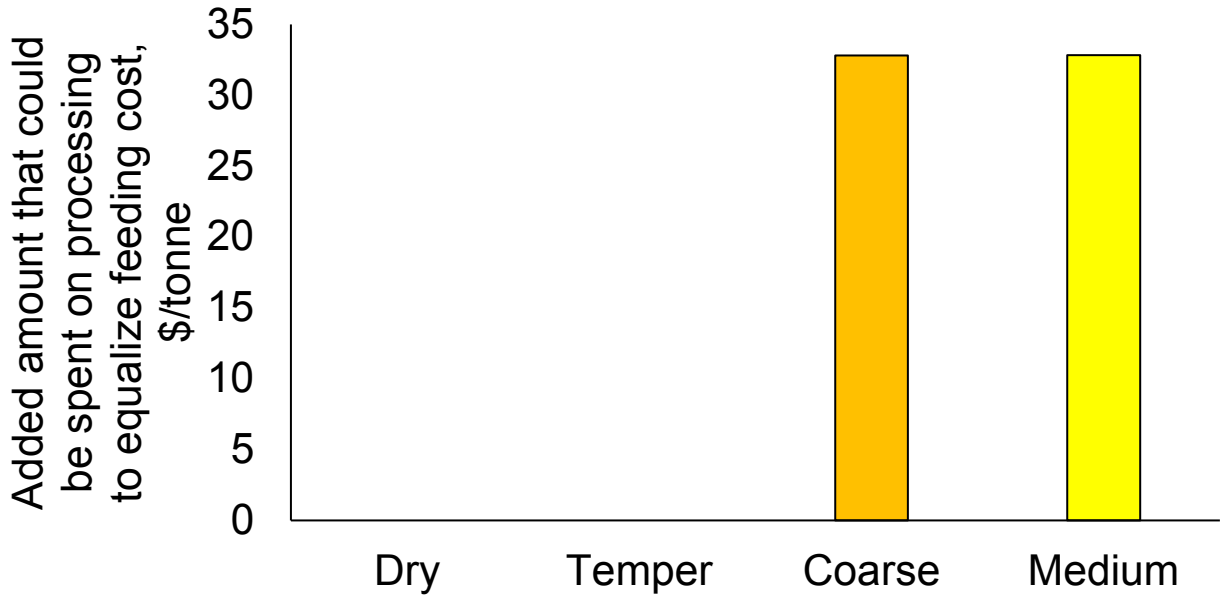
Growth performance study: starch digestibility





Economics of steam flaking

- Determined relative cost available based on changes in performance (DMI, ADG, G:F)
- Total gain was equalized (yardage @ $0.60/d)



Take home messages

- Steam-flaking barley decreases DMI, but improves starch digestibility and G:F relative to DR
- No advantage of TR relative to DR
- Severity of steam flaking (flaking density) can have a large impact suggesting that barley should be flaked coarsely

Funding support

- Industry partners

SaskBarley Development Commission

Saskatchewan Cattlemen's Association

Saskatchewan Real Growth. Real Opportunity.

DuPont Pioneer

Cargill