Effects of Grain Sorghum on Pig Performance and Carcass Traits

高粱对猪生产性能及胴体性状的影响

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Use of sorghum in swine diets
猪料中的高粱使用

- Background
  - 背景
  - 加工
- Nutrient values
  - 营养价值
- Nursery, finishing, and sow nutrition

Background on Sorghum
有关高粱的事实

- Sorghum grain is an excellent energy source
- 高粱是一种很好能量来源
- Can completely replace the corn in swine diets.
- 在猪料中，高粱能完全替代玉米
- The keys to using grain sorghum in swine diets is recognizing:
- 猪料中使用高粱的重点：
  - Slightly lower energy value compared with corn (98%)
  - 能量比玉米低一点，约为玉米能量成分的98%
  - Need for proper grinding
  - 需要合适的粉碎加工
  - Capitalizing on its standardized ileal digestible amino acid profile
  - 利用其标准化的回肠可消化的氨基酸资料

Nutrient composition of sorghum

高粱营养成分

	Sorghum高粱	Corn玉米	Sorghum:corn 高粱比玉米
干物质 Dry matter, %	89.0	89.0	100%
能量 Energy(千卡/kg)			
消化能 Digestible	3,380	3,525	96%
代谢能 Metabolizable	3,340	3,420	98%
粗蛋白 Crude Protein %	9.2	8.3	**111%**
钙质Calcium, %	0.03	0.03	100%
磷 Phosphorus, %	0.29	0.28	104%
可用磷Available P, %	0.058	0.039	**149%**
粗脂肪Crude fat, %	2.9	3.9	**74%**
亚油酸Linoleic acid%	1.13	1.92	**59%**
粗纤维Crude fiber, %	2.4	2.2	109%
中性洗涤纤维NDF, %	9.4	10.4	90%
酸性洗涤纤维ADF, %	3.8	2.6	146%

	Corn玉米	Sorghum高粱
Corn 玉米	73.33	---
Sorghum 高粱	---	75.02
Soybean meal 豆粕	23.84	**21.77**
Monocalcium P 磷酸二氢钙	0.60	**0.55**
L-Lys-HCL L-赖氨酸盐酸盐	0.30	**0.40**
DL-Met DL-蛋氨酸	0.05	0.11
L-Thr L-苏氨酸	0.08	0.10
L-Trp L-色氨酸	0.01	0.02
Vitamin & minerals 维生素和矿物质	1.80	1.85
TOTAL 总计	100	100
Lysine, % 赖氨酸 %	1.00	1.00
Isoleucine:lysine 异亮氨酸：赖氨酸	62	63
Met & cys:lysine 蛋氨酸加半胱氨酸：赖氨酸	55	55
Threonine:lysine苏氨酸：赖氨酸	61	61
Tryptophan:lysine色氨酸：赖氨酸	18.5	18.5
Valine:lysine 缬氨酸：赖氨酸	69	69
Ca, % 钙%	0.61	0.61
Available P, % 可用磷	0.29	0.29

Available Phosphorus in Sorghum

- Because grain sorghum contains more available P than corn, the amount of monocalcium P added to diets can be reduced by resulting in less P excretion in swine waste.

Sorghum vs Corn 高粱对玉米

(finishing research 研究尚未完成）

- 10 experiments before 1985 (Cromwell, 1985)
  - 85年前有10个试验
- 9 experiments after 1985 (Sulabo, 2010)
  - 85年后有9个试验

Sorghum value relative to corn

高粱相对于玉米的价值

	Cromwell	Sulabo
日均增重 ADG	98%	103%
日均采食量 ADFI	102%	106%
料重比 F/G	97%	98%

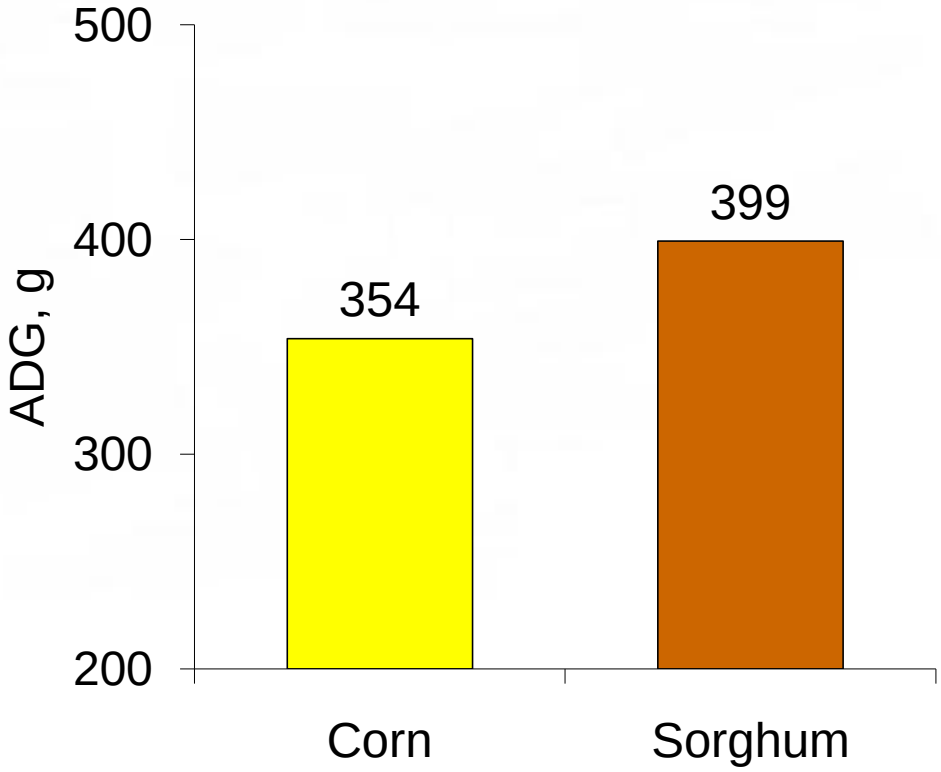
Relative value (%) of sorghum versus corn in finishing pigs

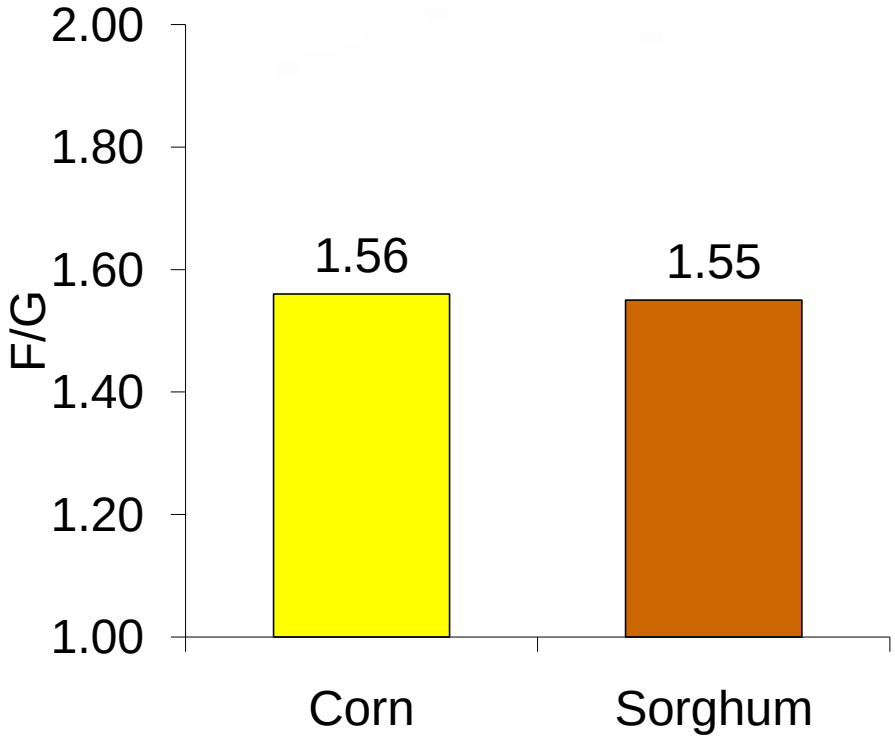
用于育肥猪相对价值（%）高粱比玉米

Study 试验	ADG 日均增重	ADFI 日均采食量	F/G 料重比	Reference 参考
1	104	109	96	Brand et al. (1990) variety 1
2	102	108	95	Brand et al. (1990) variety 2
3	98	104	95	Hancock et al. (1992)
4	106	106	100	Johnston et al. (1998)
5	104	109	95	Shelton (2004) waxy
6	106	114	93	Shelton (2004) Non-waxy
7	104	100	104	Issa (2009)
8	99	100	100	Seaboard Farms (2010)
9	106	105	101	Benz et al. (2010)
Average 平均	103	106	98	
Cromwell (1985)	98	102	97	10 exp summary

Sorghum for Nursery Pigs

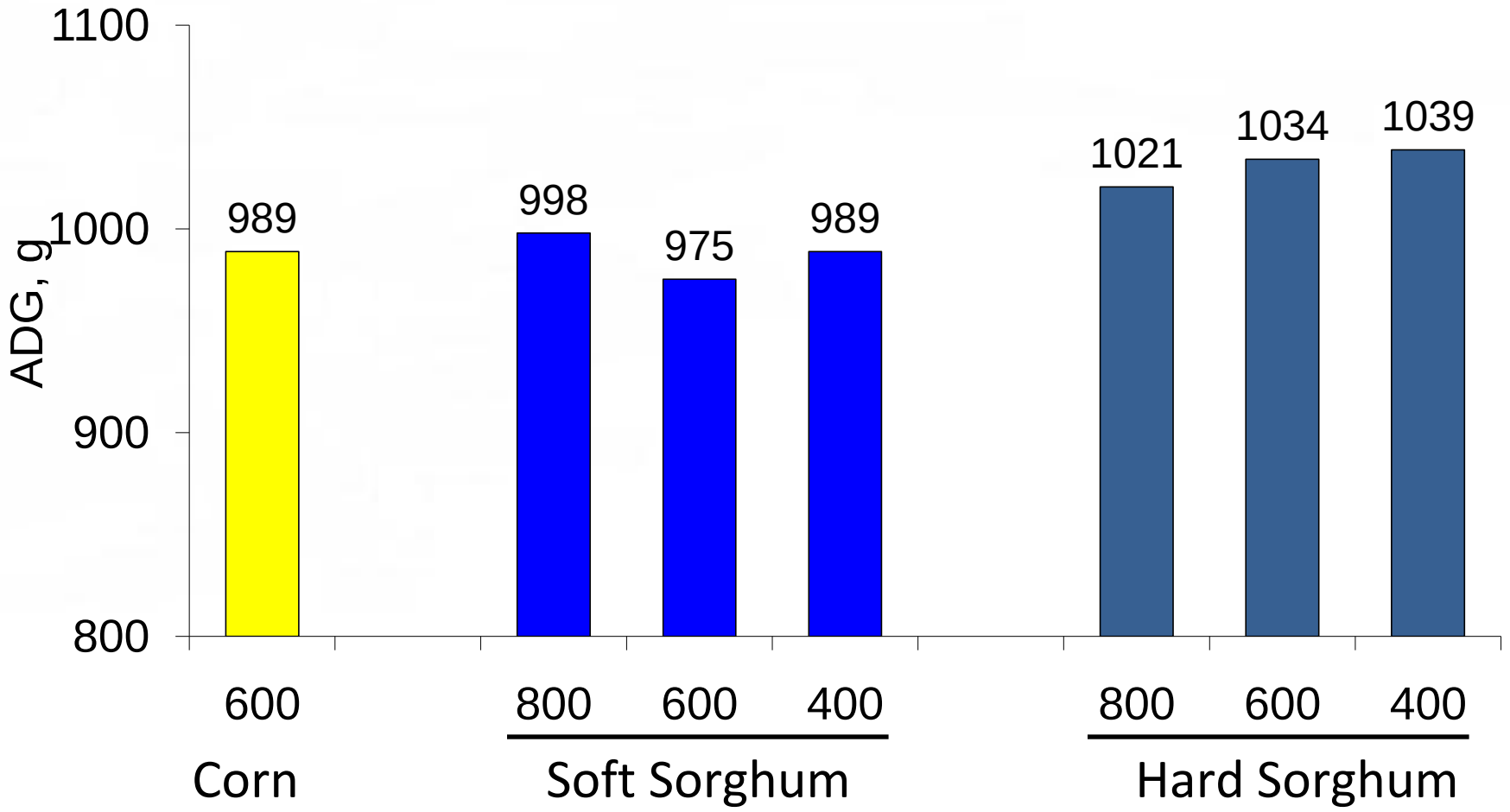
Influence of Grain Source on Nursery Pig Performance





