Feeding Value of Reduced-Oil DDGS in Livestock and Poultry Feeds

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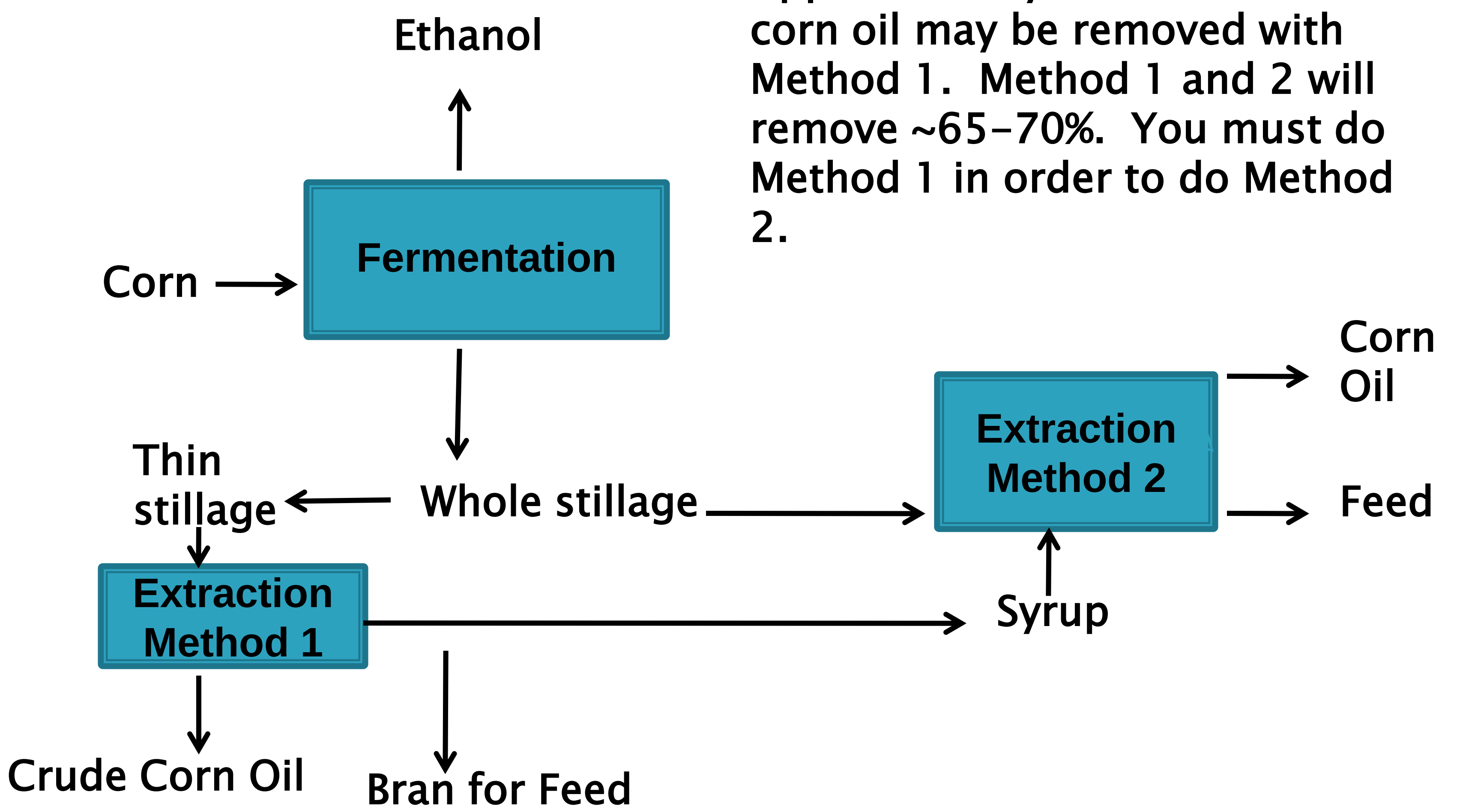
Oil extraction in the U.S. ethanol industry

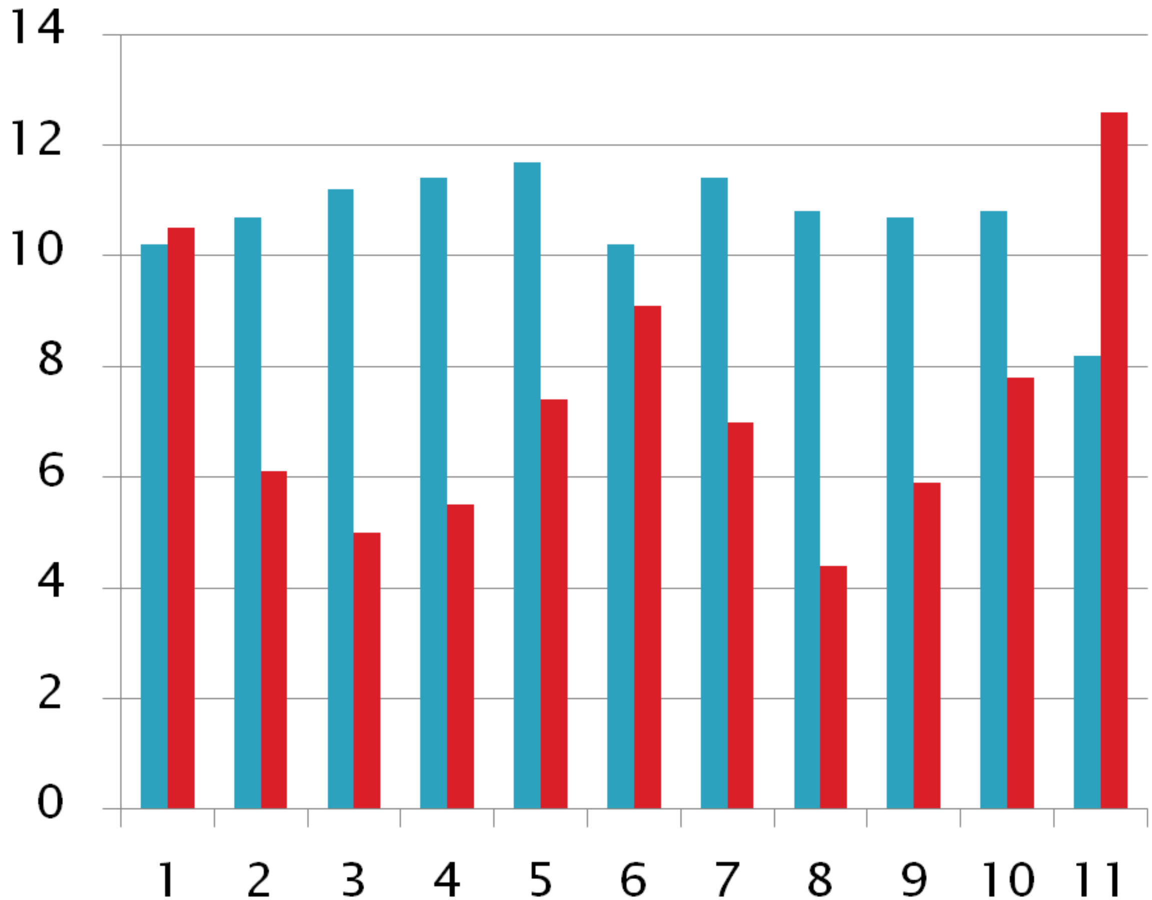
- Industry adoption
  - ~ 60% of ethanol plants are currently extracting oil
  - > 70% will be extracting oil by the end or 2012
- Oil uses
  - > 50% is being used in biodiesel production
  - < 50% is used in blended feed-fats (primarily by the poultry industry)
- Impact on DDGS
  - Reduced MT of DDGS
  - Reduced oil decreases energy content and feeding value
    - Crude fat content ranges from 5 to 13%
    - Most reduced oil DDGS is 8 to 9% crude fat
  - Research is being conducted to evaluate this impact

"Back-end" oil extraction process



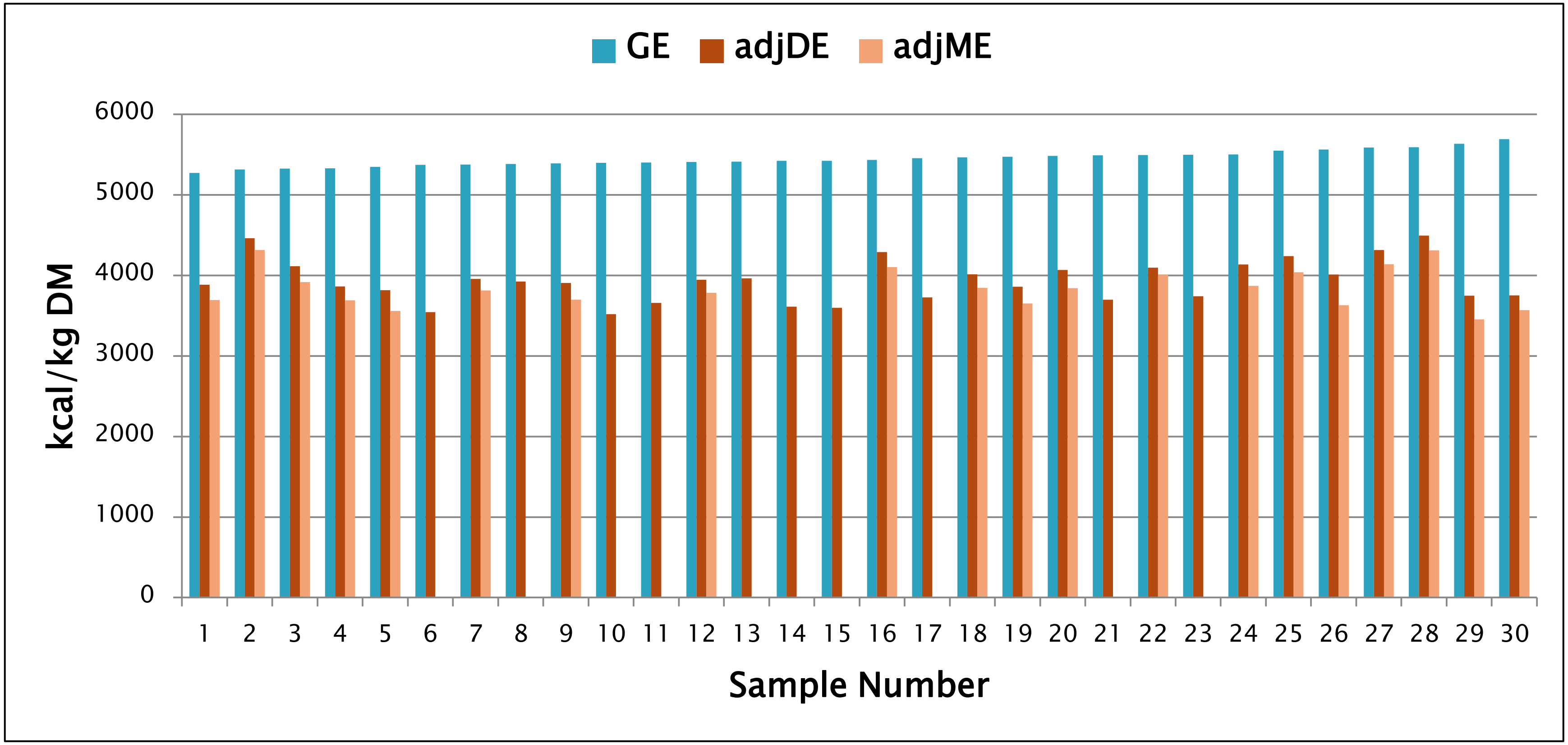
Approximately 30% of available corn oil may be removed with Method 1. Method 1 and 2 will remove ~65-70%. You must do Method 1 in order to do Method 2.

