Effect of Maternal Arginine Supplementation on Offspring Performance in a Commercial Swine Production Environment

E.A. Hines*[1,2]; M. Romoser[1]; A.F. Keating[1]; L.H. Baumgard[1]; J. Niemi[1]; N.H. Williams[2]; B. Haberl[2]; B. Kerr[1]; K. J. Touchette[3]; J.W. Ross[1]

[1]Iowa State University, Ames, IA, USA,
[2]Iowa Select Farms, Iowa Falls, IA, USA,
[3]Ajinomoto Heartland Inc., Chicago, IL, USA

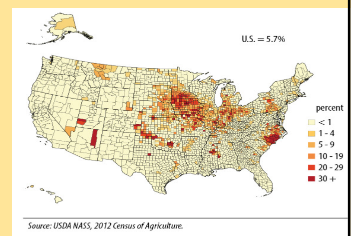
May 2017

eahines@iastate.edu

Hog Production Accounts for ~6% of Total U.S. Agricultural Sales

2

- Iowa is the leader in pig production
  - 6.8 billion in pig sales, 2012 census
- Total inventory of breeding and market pigs at 21.8 million (2016)
- Iowa State University supports this industry
- 40+ faculty across all to investigate industry production issues (examples)
  - Feed efficiency
  - Metabolic malfunction and Disease
  - Reproductive efficiency and herd longevity

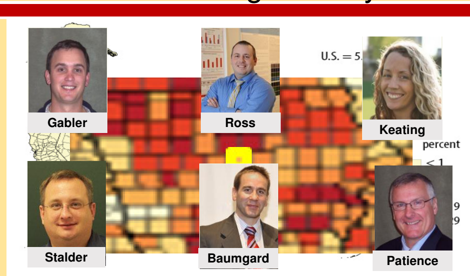


Source: USDA NASS, 2012 Census of Agriculture.

https://www.agcensus.usda.gov/Publications/2012/Online_Resources/Highlights/Hog_and_Pig_Farming/

Iowa State University is in the Heart of Pig Country

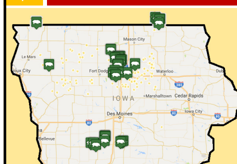
3



Source: USDA NASS, 2012 Census of Agriculture.

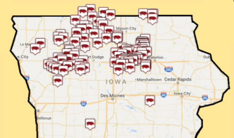
Iowa Select Farms

7

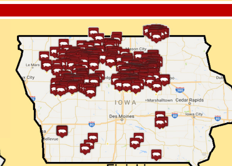


Sows
172,000 to date

- No. 8 in pig production in U.S.
- 10% of all pigs produced in Iowa come from ISF



Wean to Finish
800+ sites



Finishing
- 1.57 billion pounds of pork sold in 2016
- 3.7 million pigs sold

Commercial Production and Maternal Diets

5

- Feed 70% of operating costs, with protein 30% of diet costs
- Amino acid requirements of the developing fetus change with gestational age (Wu et al., 1999; NRC, 2012)
  - Fetal growth and development influences birth weight, later growth performance
  - Importance of Arginine (ARG) in fetal and neonatal pig development

Table 3 Effects of maternal dietary arginine supplementation during pregnancy on litter size and birth weights of piglets in swine