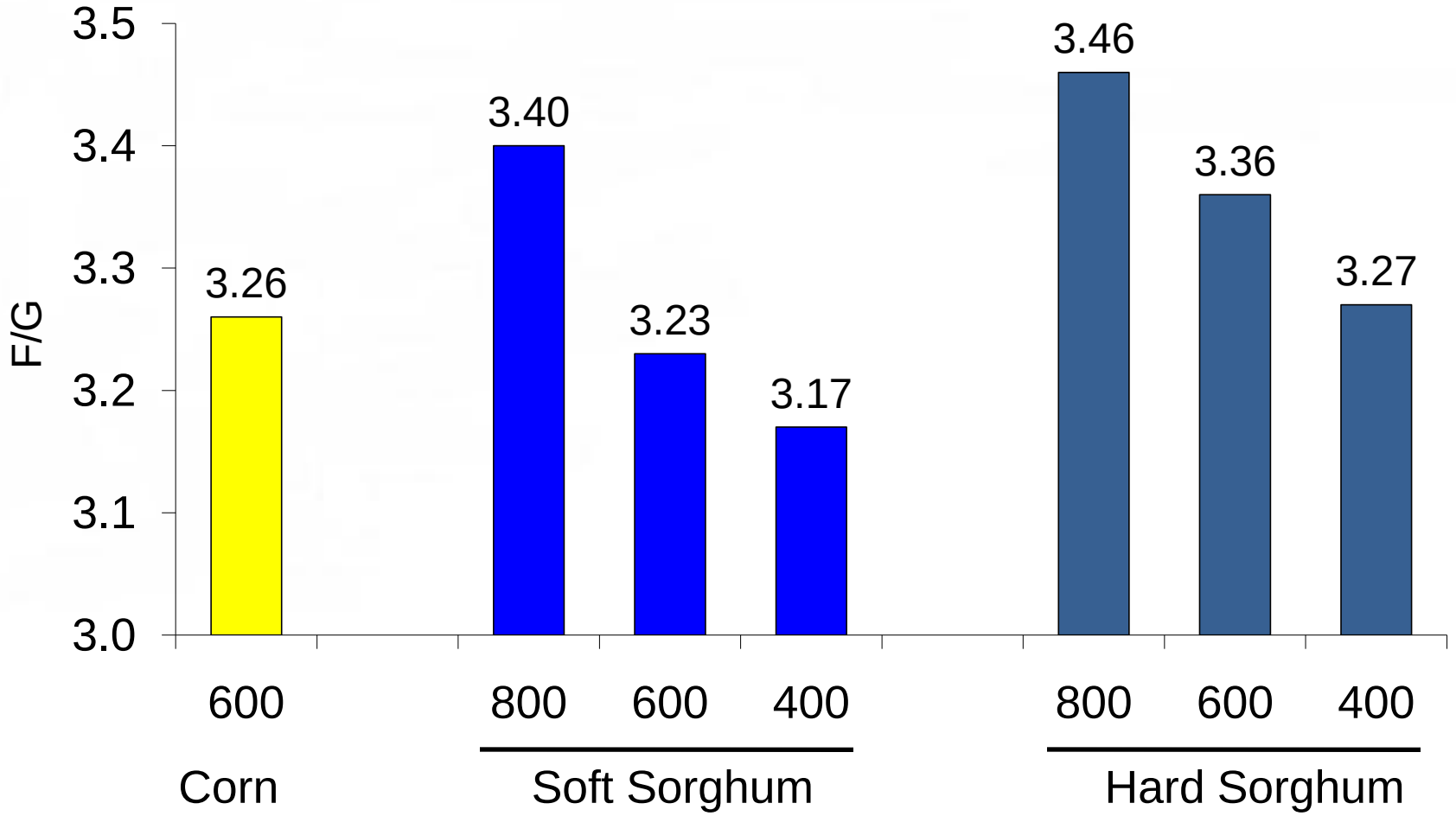
Richert et al., 1992

Effects of grain source, genotype and particle size on pig performance



Cabrera et al., 1993

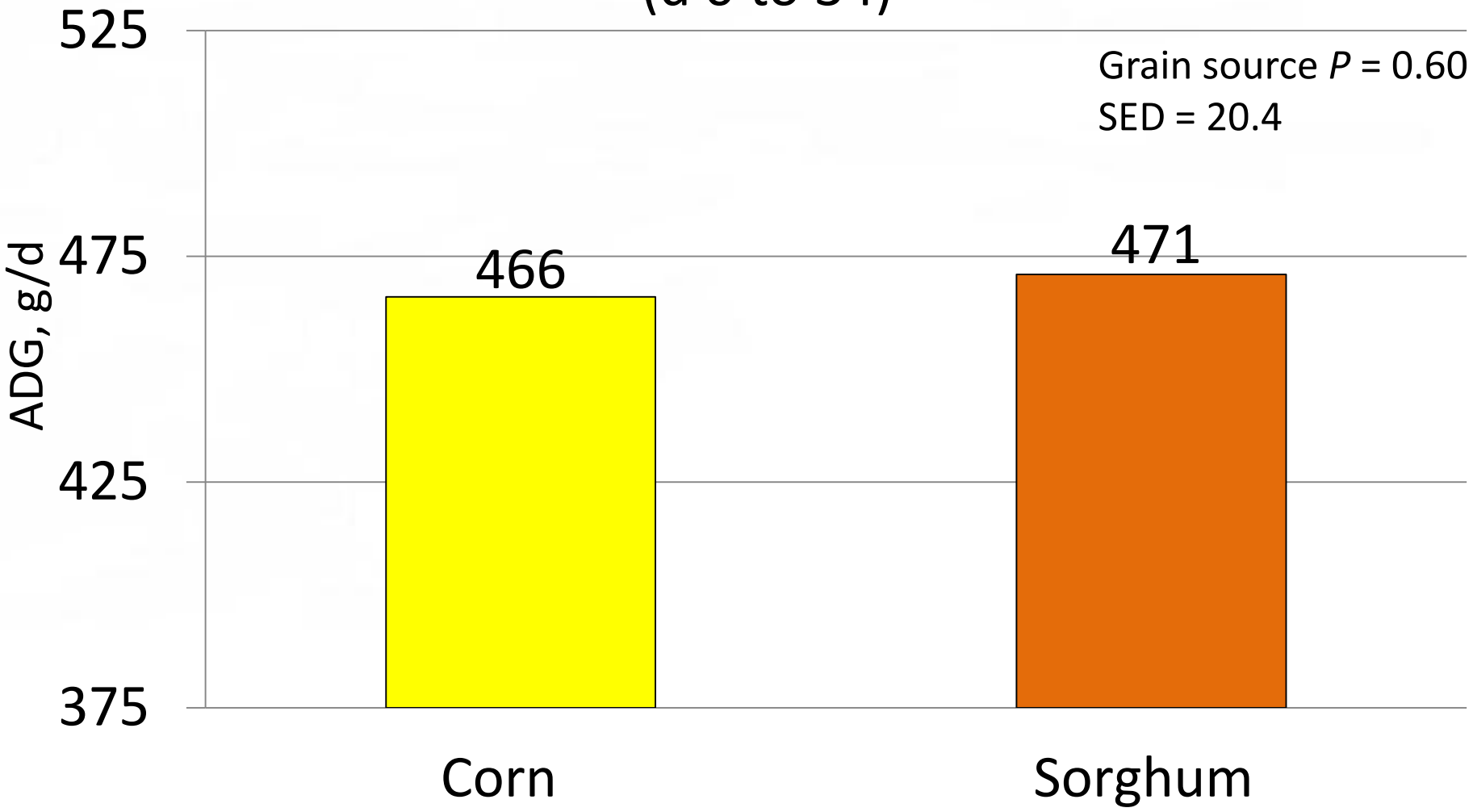
Effects of Grain Genotype and Particle Size



Cabrera et al., 1993

The effects of sorghum on nursery ADG

(d 0 to 34)



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Sotak, et al., 2011

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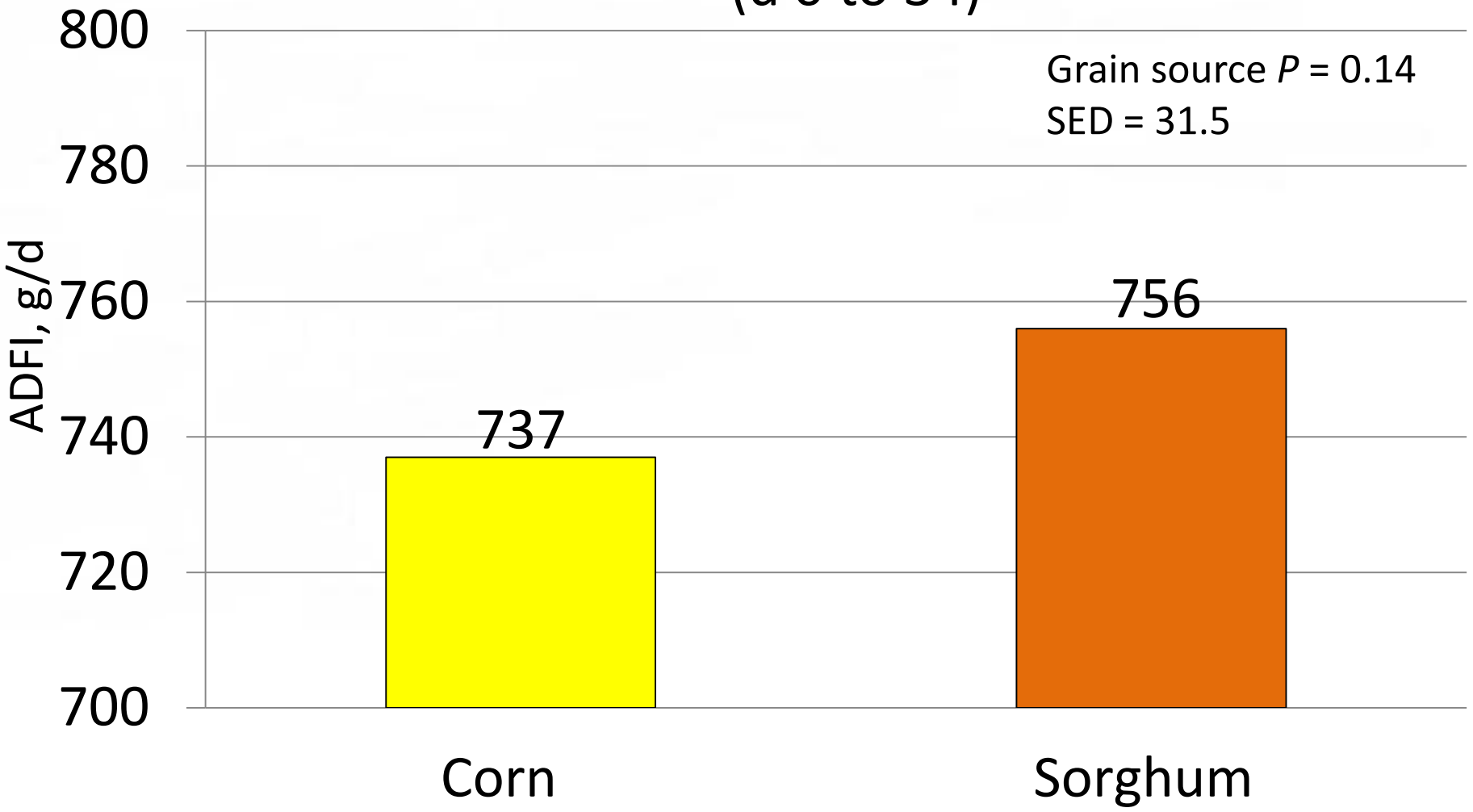
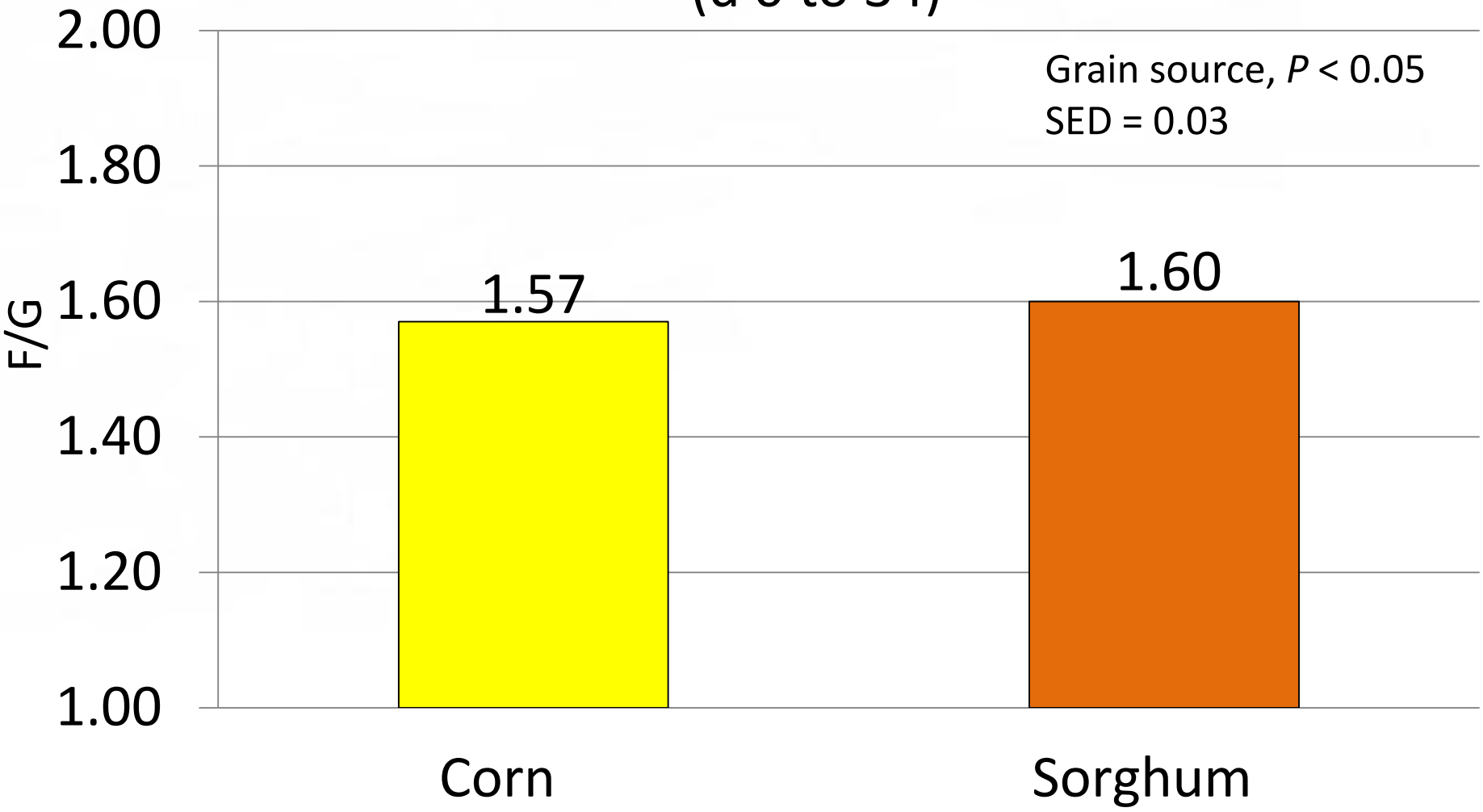
The effects of sorghum on nursery feed intake (d 0 to 34)



Sotak, et al., 2011

The effects of sorghum on nursery feed efficiency (d 0 to 34)