Crude fat content of DDGS has always varied among and within sources



Spiehs et al. (2002)

GE does not vary as much as DE and ME among DDGS sources

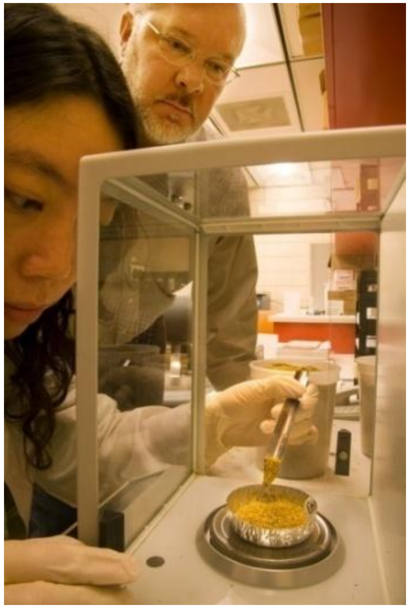


Note: DE and ME of DDGS within experiment were 'adjusted' relative to the DE and ME content of the corn basal diet

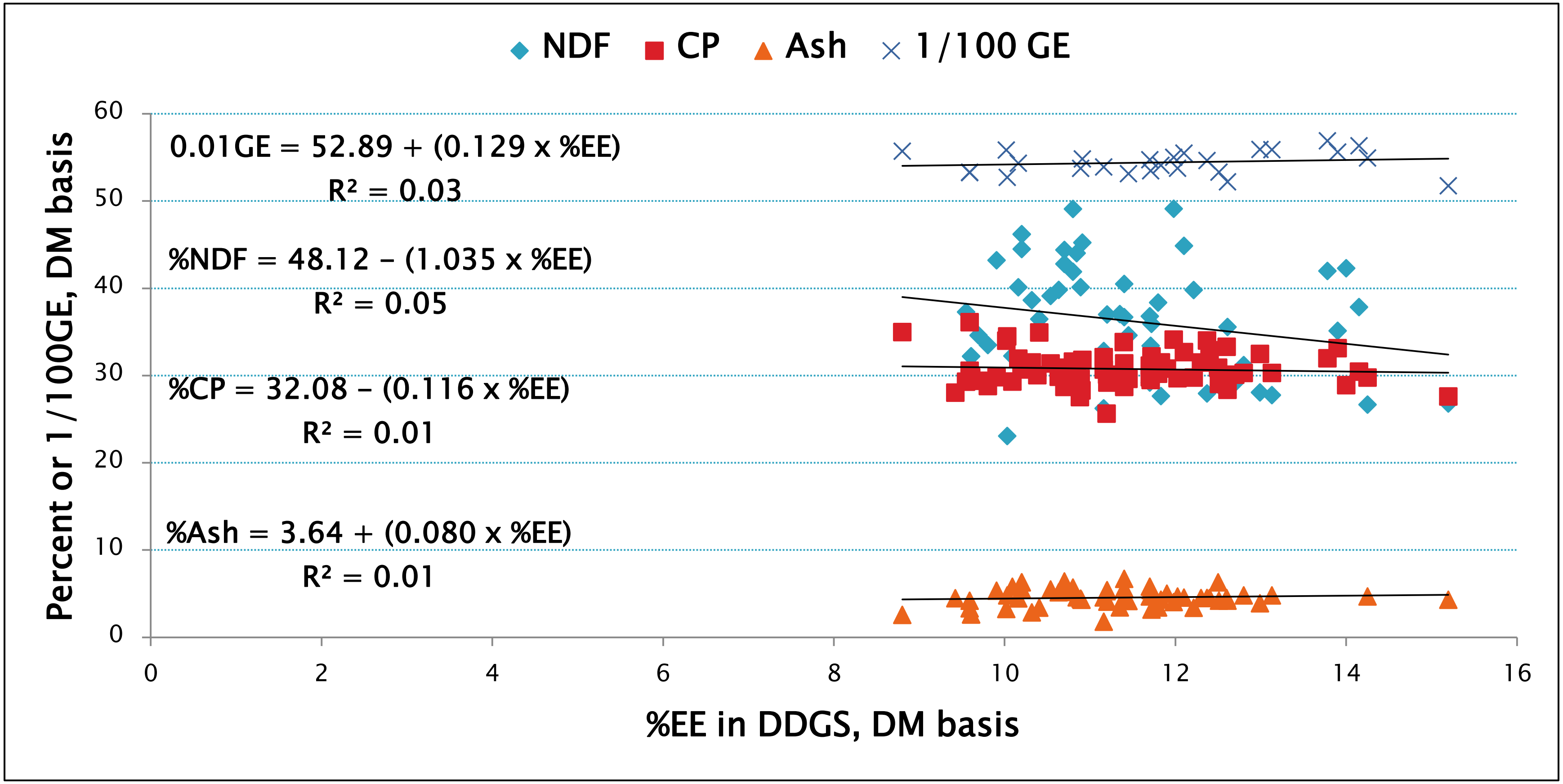
Source: Stein et al. (2006) [10], Pedersen et al. (2007) [10], Stein et al. (2009) [4], Anderson et al. (2012) [6]

Why does DE and ME content of DDGS vary so much?

- Different processes used in DDGS production
- Variable fat levels among sources
- Variable carbohydrate composition and digestibility
- Particle size varies from 200 to >1200 microns
- Experimental and analytical methods used



Poor relationships between GE, NDF, CP, and ash with crude fat (EE) in DDGS



Summary of published DDGS composition data from the scientific literature

Impact of Reduced-Oil DDGS on ME Content for Swine

Determination of DE and ME content of reduced oil DDGS in swine-Experiment 1

- 11 DDGS sources were evaluated (+basal)
- Range in nutrient profile (DM basis)
  - Crude fat – 8.6 to 13.2%
  - NDF – 28.8 to 44.0%
  - Starch – 0.8 to 3.9%
  - Crude protein – 27.7 to 32.9%
  - Ash – 4.3 to 5.3%

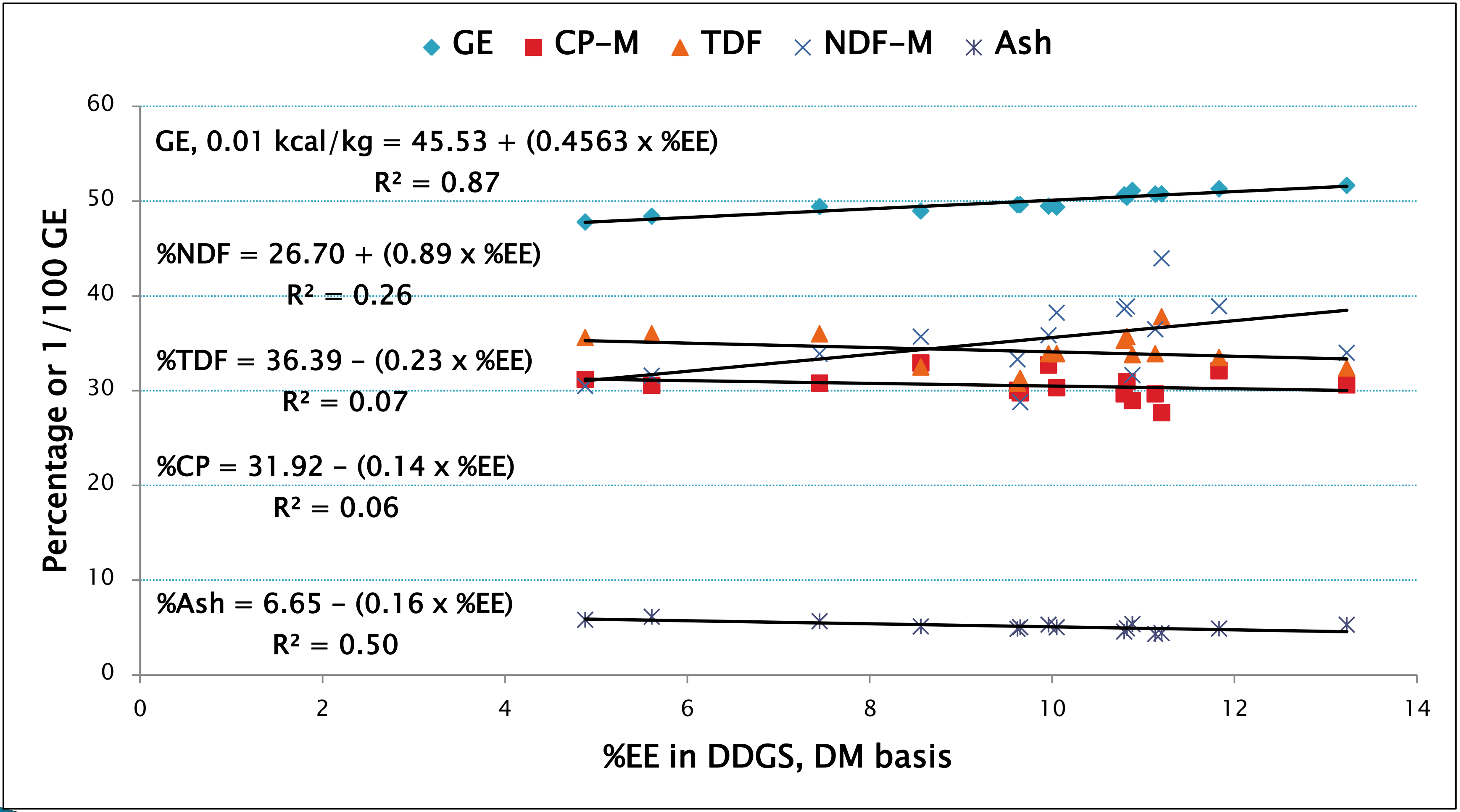
- **Particle size ranged from 622 to 1078 µm**
- 30% DDGS source was added to a corn basal diet (97.2% corn)
- **Fed to 84 kg gilts with an ADFI of 2.4 kg**
- 12 replications per DDGS source
- 9-d adaptation period and 4-d total collection period