Authors	Parity of gestation	Supplemental arginine (% of diet or g/sow per day)	Period of arginine supplementation	Amount of dietary intake per day (kg)	CP content in diet (%)	Energy content in diet (ME; MJ/kg)	Arginine content in basal diet (%)	Lysine content in basal diet (%)	Placental weight during early to mid gestation[a] or at birth[b]	Litter size of viable fetuses[c] or live-born piglets[d]	Litter weight of viable fetuses[c] or live-born piglets[d]
Studies reporting beneficial effects of dietary arginine supplementation to gestating swine on pregnancy outcomes											
Bérard and Bee (2010)	1	0.87 % or 21.7 g	d 14–28	3.0	14.3[§]	11.5	1.07	0.88	No effect[a]	↑ by 3.7[c] per litter[†]	↑ by 32 %[c] per litter[†]
Campbell (2009)	1 and MP	1 % or 25 g	d 14–28	ND	ND	ND	ND	ND	ND	↑ by 1 per litter[d]	↑ by 6.4 %[d] per litter
De Blasio et al. (2009)	1	1 % or 25 g	d 17–33	2.5	ND	ND	ND	ND	ND	↑ by 1.2[d]	ND
Gao et al. (2012)	1 and MP	0.8 % or 16.6 g	d 22–114	2.0 (d 22–90) 3.0 (d 90–114)	13.2	13.0	0.88	0.65	↑ by 16 %[b]	↑ by 1.1 per litter[d]	↑ by 11 % per litter[d]
Li (2011)	1	0.40 % or 8.0 g	d 14–25	2.0	12.0	12.9	0.70	0.57	↑ by 34 %[b]	↑ by 2.2 per litter[c]	No effect[c]
Li (2011)	1	0.80 % or 16.0 g	d 14–25	2.0	12.0	12.9	0.70	0.57	↑ by 21 %[b]	↑ by 1.7 per litter[c]	No effect[c]
Mateo et al. (2007)	1	0.83 % or 16.6 g	d 30–114	2.0	12.2	13.0	0.70	0.58	ND	↑ by 2.0 per litter[d]	↑ by 24 % per litter[d]
Ramaekers (2006)	1 and MP	1 % or 25 g	d 14–28	ND	ND	ND	ND	ND	ND	↑ by 1 per litter[d]	ND
Wu et al. (2012b)	MP	0.83 % or 16.6 g	d 90–114	2.0	14.7	13.5	0.80	0.78	ND	No effect[d]	↑ by 16 % per litter[d]
Studies reporting no effects or adverse effects of dietary arginine supplementation to gestating swine on pregnancy outcomes											
Greiner et al. (2012)	MP	1.23 % or 28 g	d 18–34 or d 75–115	2.27 (≤d 100)	ND	13.6	ND	0.53 SID	ND	No effect[d]	↓ 3.4 % per litter[d]
Li et al. (2010)	1	0.8 % or 16 g	d 0–25	2.0	12.0	12.9	0.70	0.57	No effect[a]	↓ 3.1 per litter[c]	↓ 34 % per litter[c]
Zier-Rush et al. (2012)	MP	1.23 % or 27.6 g	d 18–34 or d 75–115	ND	ND	13.8	ND	0.51 SID	ND	No effect[d]	No effect[d]

Academic Trials in Support of Arginine Supplementation

Academic Trials in Contradiction of Support

Wu, 2013

Why feed arginine at all?

7

- Key in urea synthesis and disposal of excess nitrogen, it is
- Utilized in polyamine synthesis and nitric oxide synthesis in uterine lumen
- Numerous metabolic processes within the trophectoderm and liver
  - Key role in trophectoderm development through SLC7 family receptors
- Contributes to cellular functions such as MTORC1
- Specific role in activation of castor proteins direct regulation of MTOR and cellular proliferation processes
- All of these contribute to the overall goal of fetal development in cellular proliferation, differentiation, and communication

Wu et al., 2009; Bazer et al., 2011; Wu, 2013; Wang et al., 2014; Gai et al., 2016

Objectives

8

- Benefit of additional ARG in commercial production and on offspring performance remains unclear
- Objectives
  - To evaluate supplementation of L-ARG (at 1% inclusion, as fed) at different stages of gestation
  - Determine its influence on offspring performance in commercial swine production

Materials and Methods

9

- Commercially reared pubertal gilts (n = 548) were divided into 4 diet by day of gestation (dg) treatments:
  - 0% additional ARG
    - Control (n = 143)
  - 1% additional ARG
    - Early, 15-45 dg (n = 138)
    - Full, 15 dg-Farrow (n = 139)
    - Late, 85 dg-Farrow (n = 128)