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Sotak, et al., 2011

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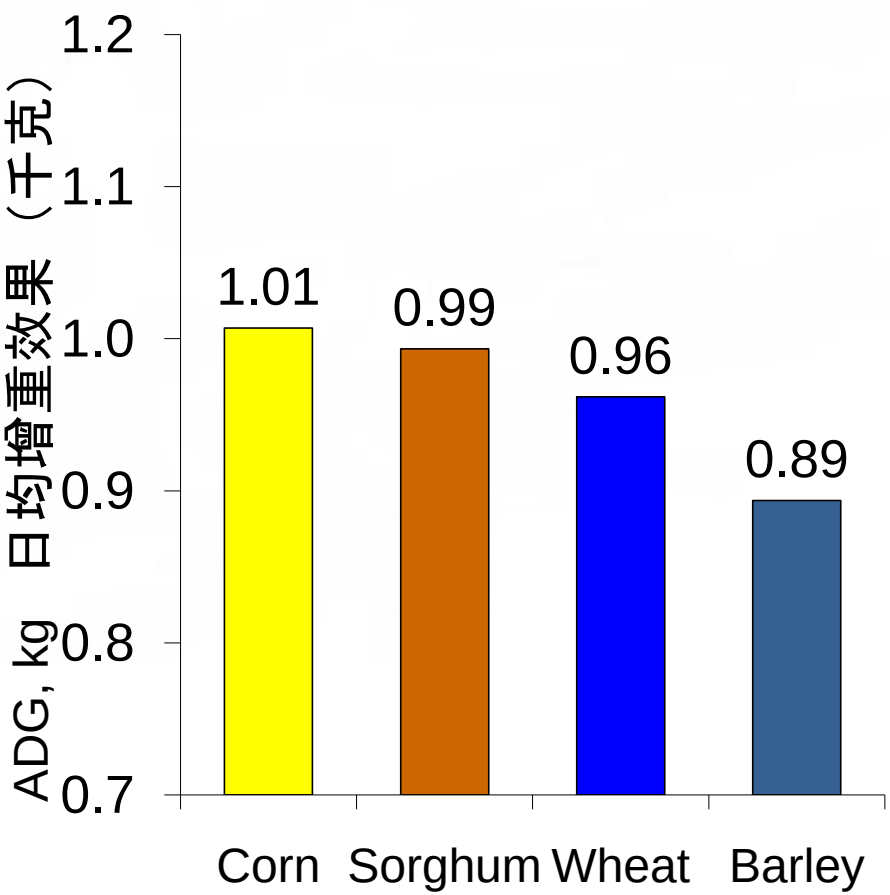
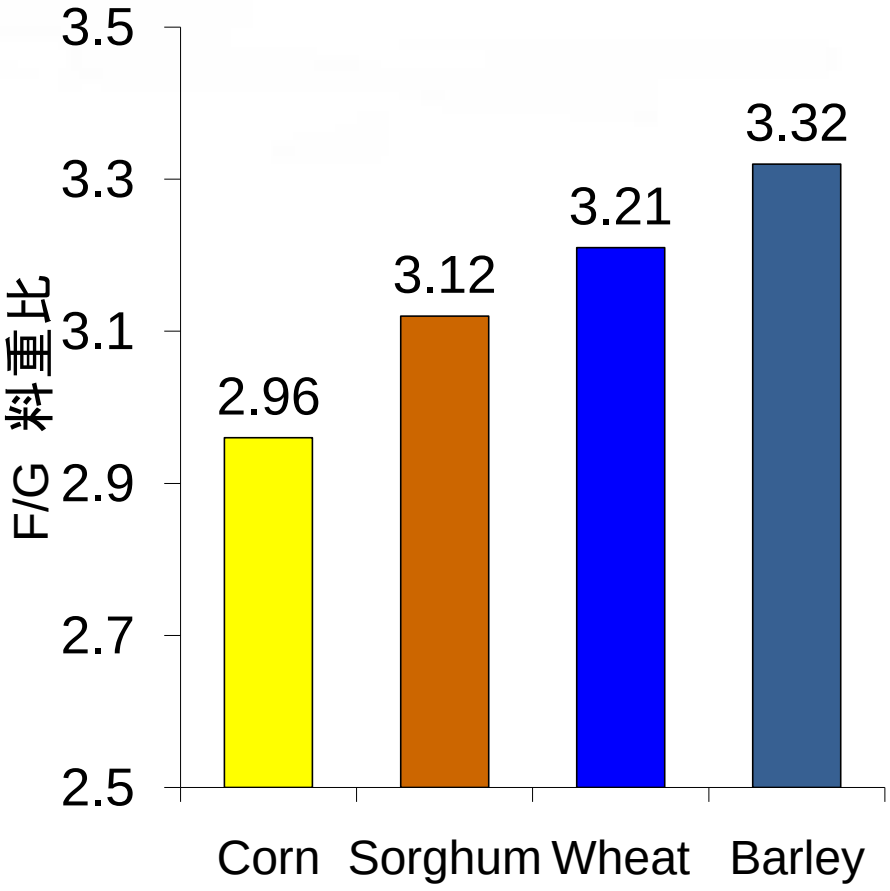
Finishing Pigs

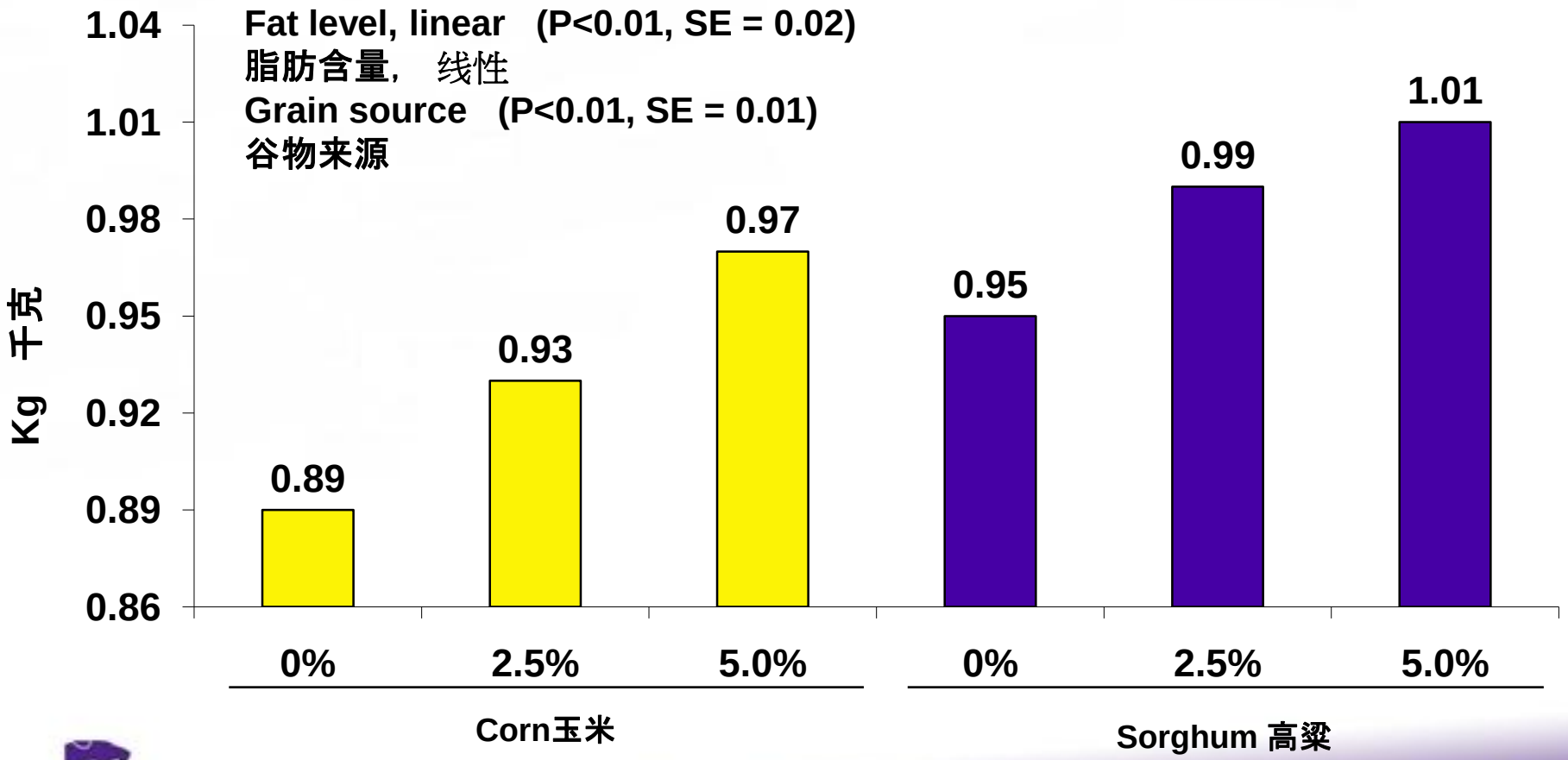
Influence of Grain Source on Pig Performance
谷物来源对于猪的性能影响