Determination of DE and ME content of reduced oil DDGS in swine–Experiment 2

- 4 DDGS sources were evaluated (+basal)
- Range in nutrient profile (DM basis)
  - **Crude fat – 4.9 to 10.9%**
  - **NDF – 30.5 to 33.9%**
  - **Starch – 2.5 to 3.3%**
  - **Crude protein – 29.0 to 31.2%**
  - **Ash – 5.4 to 6.1%**

- **Particle size ranged from 294 to 379 µm**
- 30% DDGS source was added to a corn basal diet (97.2%)
- **Fed to 106 kg gilts with an ADFI of 2.7 kg**
- 15 replications per DDGS source
- 8-d adaptation period and 3-d total collection period

Relationship of RO-DDGS composition to EE content in Experiment 1 and 2



ME ranking of DDGS sources and nutrient content (DM basis) – Experiment 1

DDGS Source	ME, kcal/kg	Crude fat, %	NDF, %	Crude protein, %	Starch, %	Ash, %
8	3,603	13.2	34.0	30.6	1.3	5.3
11	3,553	11.8	38.9	32.1	1.1	4.9
9	3,550	9.7	28.8	29.8	2.8	5.0
6	3,513	9.6	33.0	30.1	3.4	4.9
7	3,423	10.1	38.2	30.3	2.2	5.0
2	3,400	11.1	36.5	29.7	3.9	4.3
4	3,362	8.6	35.7	32.9	0.8	5.1
3	3,360	10.8	38.6	29.7	1.6	4.6
10	3,327	10.0	35.9	32.7	1.0	5.3
1	3,302	11.2	44.0	27.7	1.8	4.4
5	3,277	11.1	39.7	31.6	0.9	5.0

Green = highest value
Red = lowest value

We can't use crude fat to estimate ME content!! (Experiment 1)

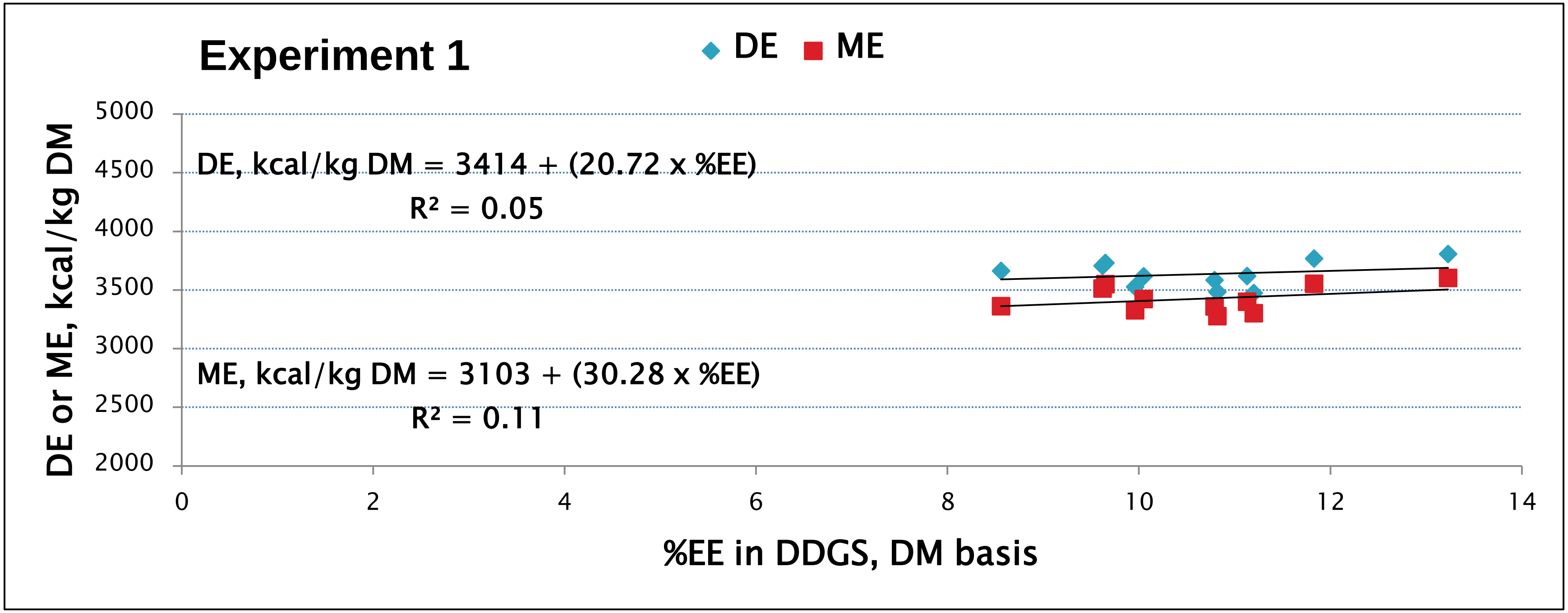
DDGS Source	DDGS Source 11	DDGS Source 9	DDGS Source 8	DDGS Source 5
ME, kcal/kg	3,553	3,550	3,603	3,277
Crude fat, %	11.8	9.7	13.2	11.1
Starch, %	1.1	2.8	1.3	0.9
NDF, %	38.9	28.8	34.0	39.7
Crude protein, %	32.1	29.8	30.6	31.6
Ash, %	4.9	5.0	5.3	5.0

Comparing DDGS Source 11 vs. 9:

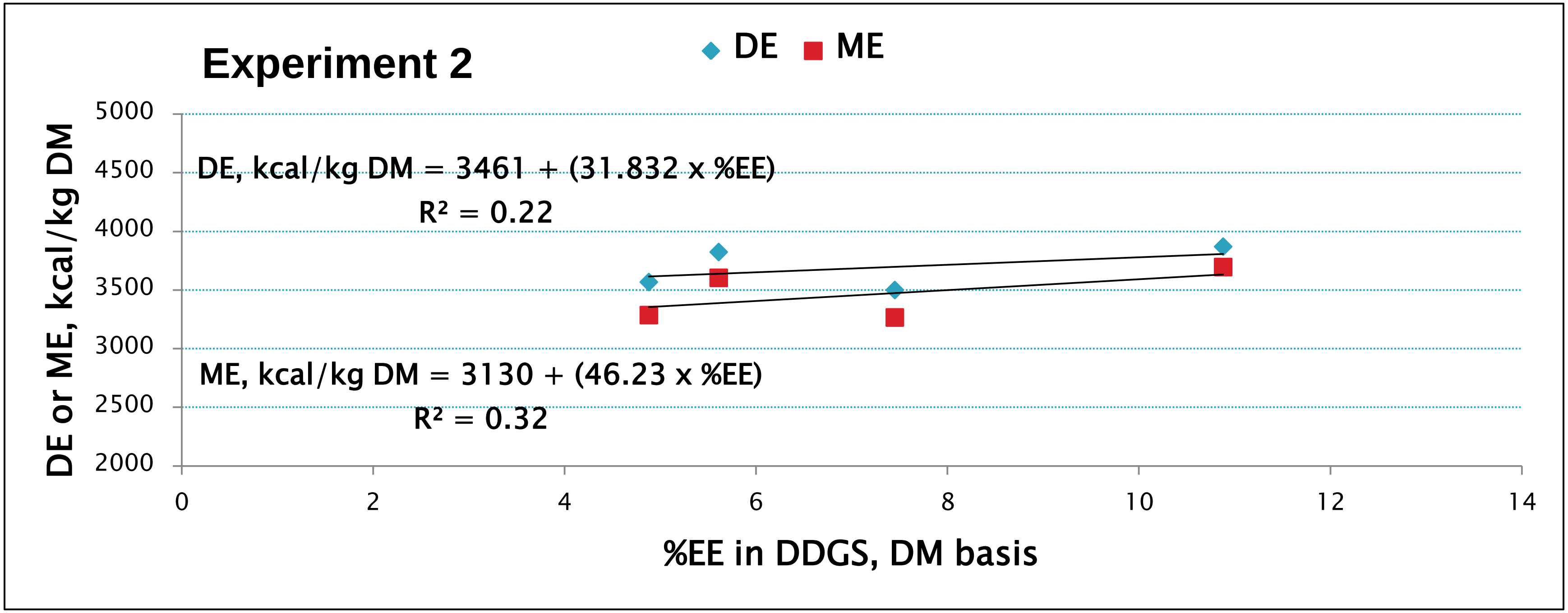
2.1 percentage unit decrease in fat reduced ME by **3** kcal/kg

Comparing DDGS Source 8 vs. 5:

2.1 percentage unit decrease in fat reduced ME by **326** kcal/kg



Experiment 1
DE
ME
DE, kcal/kg DM = 3414 + (20.72 x %EE)
R² = 0.05
ME, kcal/kg DM = 3103 + (30.28 x %EE)
R² = 0.11
DE or ME, kcal/kg DM
5000
4500
4000
3500
3000
2500
2000
0
2
4
6
8
10
12
14
%EE in DDGS, DM basis



Experiment 2
DE
ME
DE, kcal/kg DM = 3461 + (31.832 x %EE)
R² = 0.22
ME, kcal/kg DM = 3130 + (46.23 x %EE)
R² = 0.32
DE or ME, kcal/kg DM
5000
4500
4000
3500
3000
2500
2000
0
2
4
6
8
10
12
14
%EE in DDGS, DM basis