Materials and Methods- Maternal Diets

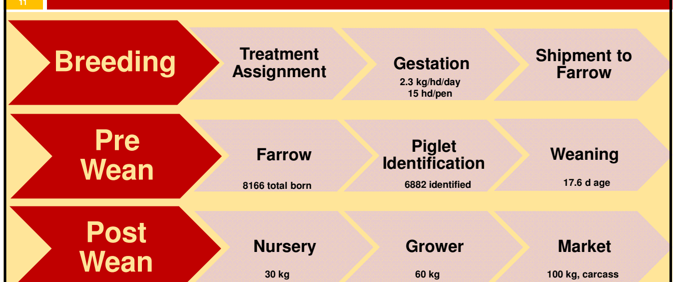
10

Diet Component	Trial Diets		NRC Req.- Total Basis (%)			
	Arginine	Control	Gilts (100-135 kg)	P1 (140 kg, <90d gest	P1 (140 kg, >90d gest	NRC Average
Dry Matter	87.63	87.46				
Crude Protein	16.30	14.88				
Alanine	1.00	1.02				
Arginine	1.28	0.65	0.34	0.32	0.42	0.36
Leucine	1.58	1.60	0.75	0.55	0.75	0.68
Lysine	0.78	0.75	0.74	0.61	0.8	0.72
Met+CYS	0.53	0.54	0.45	0.41	0.54	0.47
Methionine	0.26	0.26	0.22	0.18	0.23	0.21
Phenylalanine	0.69	0.70	0.45	0.34	0.44	0.41
Threonine	0.53	0.53	0.51	0.46	0.58	0.52
Tryptophan*	0.12	0.12	0.13	0.11	0.15	0.13
Valine	0.68	0.69	0.51	0.45	0.58	0.51

*Tryptophan as fed was 0.0049% lower than NRC, on average

Materials and Methods- Experimental Flow

11



Statistical Analysis

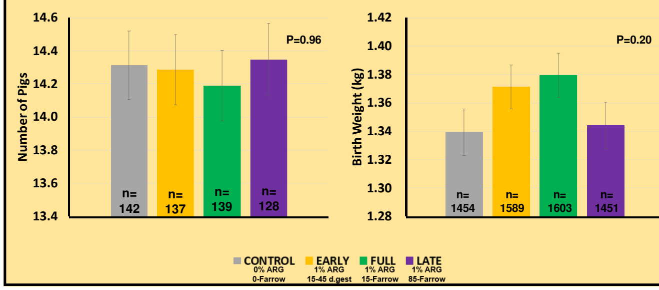
12

- Statistical analyses (SAS 9.0, Cary, NC) were performed on gilt and offspring performance
  - Cross foster events were removed for offspring growth performance parameters
  - All offspring growth performance analyzed using birth weight and weaning weight age as covariates
  - Gilt and gestation pen utilized as a random effect

13

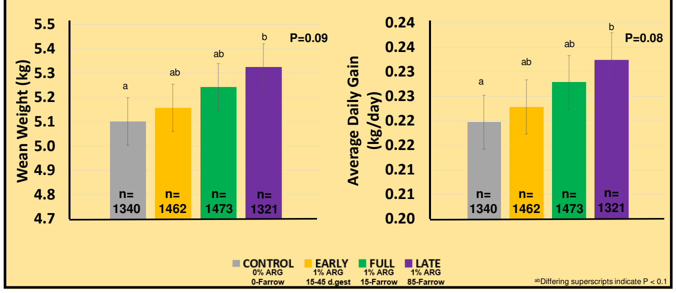
Supplementation of ARG Did Not Affect Litter Size or Birth Weight

14



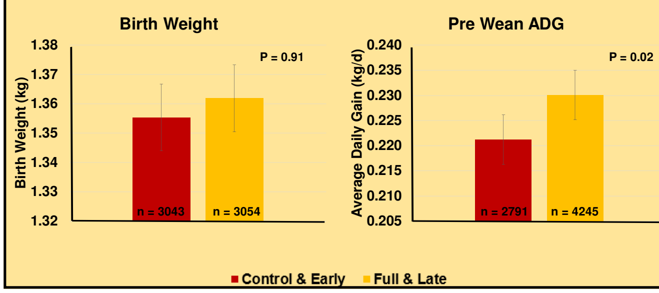
Supplemental ARG Tended to Increase Wean Weight and Pre Wean Average Daily Gain

15



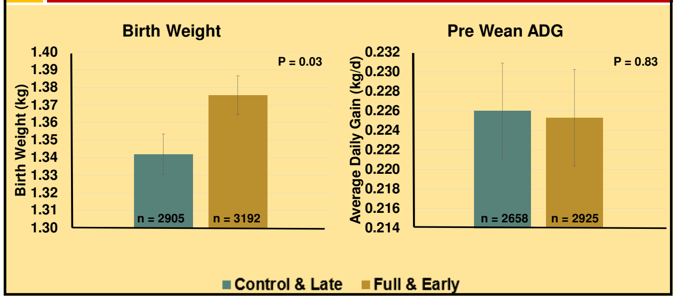
Contrasts Suggest Improved Pre Wean Growth Performance with Late ARG