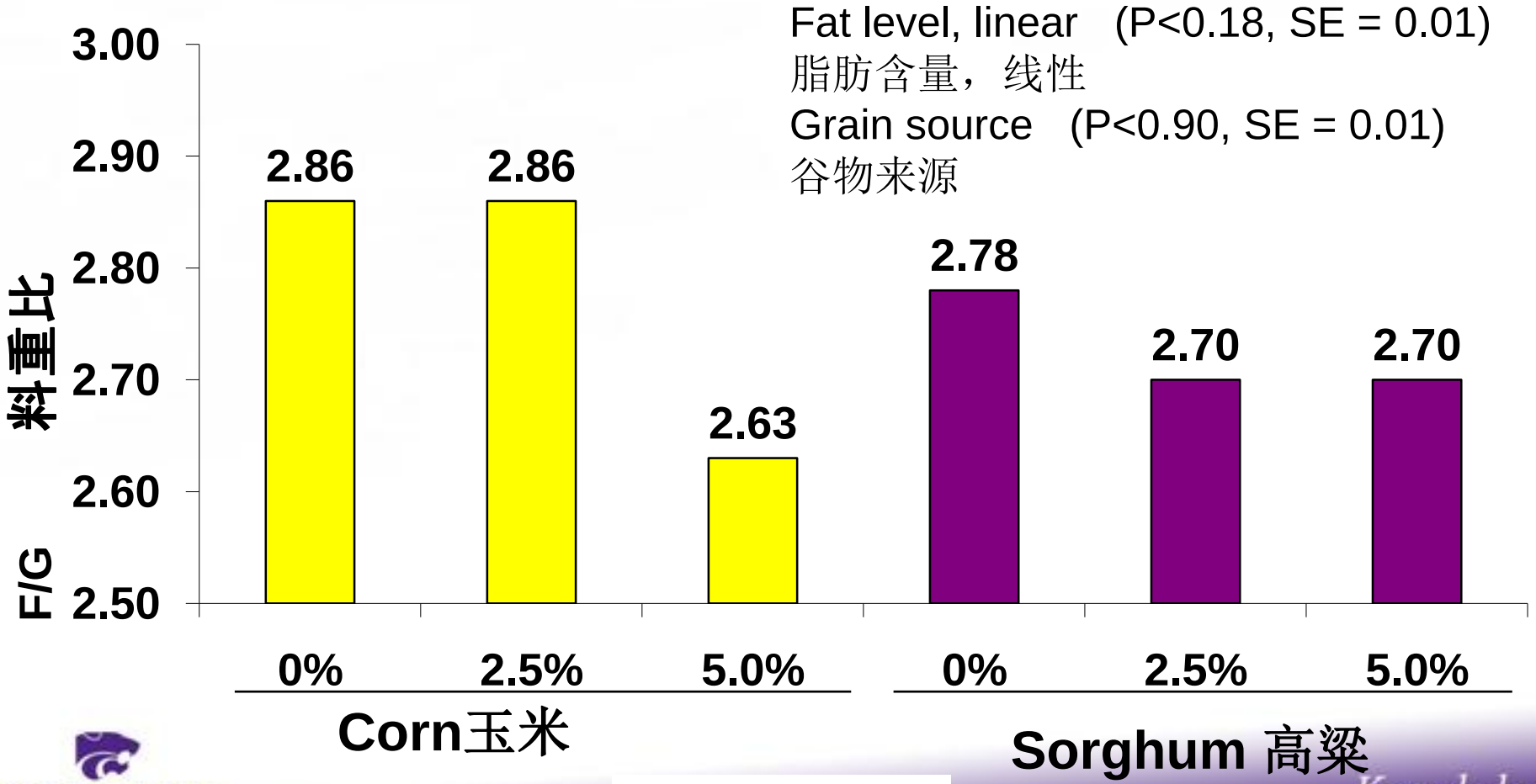
Hancock et al., 1992

Effect of grain source and fat level on ADG
谷物来源和脂肪含量对于日均增重影响



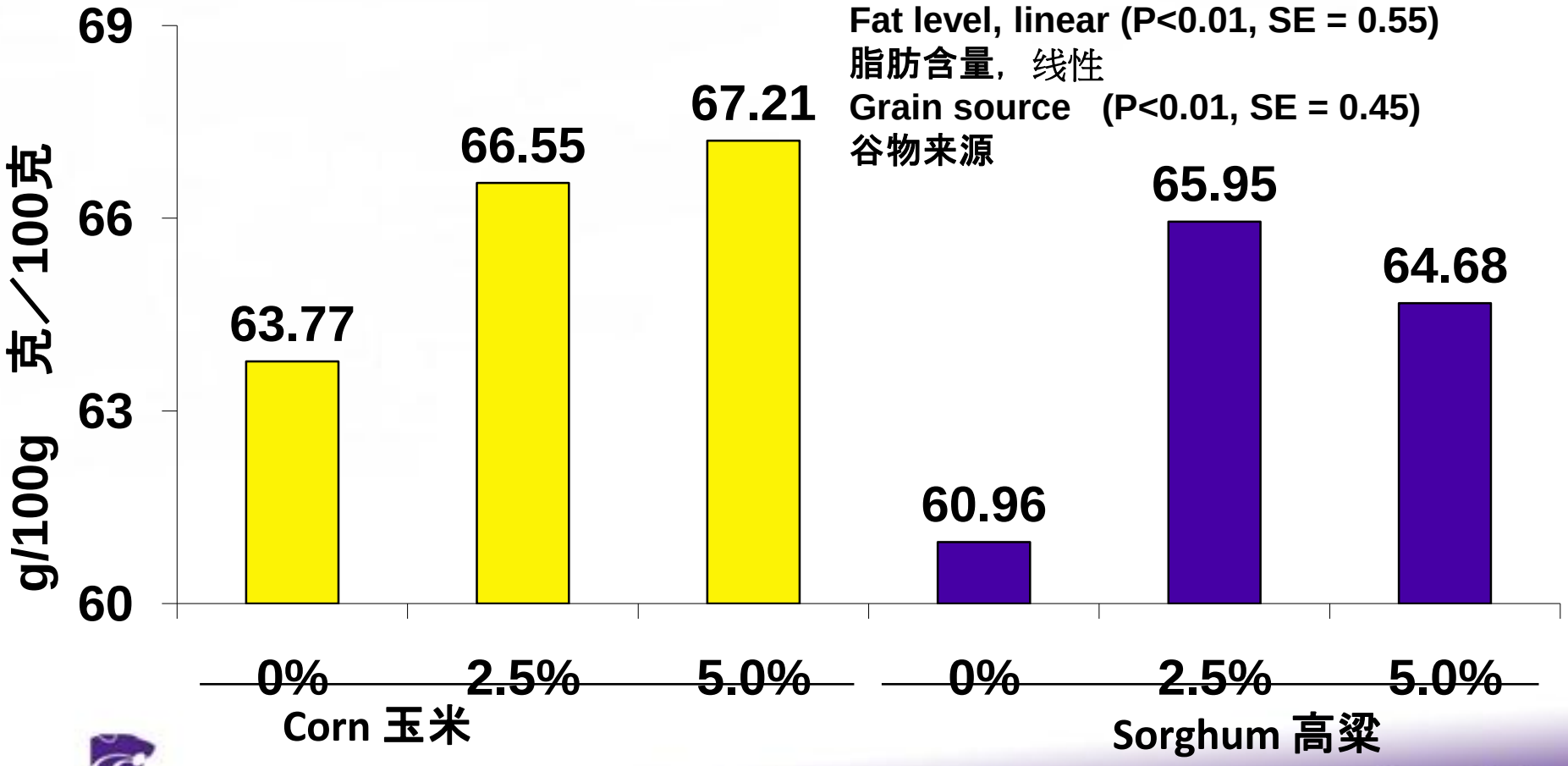
Benz et al., 2010

Effect of grain source and fat level on F/G
谷物来源和脂肪含量对于料重比的影响



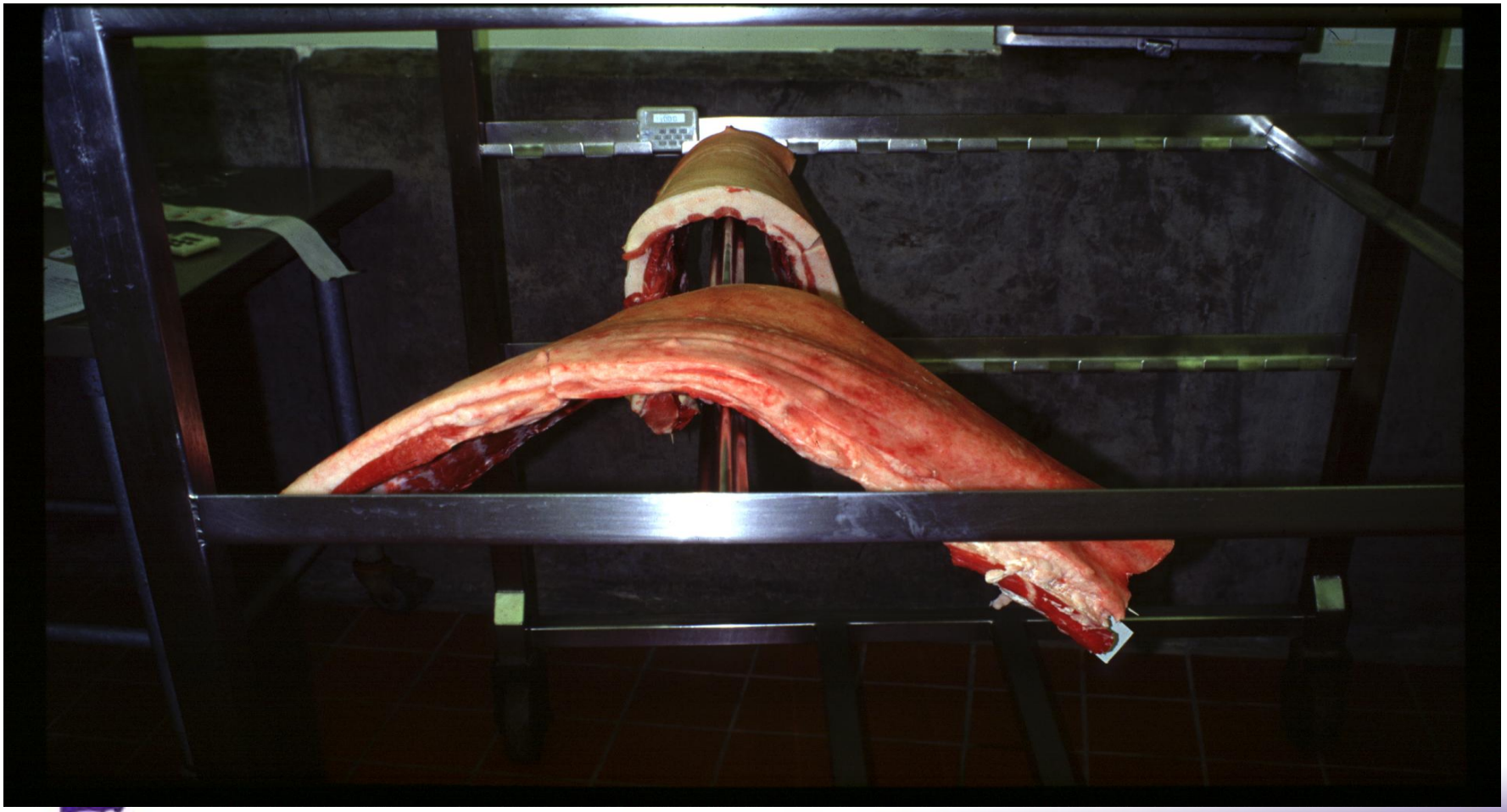
Benz et al., 2010

Effect of grain source and fat level on backfat iodine value
谷物来源和脂肪含量对于背脂肪碘值影响



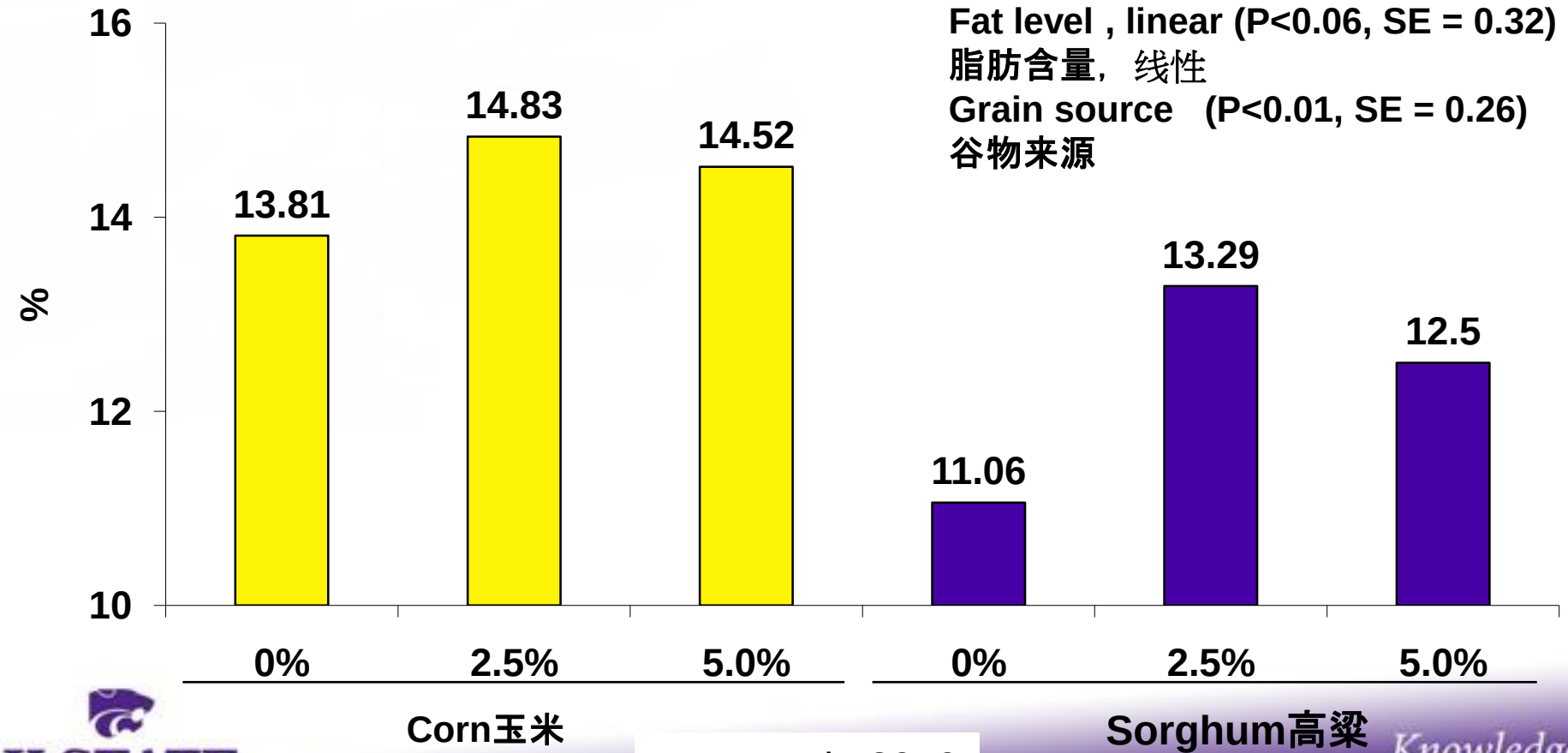
Benz et al., 2010

Effect of Fat Source on Carcass Quality
脂肪来源对于胴体质量影响



Effect of grain source and fat level on backfat percentage 18:2 fatty acids

谷物来源和脂肪含量对背脂肪比例18:2脂肪酸的影响



Benz et al., 2010

Amino Acid Profile of Sorghum
高粱氨基酸资料

(Percentage Relative to Lysine,与赖氨酸比例关系SID basis)

Amino Acid, % 氨基酸%		Sorghum 高粱	Corn 玉米
Lysine	赖氨酸	100	100
Isoleucine	异亮氨酸	**190**	124
Leucine	亮氨酸	679	451
Methionine	蛋氨酸	85	81
Met + Cys蛋氨酸加半胱氨酸		167	163
Threonine	苏氨酸	**152**	117
Tryptophan	色氨酸	**35**	26
Valine	缬氨酸	**239**	168

Amino Acid Profile of Sorghum
高粱氨基酸资料

(standardized ileal digestibility coefficients)*

Total amino acids, % 总氨基酸%		Sorghum 高粱	Corn 玉米
Lysine	赖氨酸	0.20 (74)	0.25 (74)
Isoleucine	异亮氨酸	0.36 (78)	0.28 (82)
Leucine	亮氨酸	1.21 (83)	0.96 (87)
Methionine	蛋氨酸	0.16 (79)	0.18 (83)
Cysteine	半胱氨酸	0.18 (67)	0.19 (80)
Threonine	苏氨酸	0.30 (75)	0.28 (77)
Tryptophan	色氨酸	0.07 (74)	0.06 (80)
Valine	缬氨酸	0.46 (77)	0.38 (82)

* NRC, 2012

Amino Acid Profile of Sorghum
高粱氨基酸资料

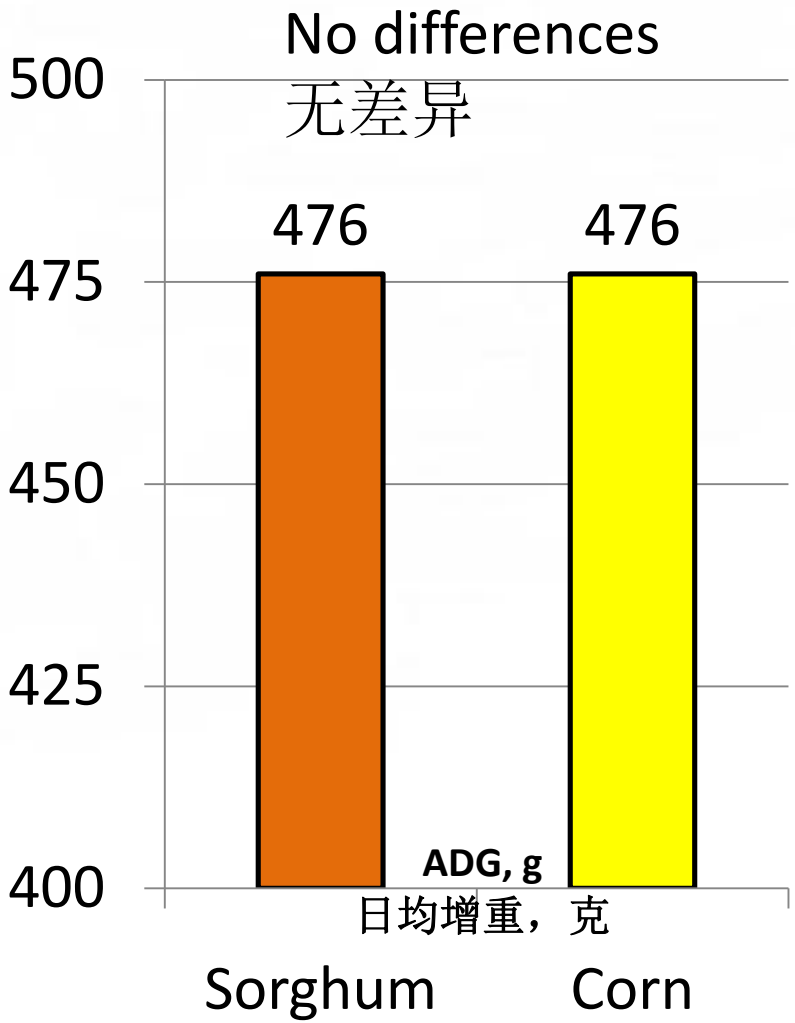
- Relative to lysine, several essential amino acids are greater in grain sorghum than in corn.
  - 相对于赖氨酸，高粱有几种必需氨基酸的含量高于玉米
- As a result, we can use proportionately more L-lysine HCL and take advantage of the greater amounts of other amino acids.
  - 因此，可以增加使用L-赖氨酸盐酸盐比例，并利用其它几种氨基酸含量更高的优势