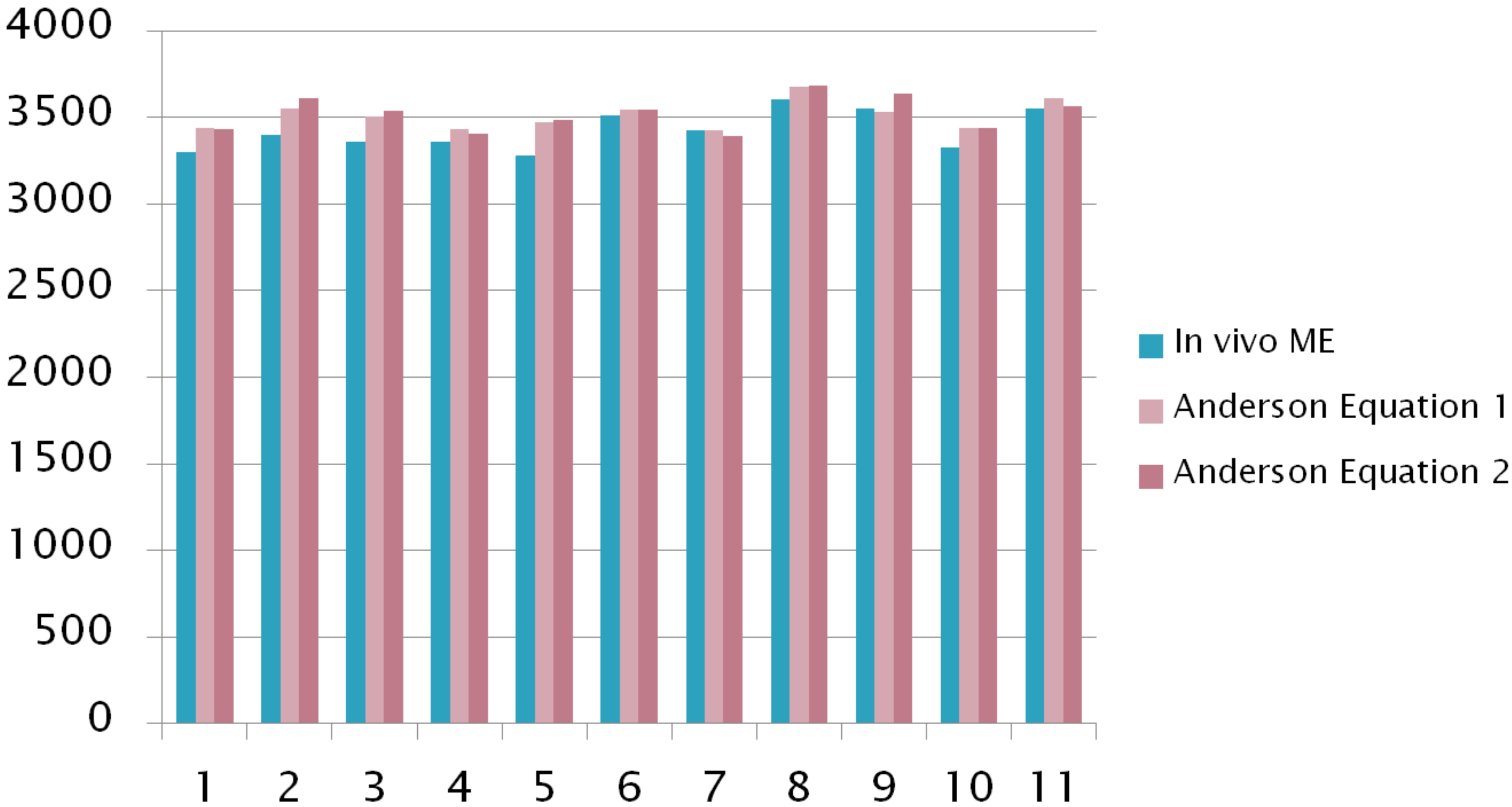
DDGS ME Prediction Equations from Anderson et al. (2012)

- Dehulled, degermed corn
- Dried solubles
- Oil
- Starch
- Germ meal (2)
- DDGS (7)
- Gluten meal
- HP-DDG (3)
- Bran (2)
- Gluten feed

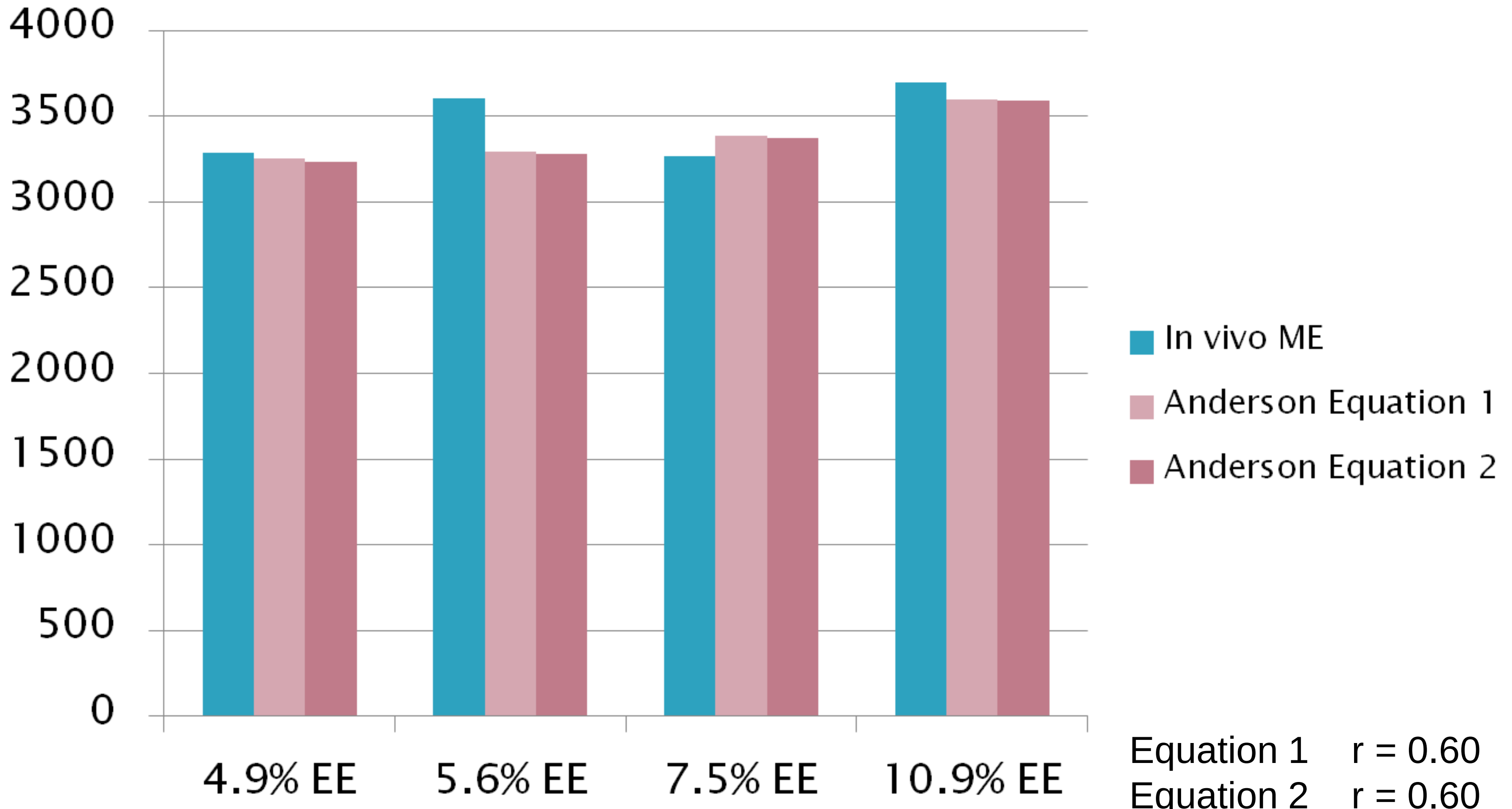
(1) ME kcal/kg DM = (0.90 × **GE**, kcal/kg) − (29.95 × % **TDF**)
$r^2 = 0.72$

(2) ME kcal/kg DM = (0.94 × **GE**, kcal/kg) − (23.45 × % **NDF**) − (70.23 × % **Ash**)
$r^2 = 0.68$

Anderson equations reasonably predict swine ME content of RO-DDGS (Experiment 1)

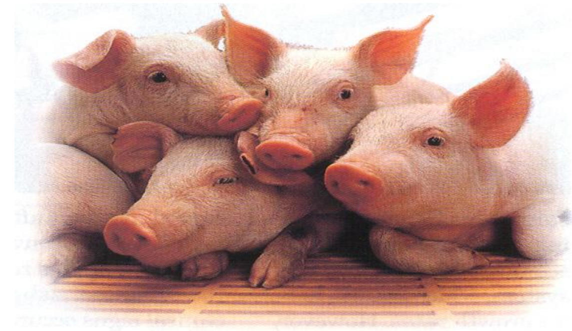


Anderson equations reasonably swine ME content of RO-DDGS (Experiment 2)



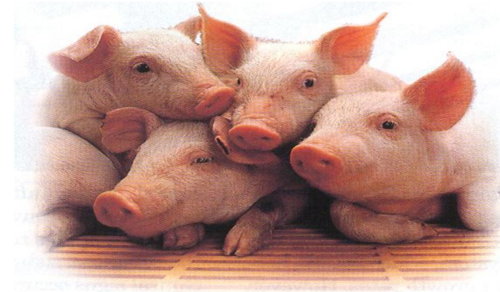
Equation 1 r = 0.60
Equation 2 r = 0.60

Conclusions



- A percentage unit reduction in crude fat DOES NOT accurately estimate the change in DE and ME in reduced oil-DDGS
- Accurate assessment of fiber content continues to be a challenge in DDGS
- There is considerable variation in chemical composition measurements among laboratories which affects ME prediction
- Recommended swine ME prediction equations for reduced-oil DDGS:
  - ME kcal/kg DM = (0.90 × GE, kcal/kg) − (29.95 × % TDF)
  - ME kcal/kg DM = (0.94 × GE, kcal/kg) − (23.45 × % NDF) − (70.23 × % Ash)
  - ME kcal/kg DM = 4,548 – (49.7 x % TDF) + (52.1 x % EE)
  - ME kcal/kg DM = 3,711 – (21.9 x % NDF) + (48.7 x % EE)
  - ME kcal/kg DM = 4,132 – (57.0 x % ADF)