16



Yet Improved Birth Weight, and Not Pre Wean ADG with Early ARG

17



Post Wean Growth Performance was Not Different by Maternal Diet

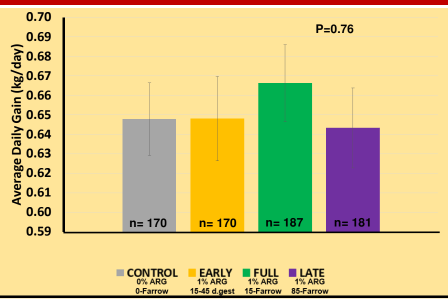
18

Average Daily Gain, kg/d	CONTROL	EARLY	FULL	LATE	SEM	P value
30 kg Target	0.41	0.41	0.42	0.41	0.02	0.83
60 kg Target	0.80	0.76	0.79	0.81	0.03	0.16
100 kg Target	1.00	1.03	1.02	1.00	0.04	0.76

CONTROL 0% ARG 0-Farrow; EARLY 1% ARG 15-45 d.gest; FULL 1% ARG 15-Farrow; LATE 1% ARG 85-Farrow

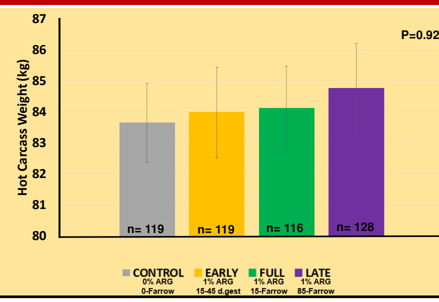
Lifetime Average Daily Gain was Not Different by Maternal Diet

19



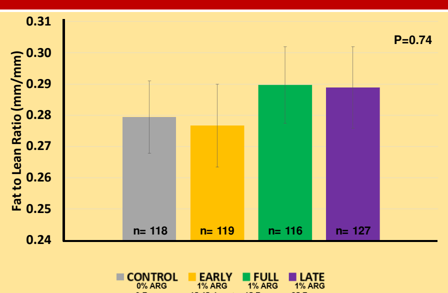
Maternal Diet Did Not Effect Hot Carcass Weight

20



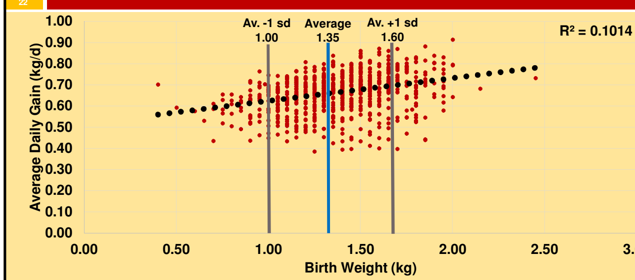
Effect of Maternal Diet on Loin Fat (mm) to Lean (mm) Ratio

21



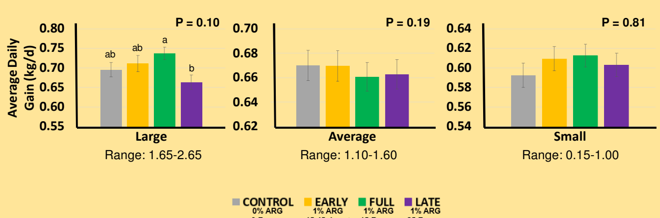
Birth Weight Does Affect Lifetime Average Daily Gain

22



Interaction of Birth Weight Class and Maternal Diet Influenced Lifetime Average Daily Gain

23



abDiffering superscripts indicate P < 0.1

Summary

24

- Supplementation of ARG did not effect litter size or birth weight
- Individual wean weights and pre wean average daily gain
  - Tended to increase, late gestation ARG
  - Maternal ARG supplementation did not affect post wean growth or carcass performance
- Birth weight improves overall growth performance
  - Birth weight classification increased strength of relationship

Conclusions

25

- Maternal supplementation of additional ARG, at 1% inclusion
  - Particularly pre wean performance, Late gestation ARG
  - Future exploration of mammary development to lactation
- Intensive data collection and further controlled analysis
  - Revealed improvements not easily observable in standard production data
  - How can we translate academic data into commercially relevant results

Thank you & Questions

- National Pork Board
- Iowa Pork Producers
- Ross & Keating Labs

pork checkoff

IOWA PORK PRODUCERS ASSOCIATION

Iowa Select FARMS