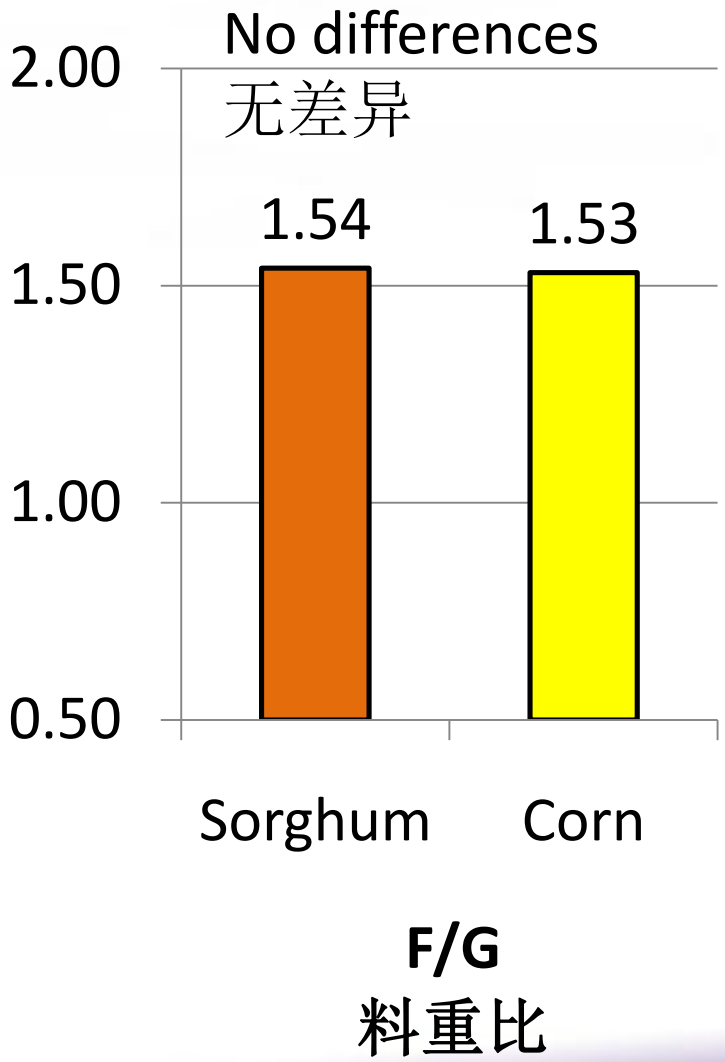
Procedures 程序

- A total of 300 pigs with 5 pigs per pen and 10 pens per treatment, 11 to 23 kg
- 一共300头猪，每栏5头，每次饲喂10个栏，11-23公斤
- All diets were formulated to the same Lys:NE ratio.
- 所有饲料配方是按照同一个赖氨酸/净能比例
- 2 × 3 factorial: 2X3阶乘
  - **Sorghum vs. corn 高粱比玉米**
  - Amino acid supplementation (low, medium, or high).
  - 氨基酸补充（低，中，高）
- **Low amino acids:** L-lysine HCl and DL-methionine.
- 低氨基酸—L—氨基酸盐酸盐及DL—蛋氨酸
- **Medium amino acids:** L-lysine HCl, DL-methionine, and L-threonine
- 中氨基酸—L—氨基酸盐酸盐，DL—蛋氨酸，L—苏氨酸
- **High amino acids:** L-lysine HCl, DL-methionine, L-threonine, and L-valine.
  - 高氨基酸：L—赖氨酸盐酸盐，DL—蛋氨酸，L—苏氨酸，L—缬氨酸

Effect of Grain Source on Average Daily Gain and Feed Efficiency – 11 to 23 kg Pigs

谷物来源对于日均增重及饲料效率影响－11-23公斤猪

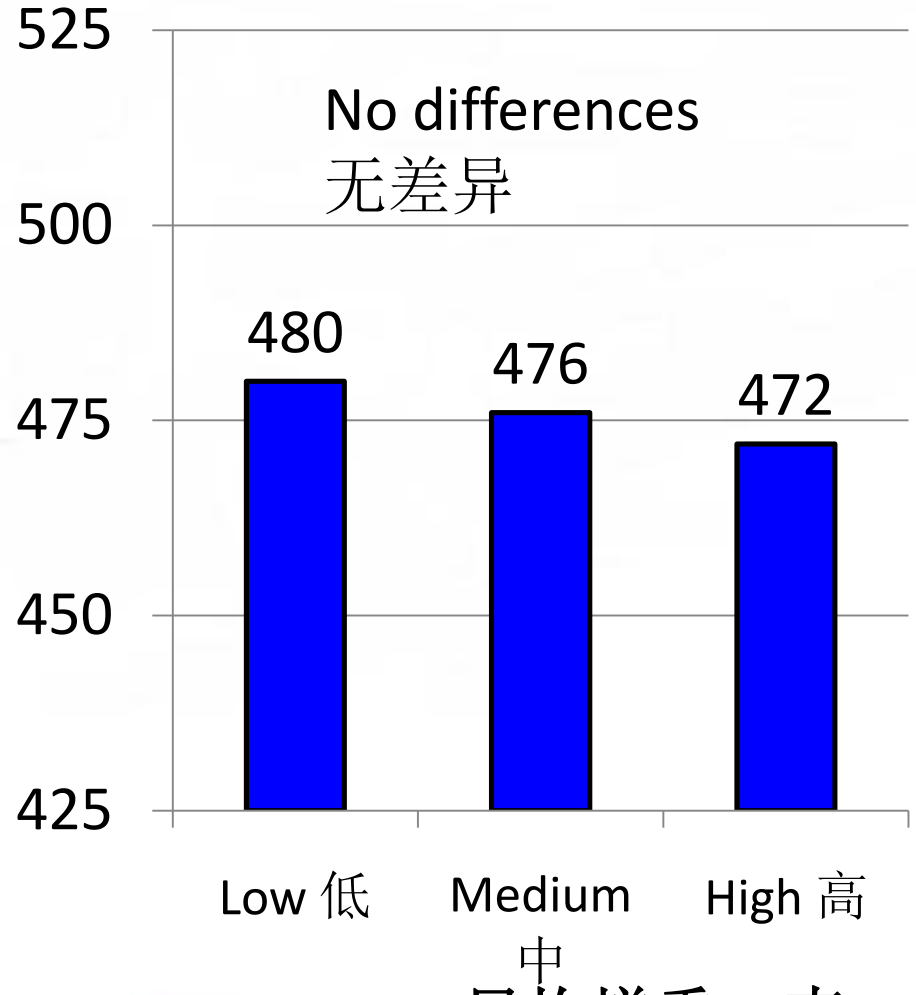




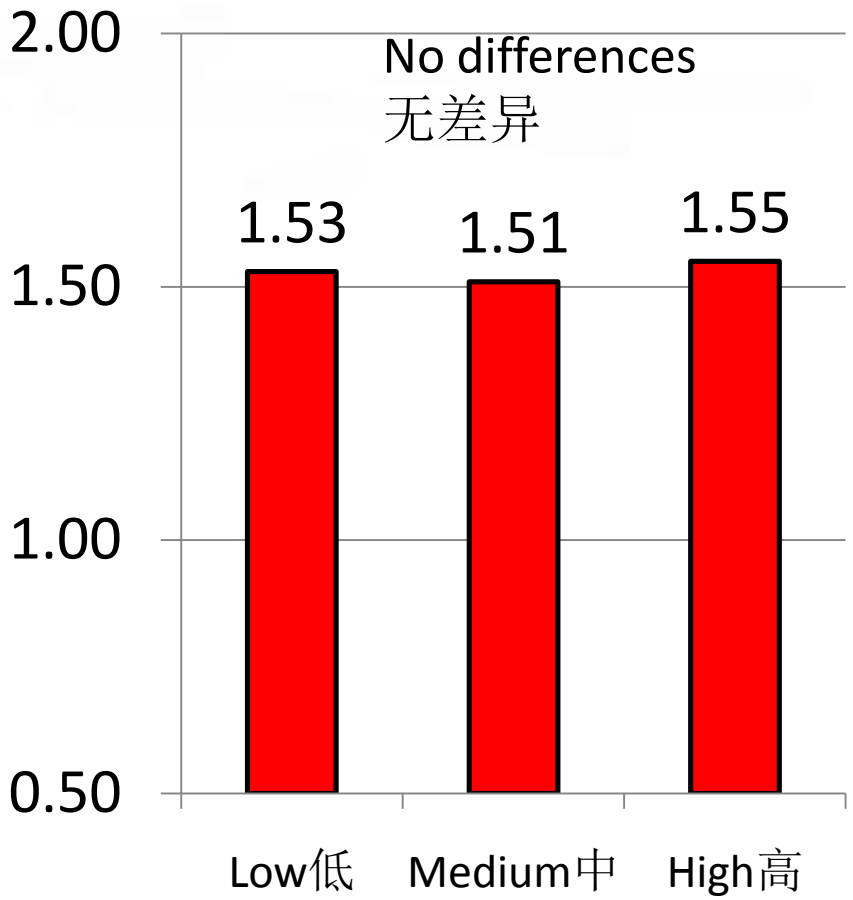
Jordan et al., 2014

Effect of Amino Acid Supplementation on Average Daily Gain and Feed Efficiency – 11 to 23 kg Pigs （11-23 公斤猪）

氨基酸补充对于日均增重及饲料效率的影响



ADG, g日均增重，克



F/G 料重比

Jordan et al., 2014

Procedures 程序

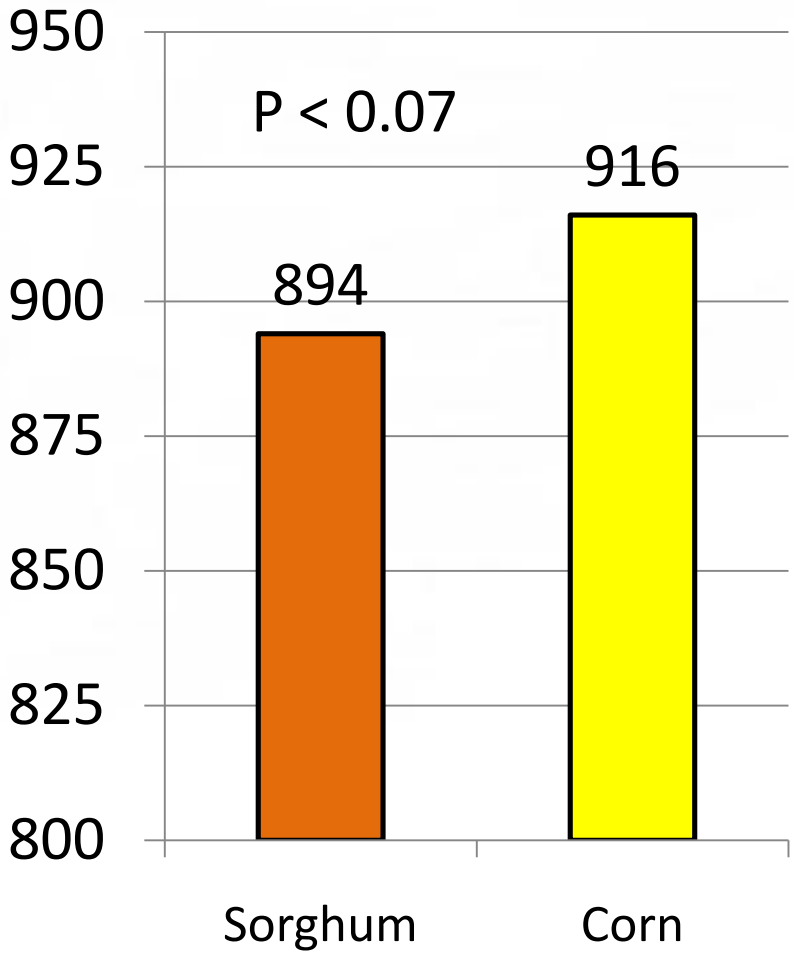
- A total of 288 pigs with 8 pigs per pen and 6 pens per treatment, 90 to 132 kg
- 共有288头，每栏8头，每次饲喂6个栏，90-132公斤
- All diets were formulated to the same Lys: NE ratio.
- 饲料配方都按照同一个赖氨酸/净能比例
- 2 × 3 factorial: 2x3 阶乘
  - **Sorghum vs. corn 高粱比玉米**
  - Amino acid supplementation (low, medium, or high).
  - 氨基酸补充 （低，中，高）
- **Low amino acids:** L-lysine HCl and DL-methionine.
- 低氨基酸—L—氨基酸盐酸盐及DL—蛋氨酸
- **Medium amino acids:** L-lysine HCl, DL-methionine, and L-threonine
- 中氨基酸—L—氨基酸盐酸盐，DL—蛋氨酸，L—苏氨酸

High amino acids: L-lysine HCl, DL-methionine, L-threonine, and L-valine (milo) or L-tryptophan (corn).

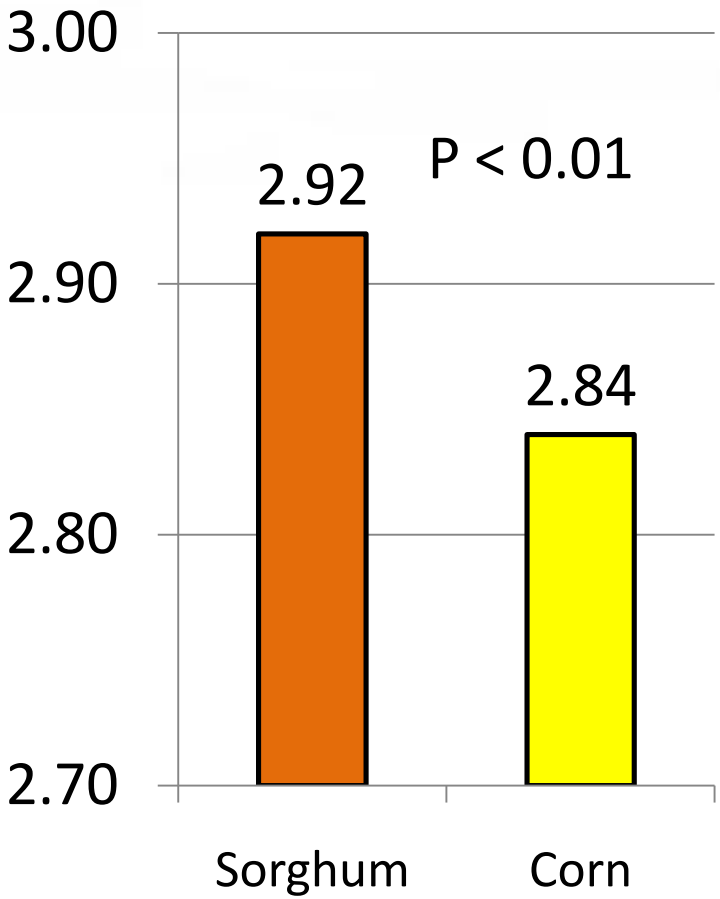
高氨基酸：L—赖氨酸盐酸盐，DL—蛋氨酸，L—苏氨酸，L—缬氨酸

Effect of Grain Source on Average Daily Gain and Feed Efficiency – 90 to 132 kg Pigs