Conclusions



- Equations containing GE and TDF are most predictive
  - GE and TDF values are more difficult to obtain from commercial laboratories

- If GE cannot be directly determined, the following GE prediction equations can be used:
  - GE kcal/kg DM = 4,195 + (21.26 × crude protein) + (48.27 × crude fat)
  - GE kcal/kg DM = 4,597 + (64.45 × % crude fat) – (52.65 × % Ash)
  - GE kcal/kg DM = 4,529 + (54.21 × % crude fat)

Impact of Reduced-Oil DDGS on AME Content and Performance for Poultry

Reduced-oil DDGS nutrient profiles

Nutrient	Normal DDGS	Medium Oil DDGS	Low Oil DDGS
Crude protein, %	28.9	28.3	27.5
Crude fat, %	11.2	7.3	5.6
Crude fiber, %	7.4	6.9	6.8
Lysine, %	1.00	0.86	0.83
Methionine, %	0.55	0.58	0.55
Cysteine, %	0.74	0.70	0.57
TSAA, %	1.19	1.28	1.12
Phosphorus, %	0.98	0.84	0.91

Source: Purdum and Kreifels (2012)

Experimental Diet Formulations

Ingredient	Control (0% DDGS)	Reduced-oil DDGS Diets
Corn	55.7	45.9
Soybean meal (47%)	29.5	19.1
DDGS	0.0	20.0
Corn oil	2.83	3.02
Limestone	9.62	9.92
Dicalcium phosphate	1.58	1.21
Salt	0.42	0.32
L-lysine	0.03	0.21
dl-methionine	0.17	0.16
VTM premix	0.20	0.20
Calculated M.E. (kcal/kg)	2,860	2,860
Protein, %	18.0	18.0

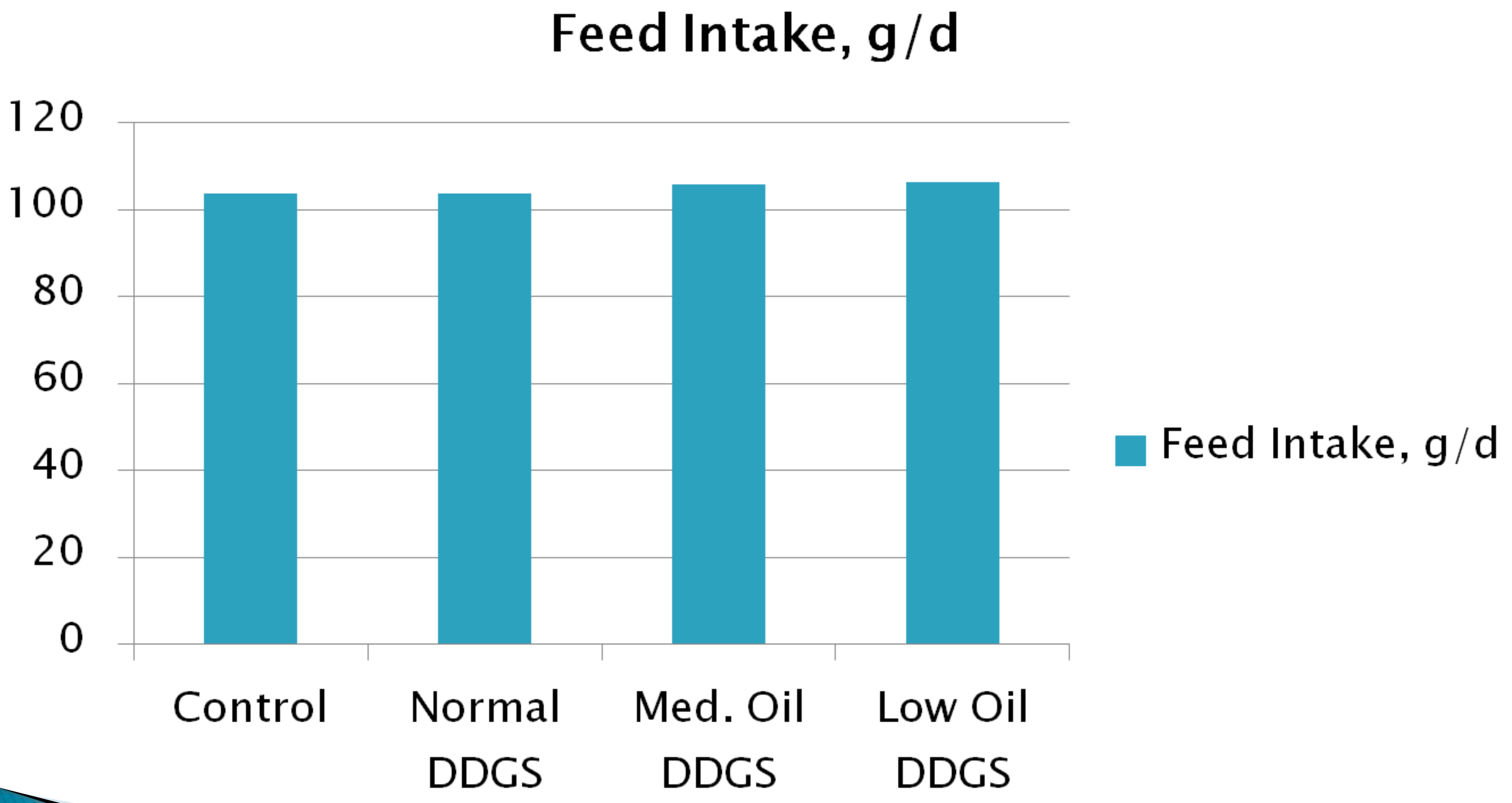
No ME adjustments were made for medium and low oil DDGS diets.
Source: Purdum and Kreifels (2012)

GE content and intake of reduced-oil DDGS diets

Diet	Dietary GE, kcal/kg	GE intake, kcal/hen/d
Control	3,780	392
Normal DDGS	3,958	410
Medium Oil DDGS	3,917	414
Low Oil DDGS	3,806	404

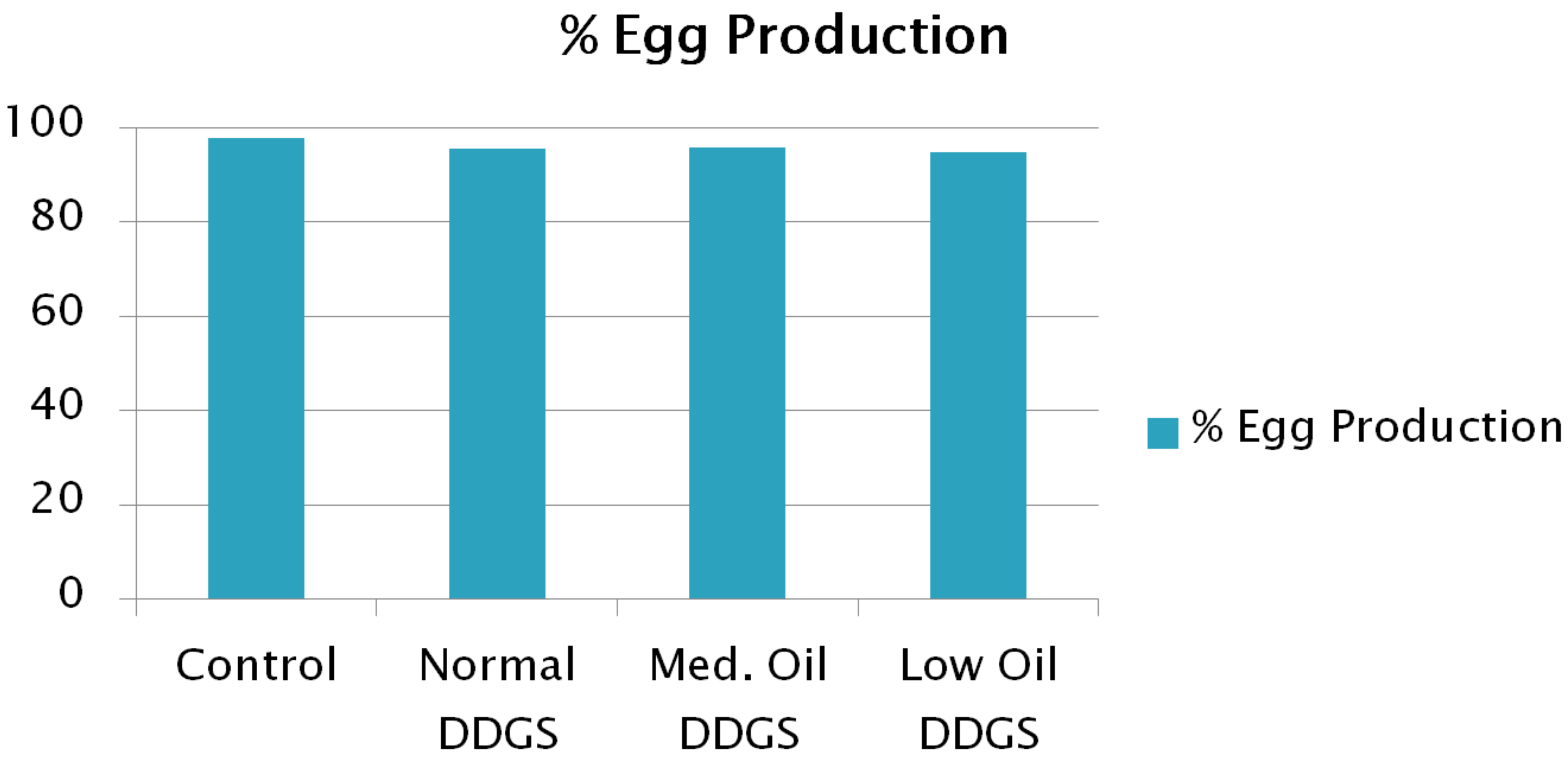
Source: Purdum and Kreifels (2012)

Effect of reduced-oil DDGS on feed intake



Source: Purdum and Kreifels (2012)

Effect of reduced-oil DDGS on % egg production



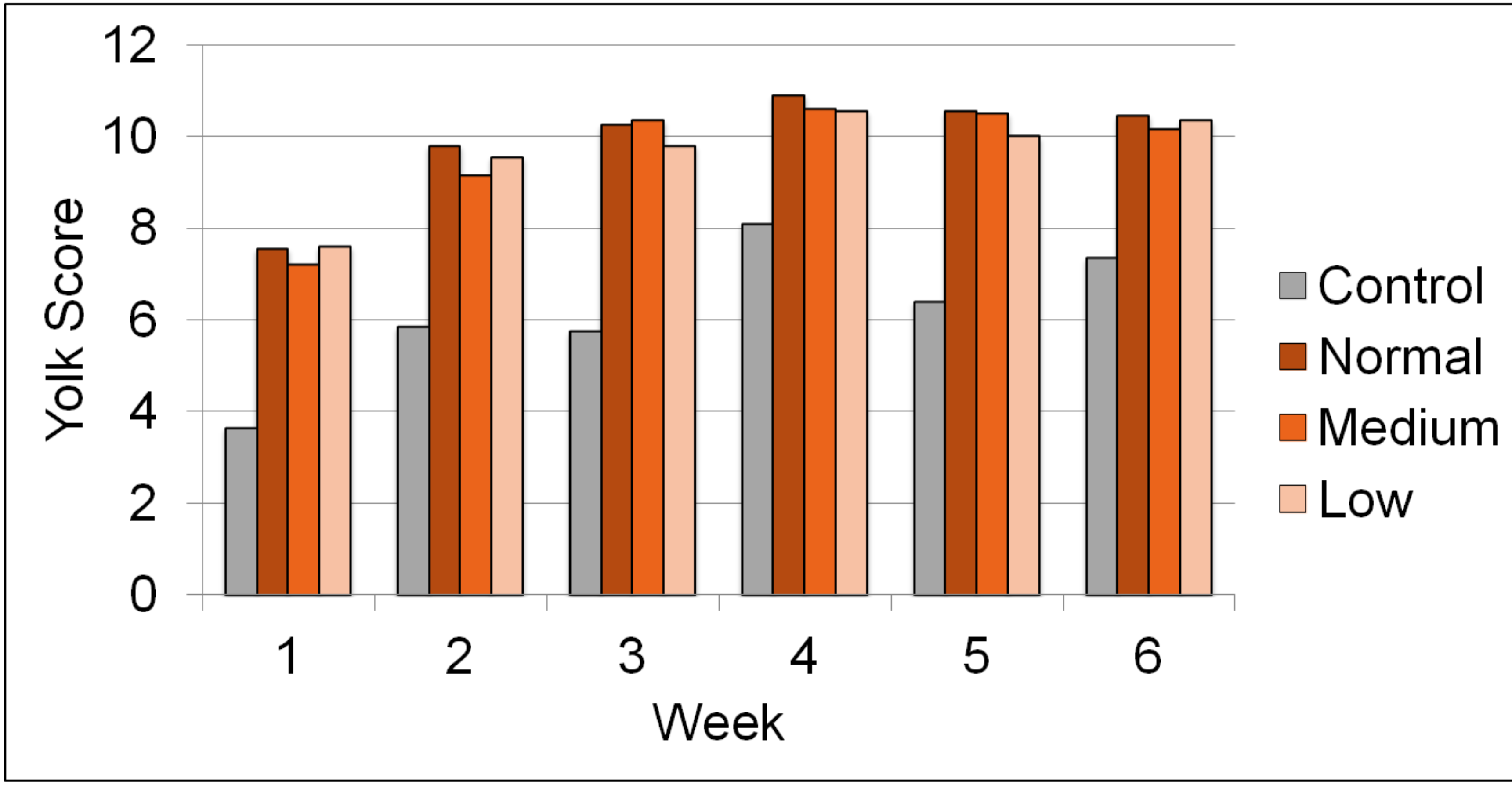
Source: Purdum and Kreifels (2012)

Effect of reduced-oil DDGS on egg weight and feed conversion

Diet	Hen BW, g	Egg Wt., g	Feed Conversion (g feed:g egg)
Control	1,515	58.8	1.76
Normal DDGS	1,541	59.0	1.77
Med. Oil DDGS	1,506	59.9	1.76
Low Oil DDGS	1,530	59.7	1.75

Source: Purdum and Kreifels (2012)

Effect of reduced-oil DDGS on yolk color Roche scores



Source: Purdum and Kreifels (2012)

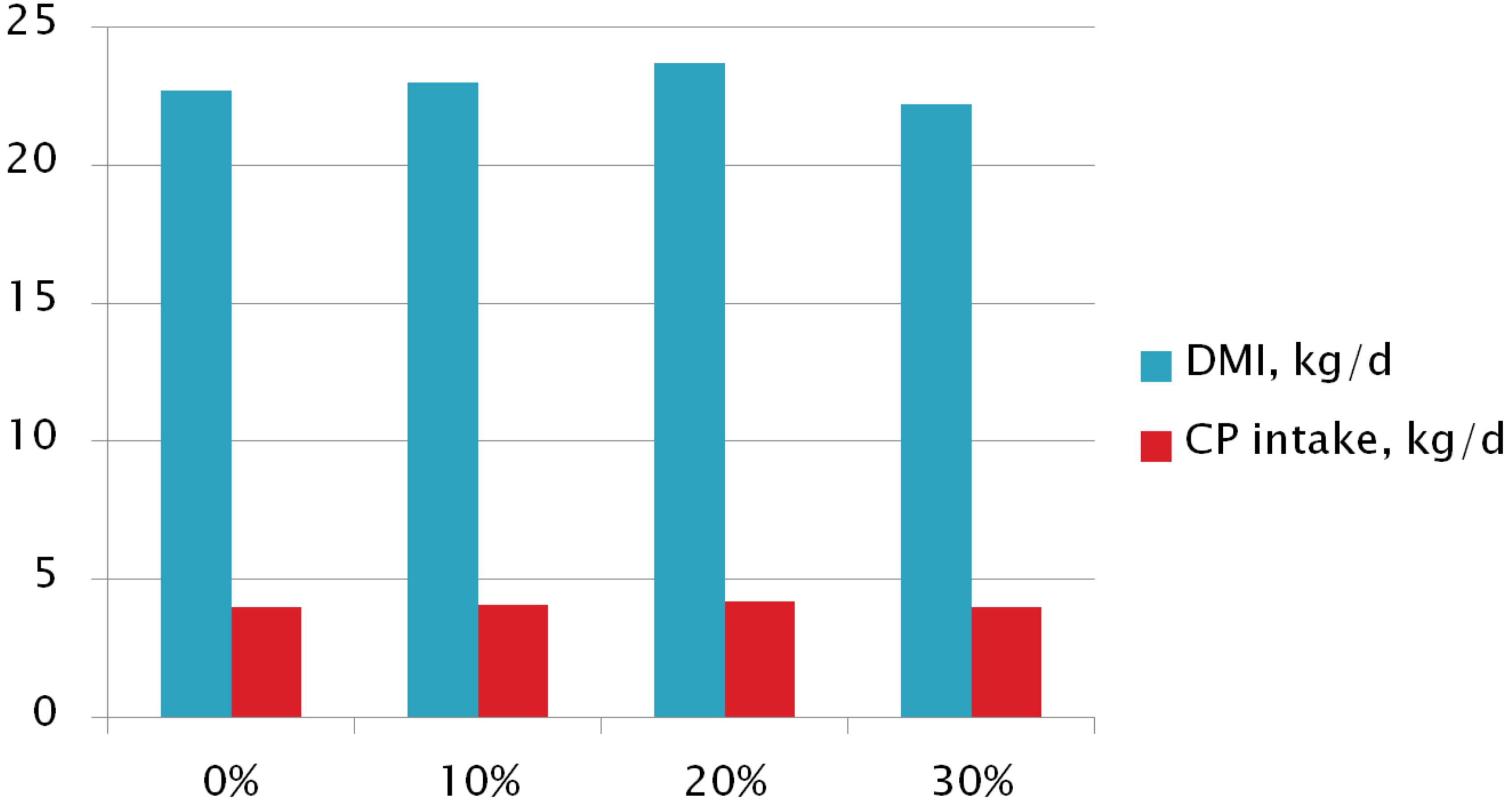
Conclusions

- Reduced-oil DDGS provides equivalent layer performance to "typical" DDGS.
- Hens slightly increase feed intake (2 to 2.4 g/d) when fed reduced-oil DDGS diets.
- Layers will be impacted less than broilers when fed reduced-oil DDGS because of lower diet ME requirements.
- AME_n of reduced-oil DDGS can be estimated by using the following equation:
  - **AME_n (kcal/kg DM) = 3,517 – (33.27 x % hemicellulose) + (46.02 x % crude fat) – (82.47 x % ash)**