谷物来源对于日均增重及饲料效率的影响 90-132公斤猪



ADG, lb日均增重，磅



F/G料重比

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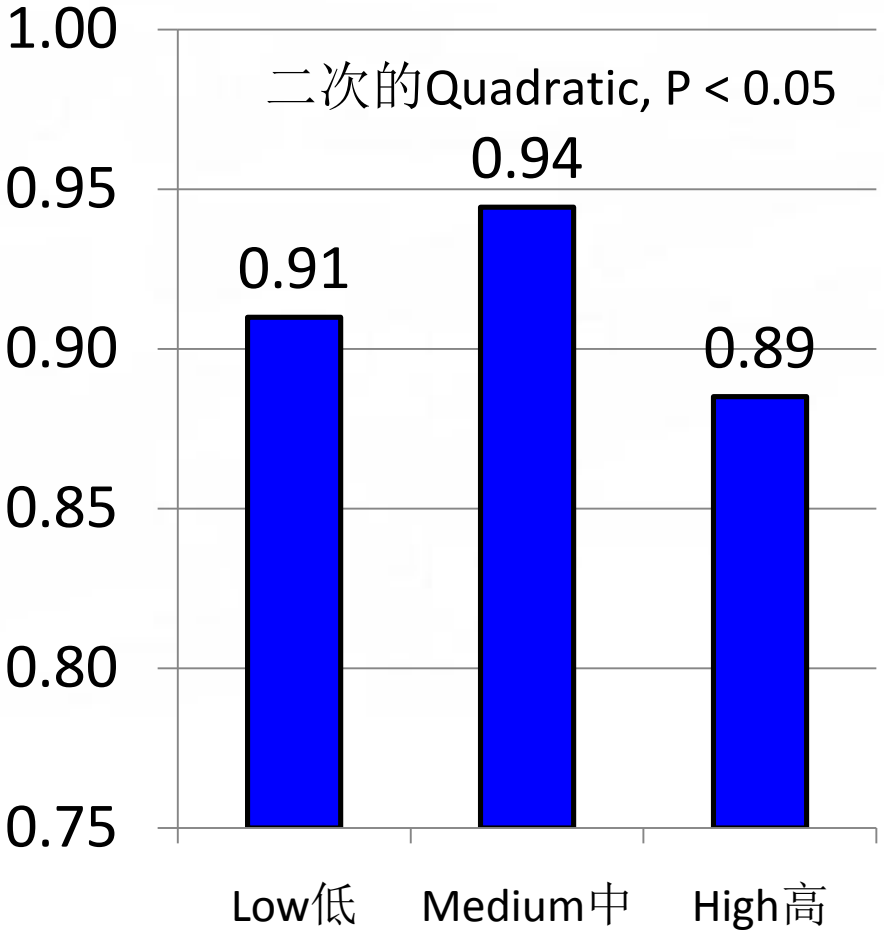
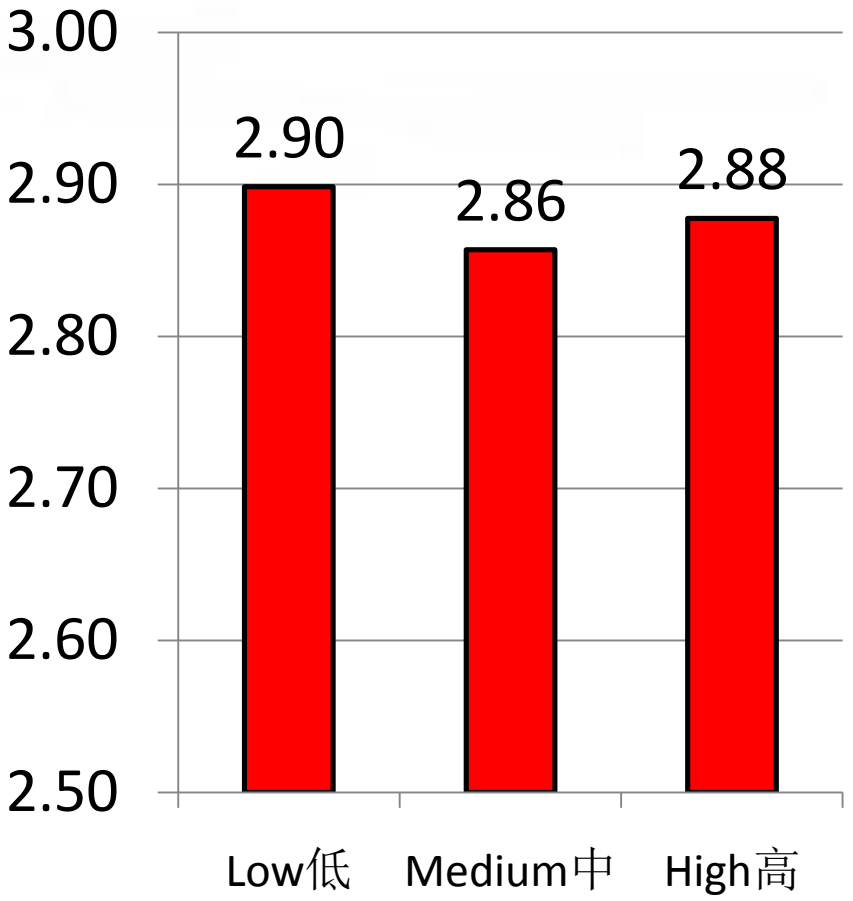
Effect of Amino Acid Supplementation on Average Daily Gain and Feed Efficiency – 90 to 132 kg Pigs

氨基酸补充对于日均增重及饲料效率的影响 90-132公斤猪



ADG, kg日均增重，千克

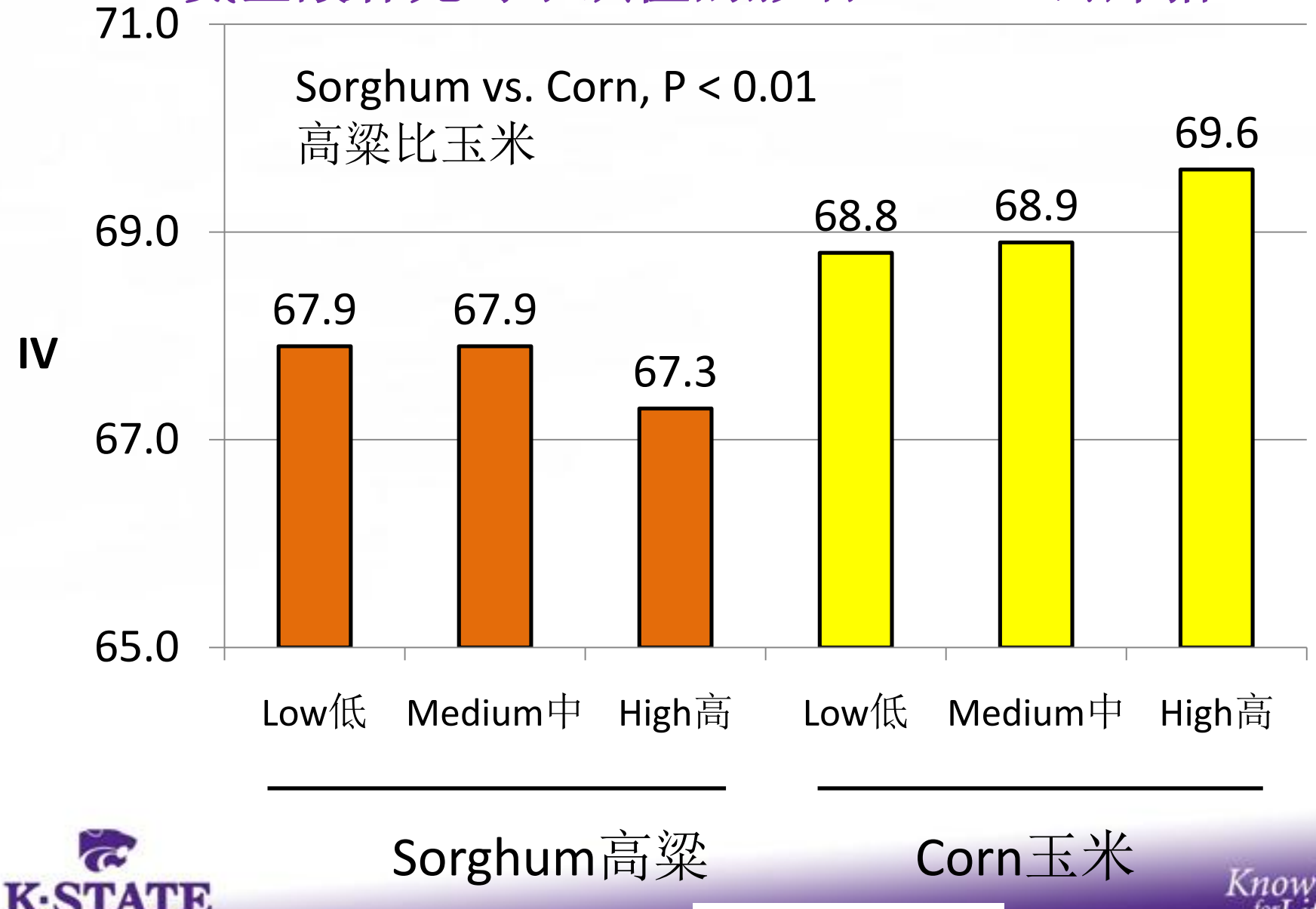


F/G料重比

Jordan et al., 2014

Effect of Amino Acid Supplementation on Iodine Value – 90 to 132 kg Pigs

氨基酸补充对于碘值的影响 90-132公斤猪



Jordan et al., 2014

Sorghum Summary
高粱总结

- Take advantage of sorghums digestible amino acid pattern relative to corn.
- 利用高粱在可消化氨基酸方面相对于玉米的优势。

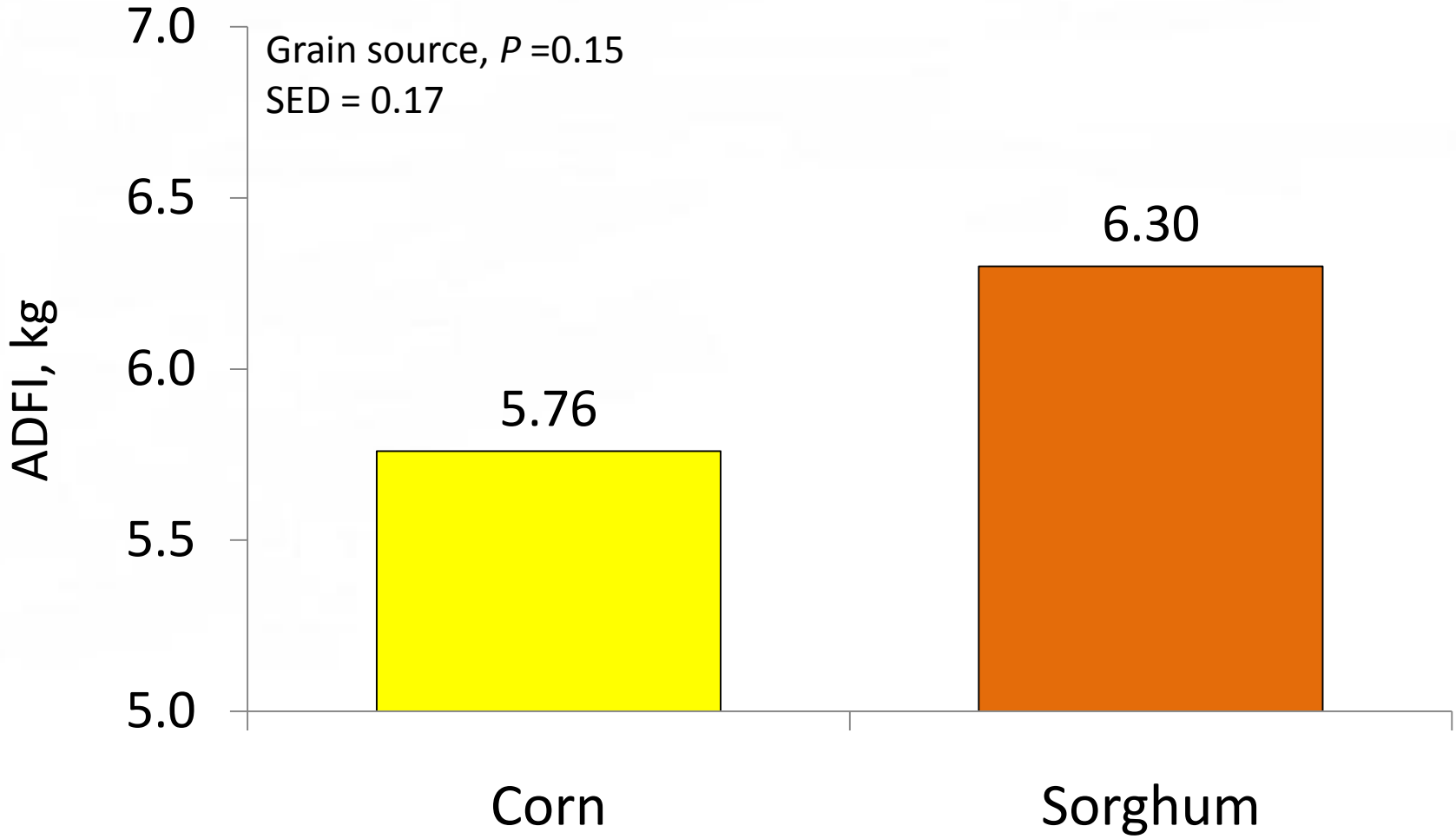
- Allows more crystalline lysine to be used, yet still meets other amino acid requirements.
- 多使用晶体氨基酸，但还要满足其它氨基酸要求。

Sorghum for sows

Relative value of sorghum vs corn (%) for lactating sows

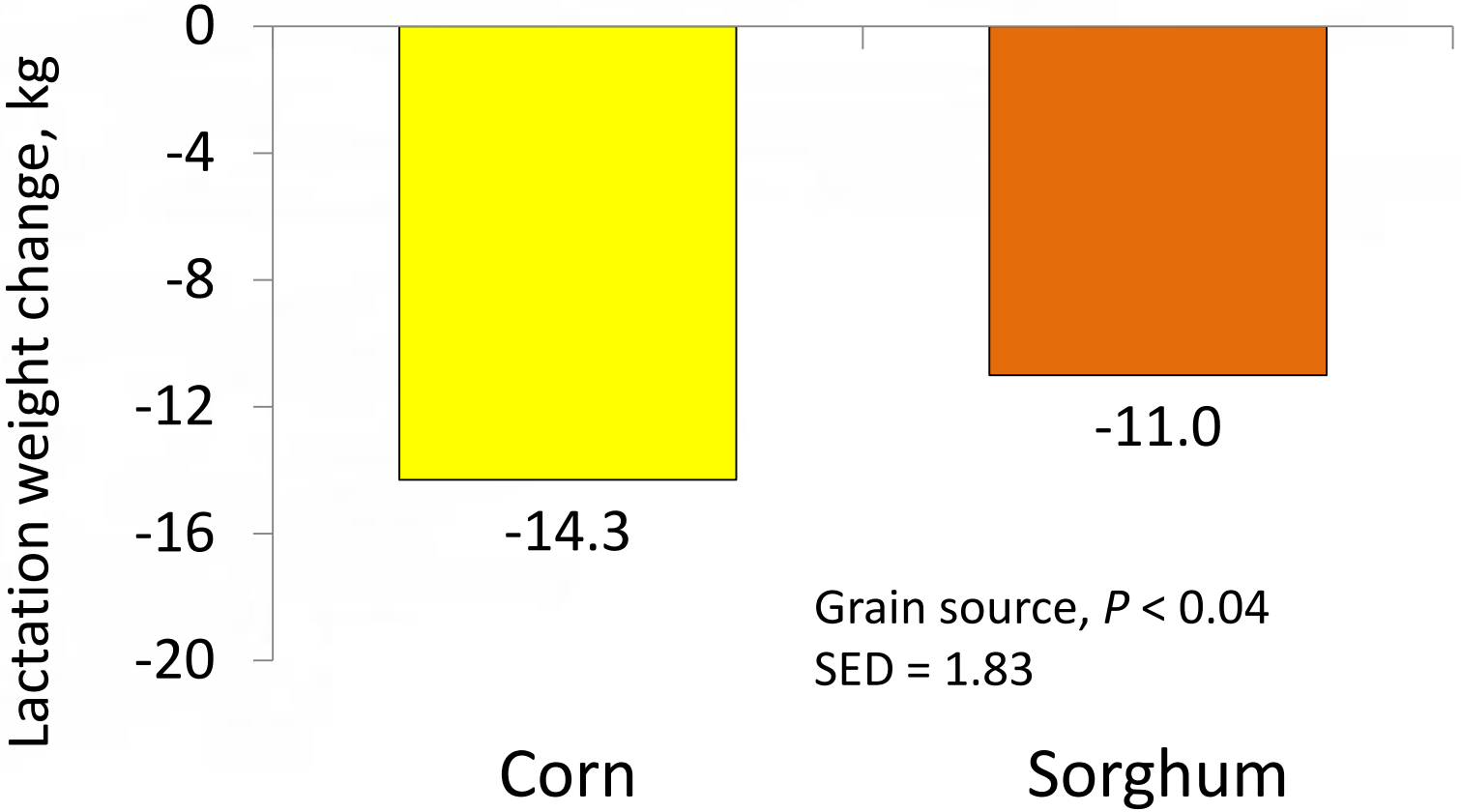
Item	Louis et al., 1991	Johnston et al., 1998	Sotak et al., 2012	Average
Sow performance				
Lactation ADFI	90	102	104	99
Lactation weight change	90	62	74	75
Wean to estrous interval	94	111	NA	103
Litter performance				
Litter size born alive	108	102	99	103
Litter size at weaning	103	99	99	100
Litter BW at birth	99	101	99	100
Litter BW at weaning	93	98	98	96
Litter BW gain	92	97	94	94

The effects of grain source on ADFI of lactating sows (d 0 to wean)



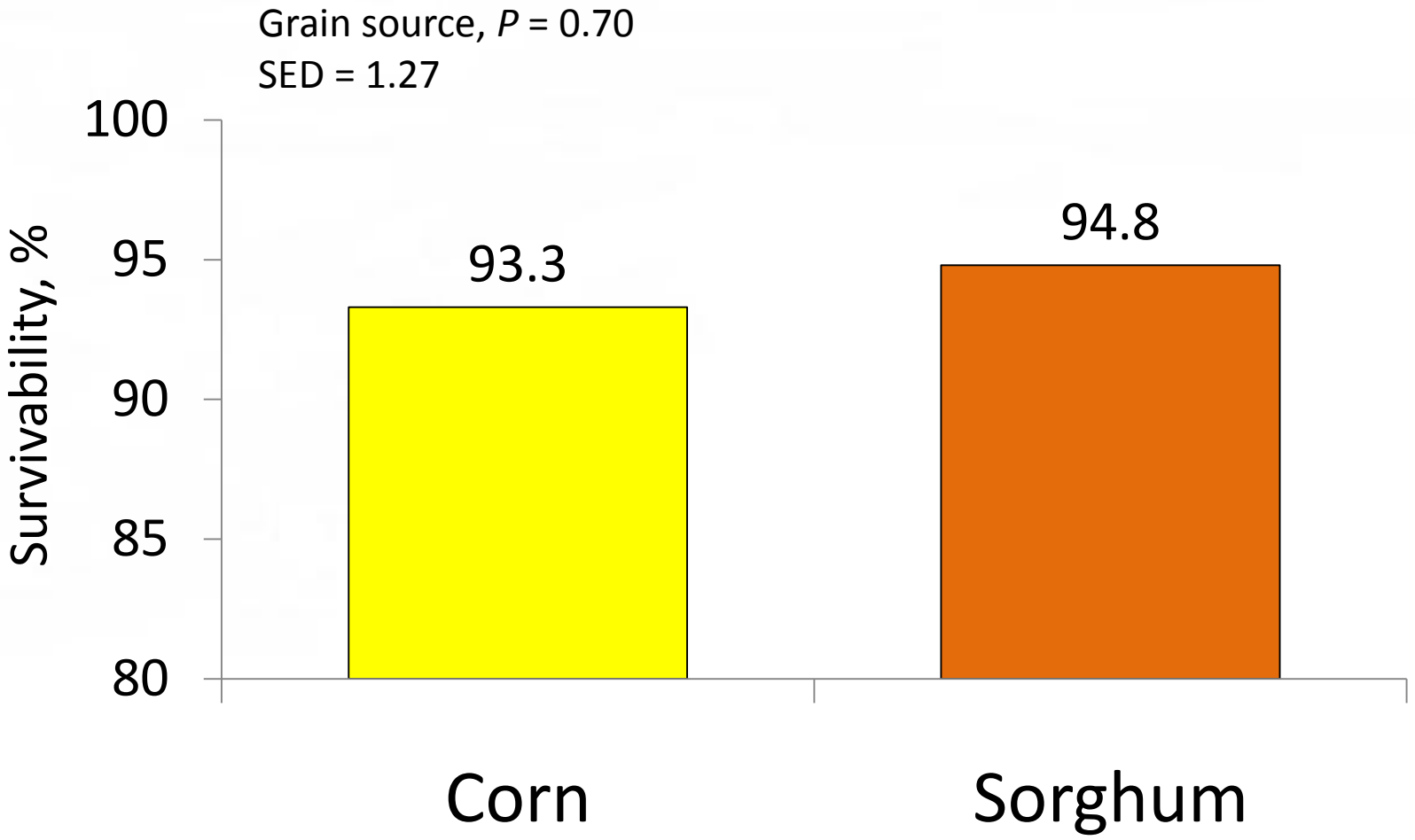
Sotak, et al. 2012

The effects of grain source on lactation weight change



Sotak, et al. 2012

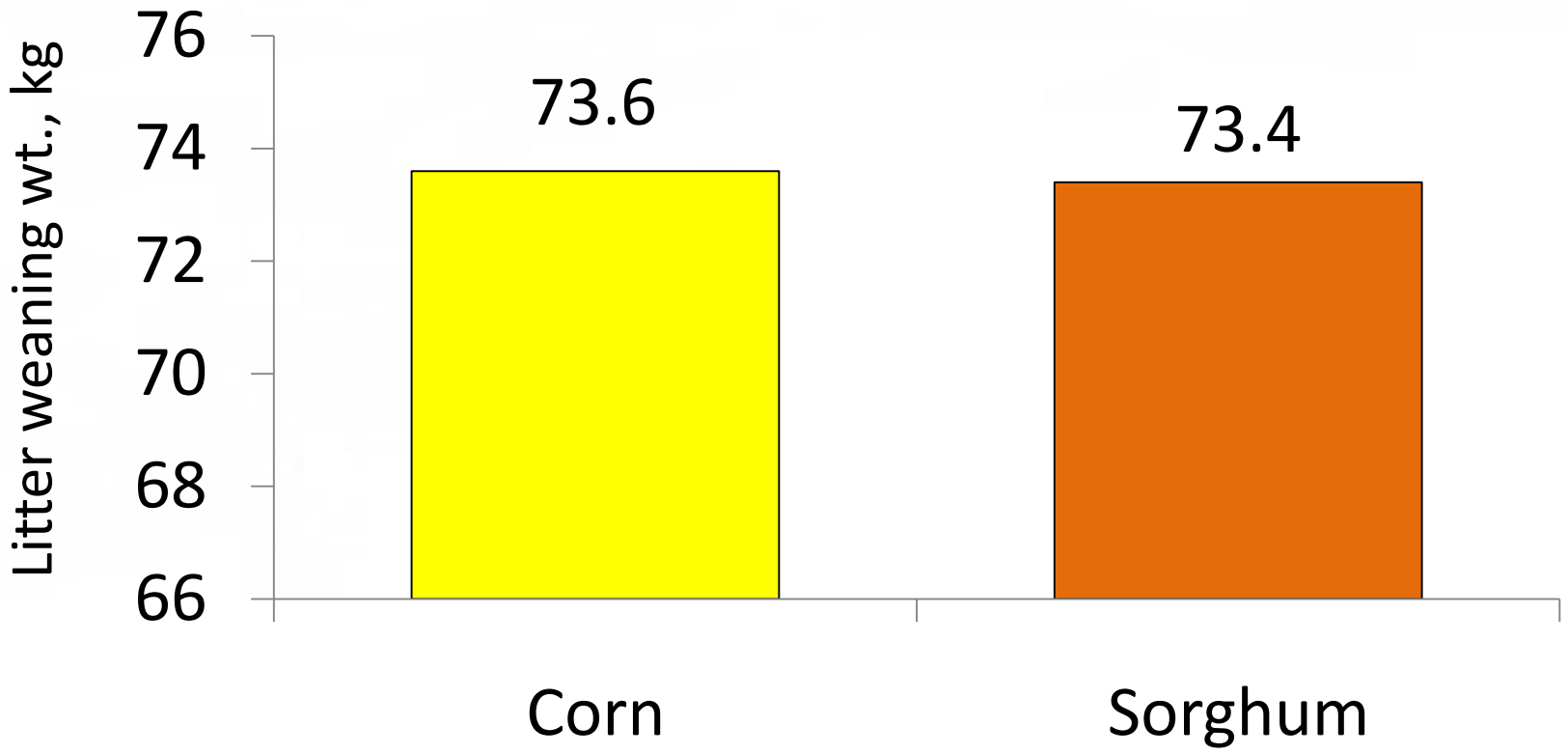
The effects of sorghum DDGS on survivability