    Rochelle et al. (2011)
  - **Hemicellulose can be calculated by % NDF – % ADF**

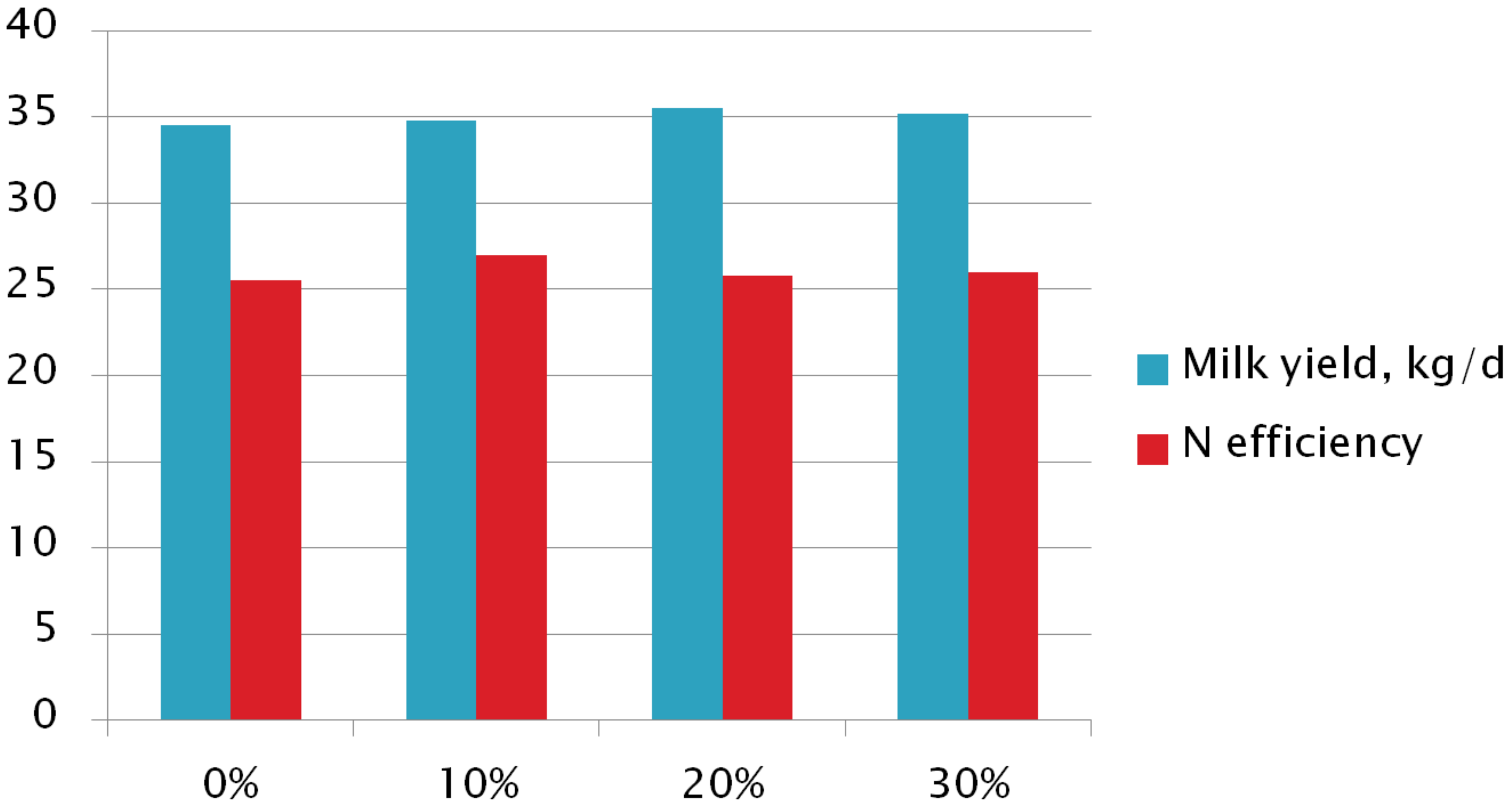
Impact of Reduced-Oil DDGS on Milk Production of Lactating Dairy Cows

Dry matter and protein intake of lactating dairy cows fed 0 to 30% reduced-oil DDGS (3.5% crude fat)



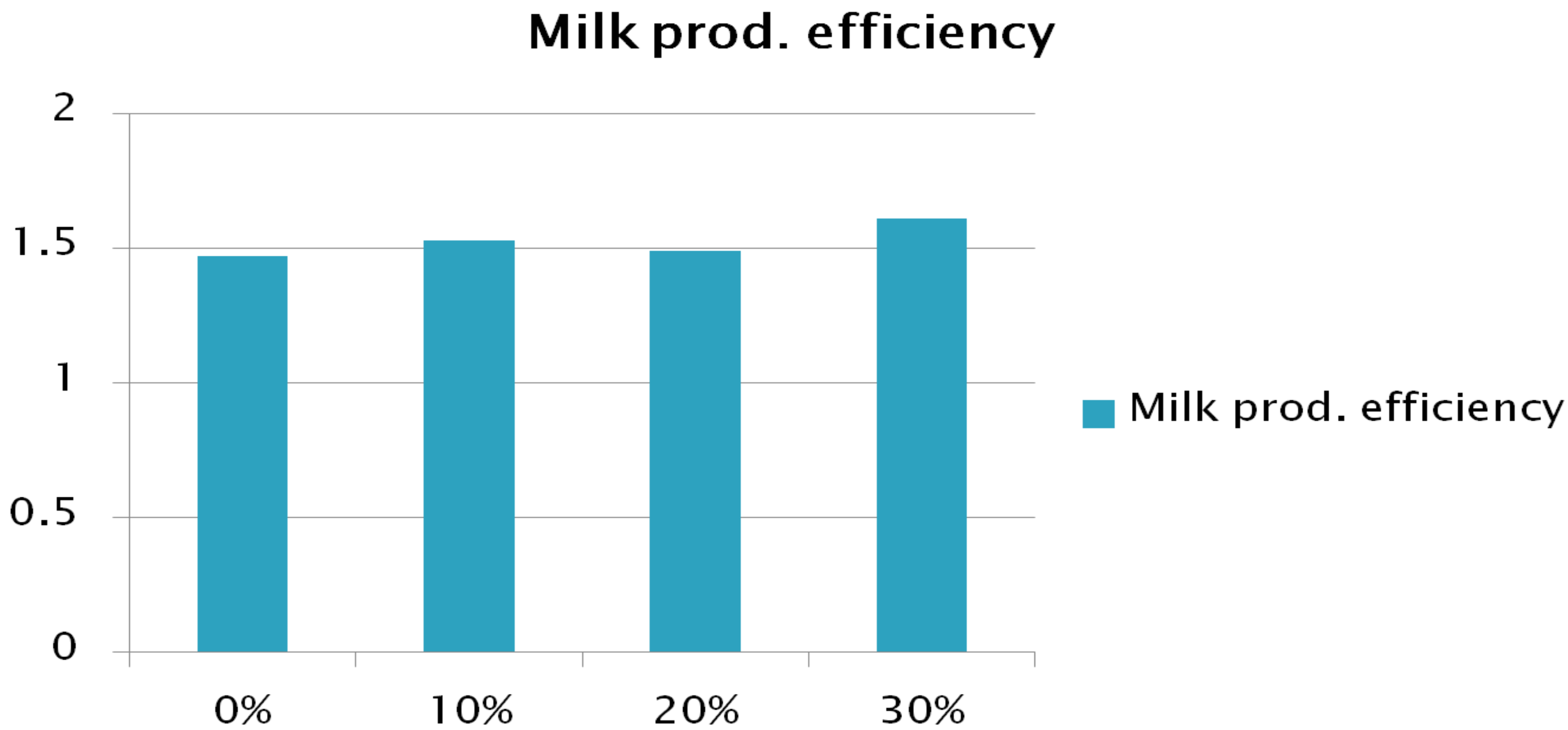
No differences among treatments

Milk yield and N efficiency of lactating dairy cows fed 0 to 30% reduced-oil DDGS (3.5% crude fat)



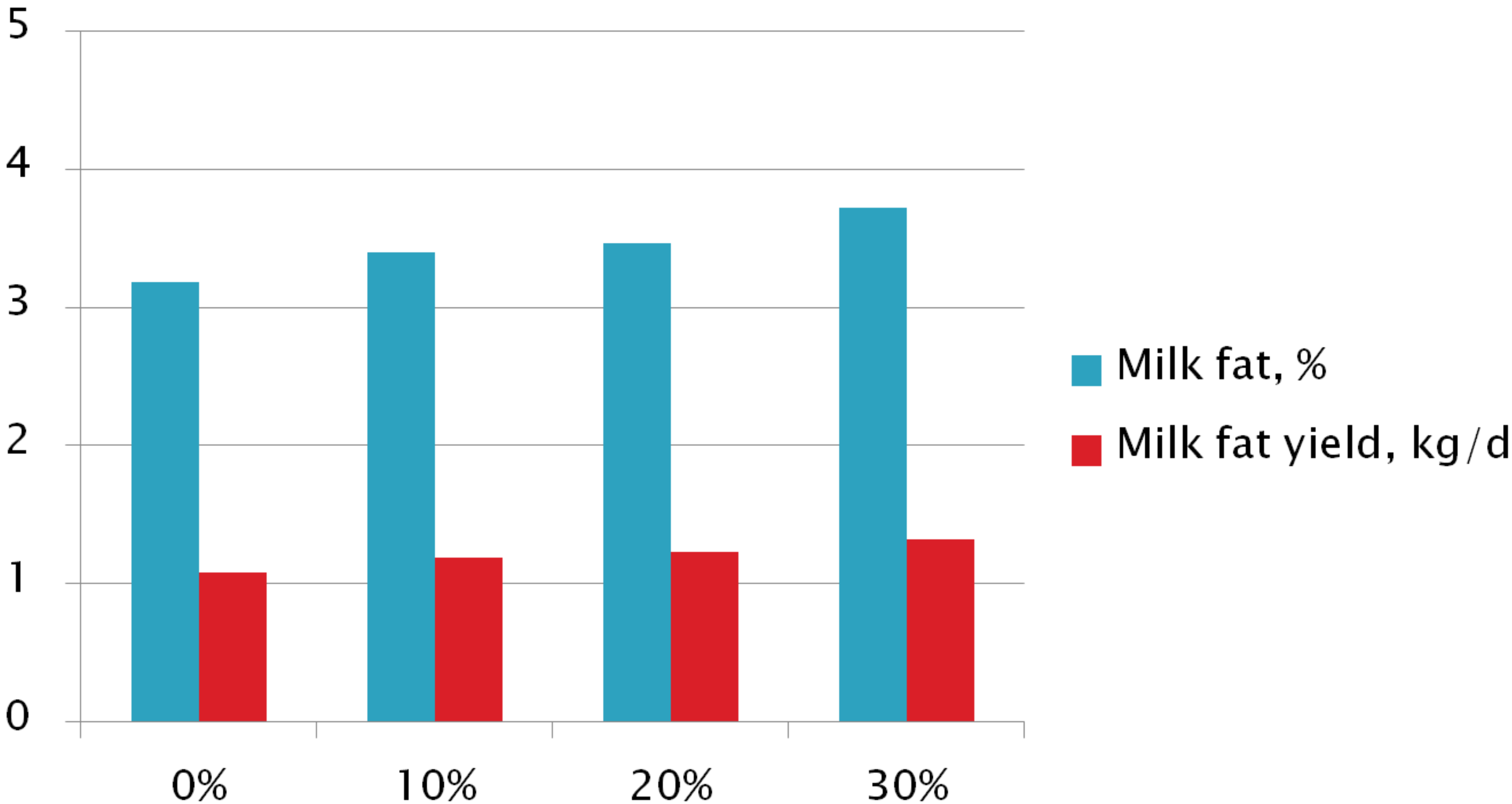
Linear increase in milk yield ($P < 0.05$)
N efficiency = kg milk N per d / kg N intake per d
Mjoun et al. (2010)

Milk production efficiency of lactating dairy cows fed 0 to 30% reduced-oil DDGS (3.5% crude fat)



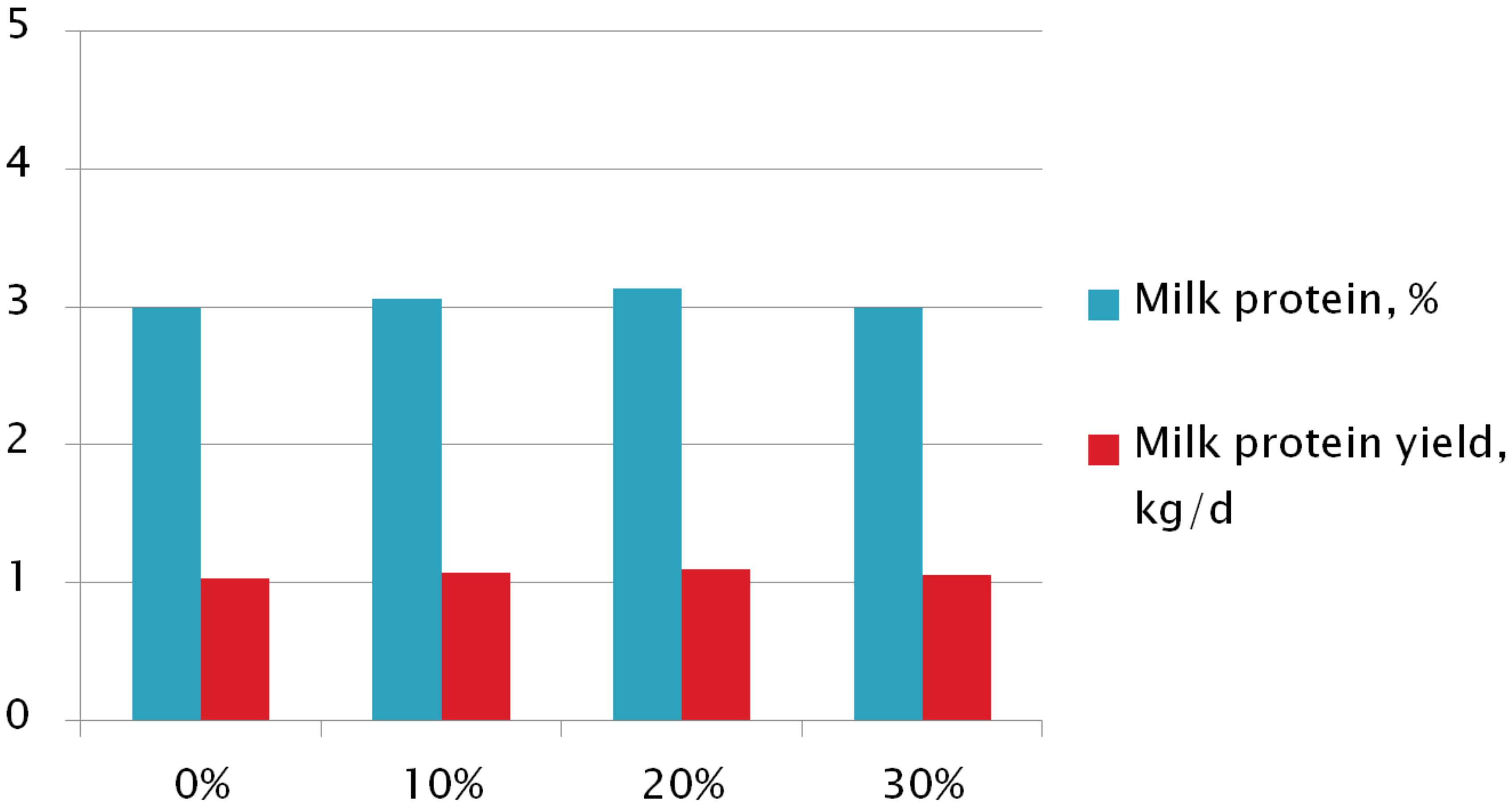
Linear increase (P < 0.06)
Milk prod. efficiency = energy-corrected milk / DMI
Mjoun et al. (2010)

Milk fat concentration and yield of lactating dairy cows fed 0 to 30% reduced-oil DDGS (3.5% crude fat)



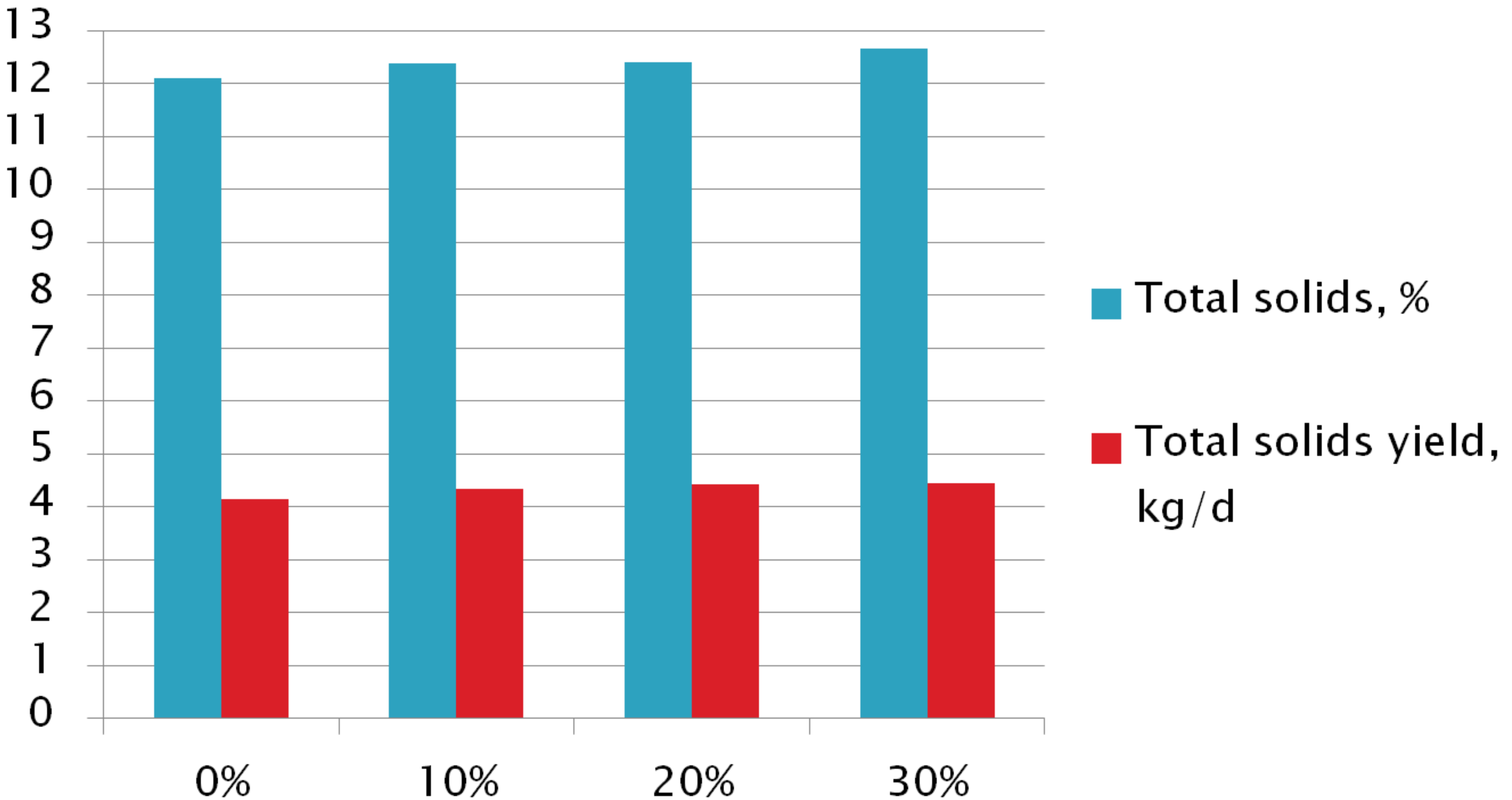
Linear increase in milk fat % and fat yield ($P < 0.05$)
Mjoun et al. (2010)

Milk protein concentration and yield of lactating dairy cows fed 0 to 30% reduced-oil DDGS (3.5% crude fat)



Quadratic effect on milk protein % ($P < 0.02$)
Mjoun et al. (2010)

Milk total solids concentration and yield of lactating dairy cows fed 0 to 30% reduced-oil DDGS (3.5% crude fat)



Linear increase in milk total solids % and yield ($P < 0.05$)
Mjoun et al. (2010)

Summary

- Feeding diets containing up to 30% reduced-oil DDGS (3.5% crude fat):
  - Had no effect on:
    - Dry matter intake
    - Crude protein intake
    - Nitrogen efficiency
    - Milk yield
  - Increased:
    - Milk production efficiency
    - Milk fat % and milk fat yield
    - Milk protein % (quadratically)
    - Milk total solids %

Impact of Reduced-Oil DDGS on Performance and Carcass Composition of Beef Cattle

Reduced-oil DDGS for finishing beef cattle

	Corn	DDGS (6.7% crude fat)	DDGS (12.9% crude fat)
Initial BW, kg	403	402	402
Final BW, kg	587[a]	587[a]	604[b]
DMI, kg/day	11.1	11.1	11.1
ADG, kg	1.55[a]	1.55[a]	1.68[b]
Feed:Gain	7.19	7.19	6.58
HCW, kg	370[a]	370[a]	380[a]
12th rib fat, mm	11.9	13.2	13.5
Loin muscle area, cm^2	864	832	845
Marbling score	614	591	617

[a,b]Means with different superscripts are different ($P < 0.05$).

Source: University of Nebraska (Gigax et al., 2011).

For each one percentage point decrease in DDGS oil content, NE_g decreases 1.3%

Conclusions

- Feeding reduced-oil DDGS (6.7% crude fat):
  - Provides equal growth performance and carcass quality compared to corn
  - Reduces growth performance compared to "typical" DDGS (12.9% crude fat)
  - NE_g content of reduced-oil DDGS can be estimated for beef cattle based on:
    - Each one percentage point decrease in DDGS oil content decreases NE_g by 1.3%