Sotak, et al. 2012

The effects of sorghum DDGS on litter weaning weight

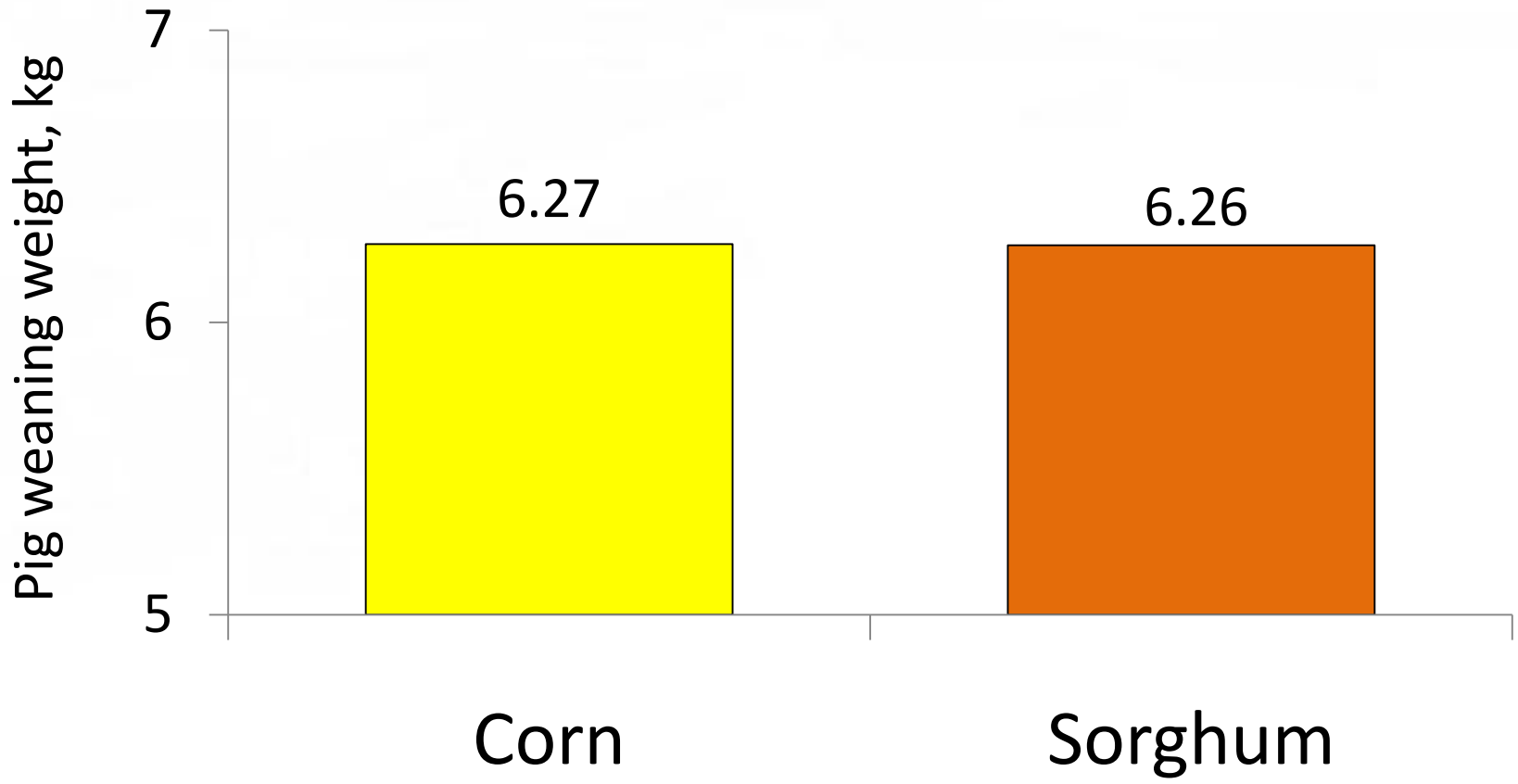
Grain source, *P* = 0.46
SED = 2.90



Sotak, et al. 2012

The effects of sorghum DDGS on pig weaning weight

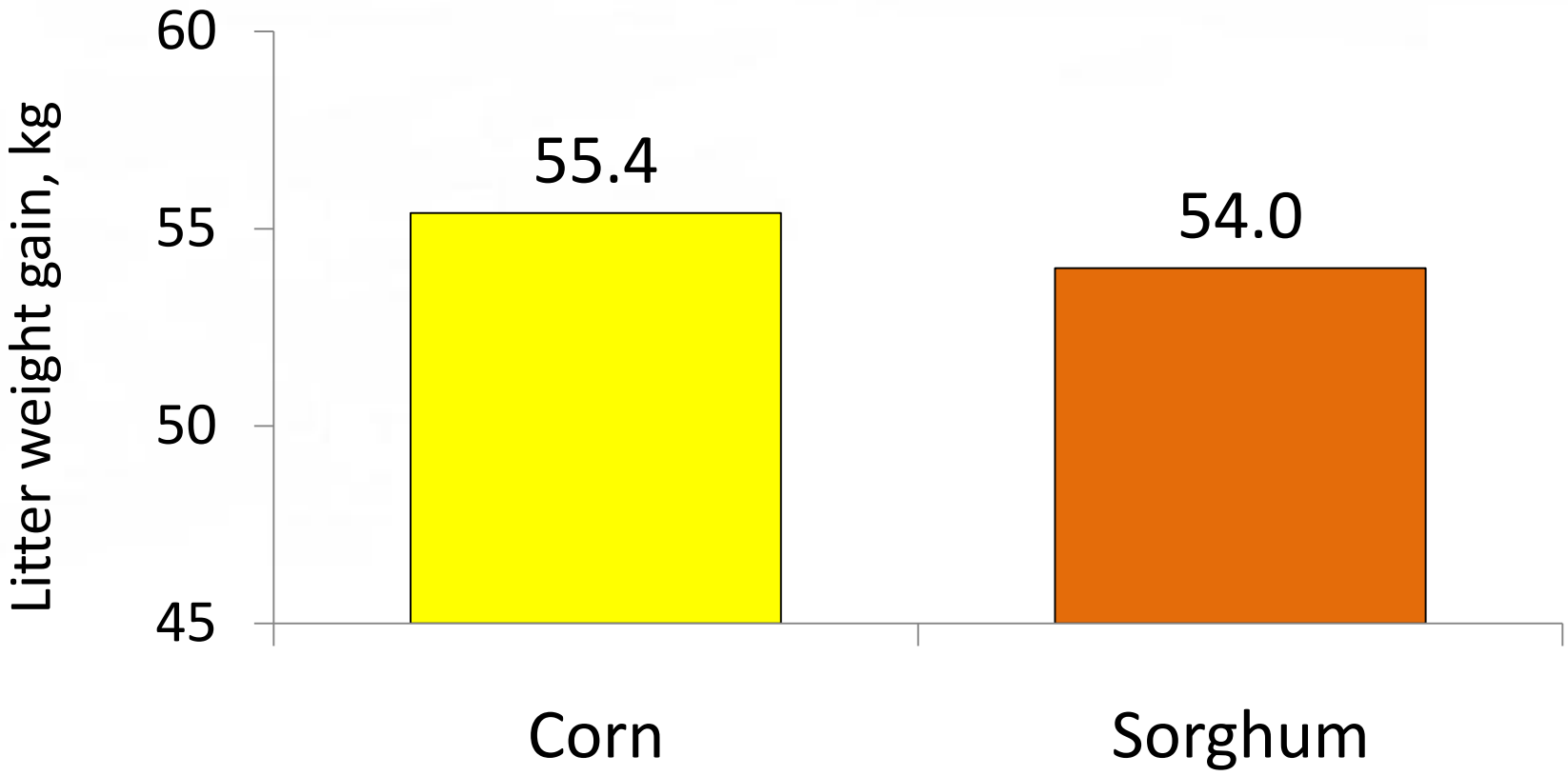
Grain source, *P* = 0.46
SED = 0.43



Sotak, et al. 2012

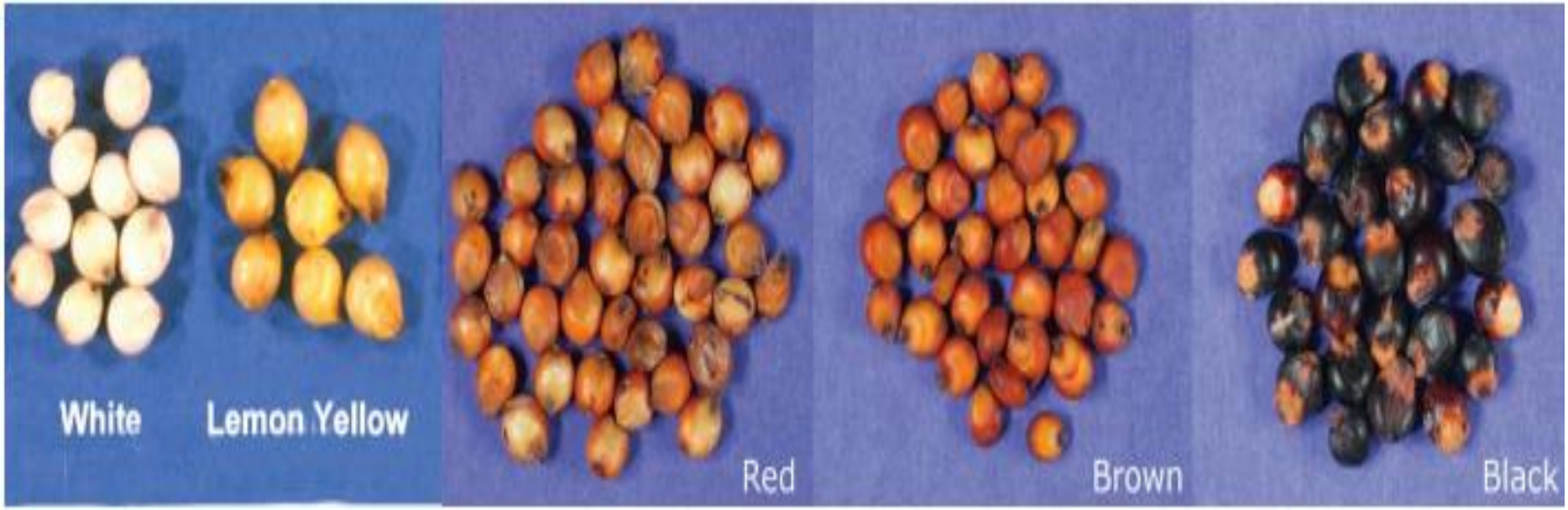
The effects of sorghum DDGS on litter weaning weight gain

Grain source, *P* = 0.20
SED = 3.54

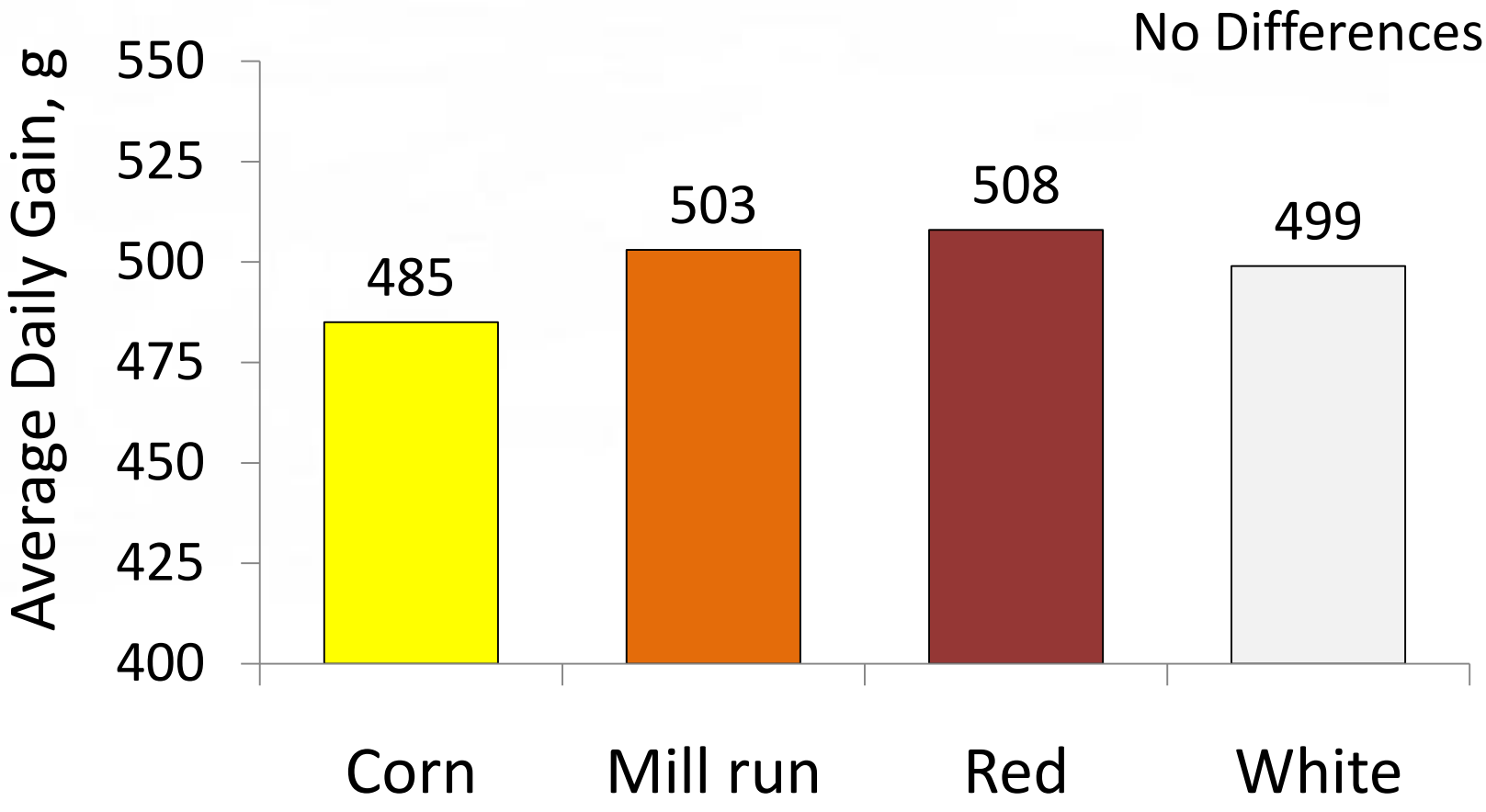


Sotak, et al. 2012

Effects of Sorghum Color for Swine

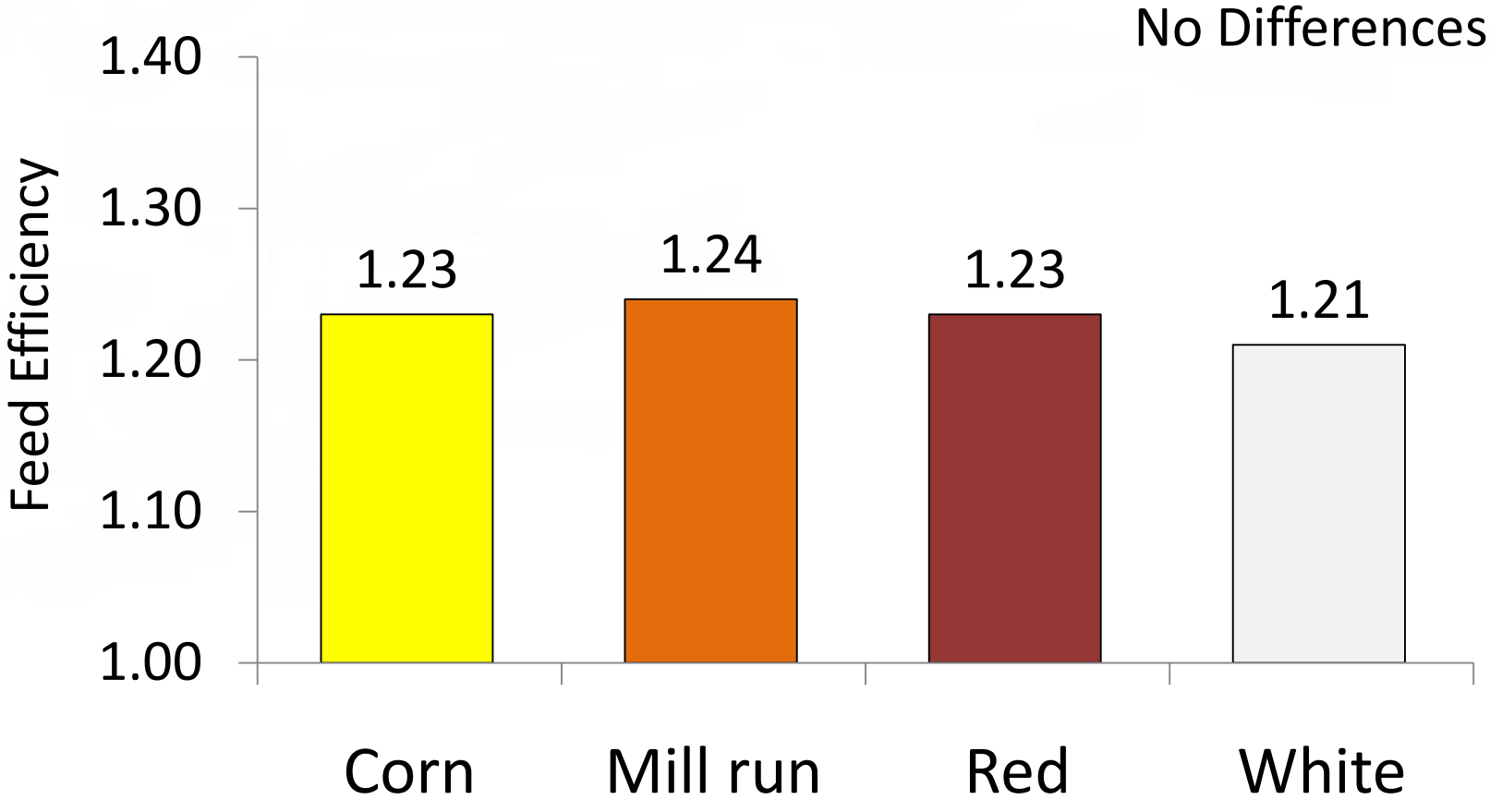


The effects of sorghum color on ADG



Jones, et. al. 2000

The effects of sorghum color on feed efficiency



Jones, et. al. 2000

Why do we see the improved feeding value of grain sorghum than in the past?
为什么我们看到高粱的饲用价值比过去提高了呢？

- **Better sorghum varieties** – improvement in plant genetics
- 更好的品种—植物基因的改善
- **Feed processing** – understanding the importance of particle size
- 饲料加工—了解粉碎粒度的重要性
- **Amino Acids** –the use of standardized ileal digestible amino acids in diet formulation
- 氨基酸—在饲料配方里使用标准化的回肠可消化氨基酸

Sorghum Summary
高粱总结

- Take advantage of sorghums digestible amino acid pattern relative to corn.
- 利用高粱在可消化氨基酸方面相对于玉米的优势。

- Allows more crystalline lysine to be used, yet still meets other amino acid requirements.
- 多使用晶体氨基酸，但还要满足其它氨基酸要求。

- Feed processing critical to effectively use sorghum as an alternative to corn-based diets.
- 为了有效的用高粱替代玉米，饲料加工技术很关键。

Thank you!
谢谢～！

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Sorghum for Swine Diets
猪料中用高粱