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Impact of dietary L-arginine supply during early gestation on myofiber development in newborn pigs exposed to intra-uterine crowding

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Background

- Selection for high prolificacy in modern sows
- Marked increase in litter size
  - More pigs suffered from intra-uterine growth retardation (IUGR)
- More low birth weight (L-BtW) pigs with low viability

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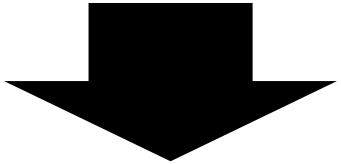
Background

- Lower prenatal hyperplasia
- Impaired postnatal growth and lean meat deposition rate



- Nutritonal intervention during pregnancy?
- Impact independent of BtW?

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Background

Use of natural and artificially crodwed sows (surgical procedure)

Study objective

Investigate effects of dietary L-arginine supplementation in early gestation on myofiber development in the offspring at birth

L-arginine:

- Semi-essential amino acid
- Substrate for nitric oxide and polyamine synthesis
- Regulators of angiogenesis and placental growth.

L-arginine positively influences hyperplasia of primary (P) fibers in 75-d old fetuses from sows fed L-arginine from d 14-28 of gestation (Bérard et al., 2010)

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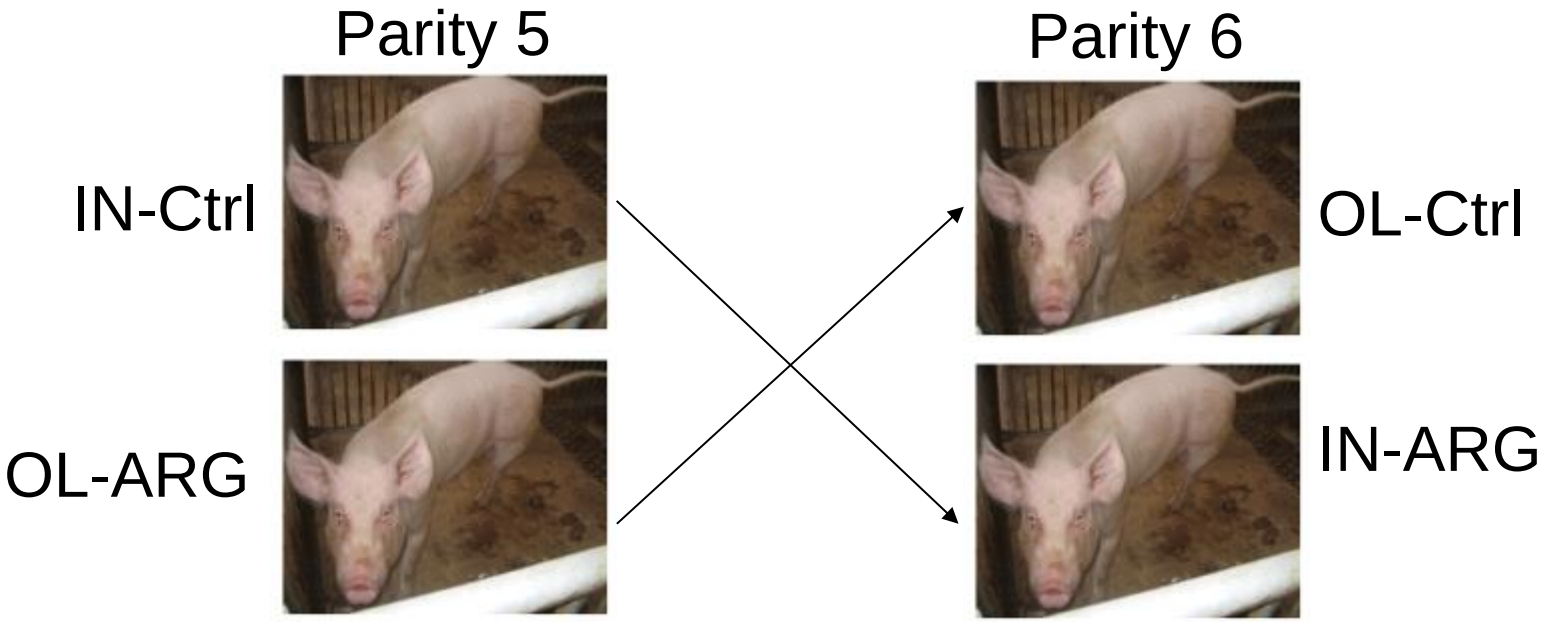
Material and methods

- Experimental sow model
  - Moderately crowded intra-uterine environment (**IN**)
    - Use of hyperprolific sows
  - Uncrowded intra-uterine environment (**OL**)
    - Use of sows subjected to unilateral oviduct ligation

Materials and methods

5 IN and 5 OL sows received daily from d 14 to 28 of gestation either

- 25 g L-arginine·HCl (**ARG**)
- 43 L-alanine (**Ctrl**)



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Materials and methods

- Sows were fed daily 2.8 kg of a standard gestation diet
  - 15% CP, 7% fat, 13.70 DE MJ/kg DM.

- Recorded litter characteristics were:
  - Total born
  - Born alive
  - Birth weight

- Within litter one female and male piglet with the lowest and medium birth weight were sacrificed for further analysis.

- Traits assessed in the selected piglets:
  - Birth weight
  - Weight of the semitendinosus (STM) and psoas major (PM) muscle
  - Myofiber related traits assessed in the STM
  - Expression of myogenic-related genes analyzed in the STM

Reproductive traits

S: Surgical treatment
D: Dietary treatment

	Surgical treatment		Diet			*P*-value	
Item	IN	OL	Ctrl	ARG	SEM	S	D
Total born	15.4	11.3	12.9	13.6	1.21	ns	ns
Born alive	13.8	9.7	11.1	12.4	1.07	ns	ns
Stillborn	1.6	1.6	1.9	1.2	0.37	ns	ns
Male:female ratio	0.55	0.46	0.48	0.52	0.056	ns	ns
Birth weight, kg							
Total born	1.351	1.541	1.396	1.496	0.059	ns	ns
Born alive	1.372	1.562	1.417	1.516	0.059	ns	ns

IN vs. OL: Intra-uterine crowding had no significant effect on reproductive traits

ARG vs. Ctrl: Arginine had no significant effect on reproductive traits

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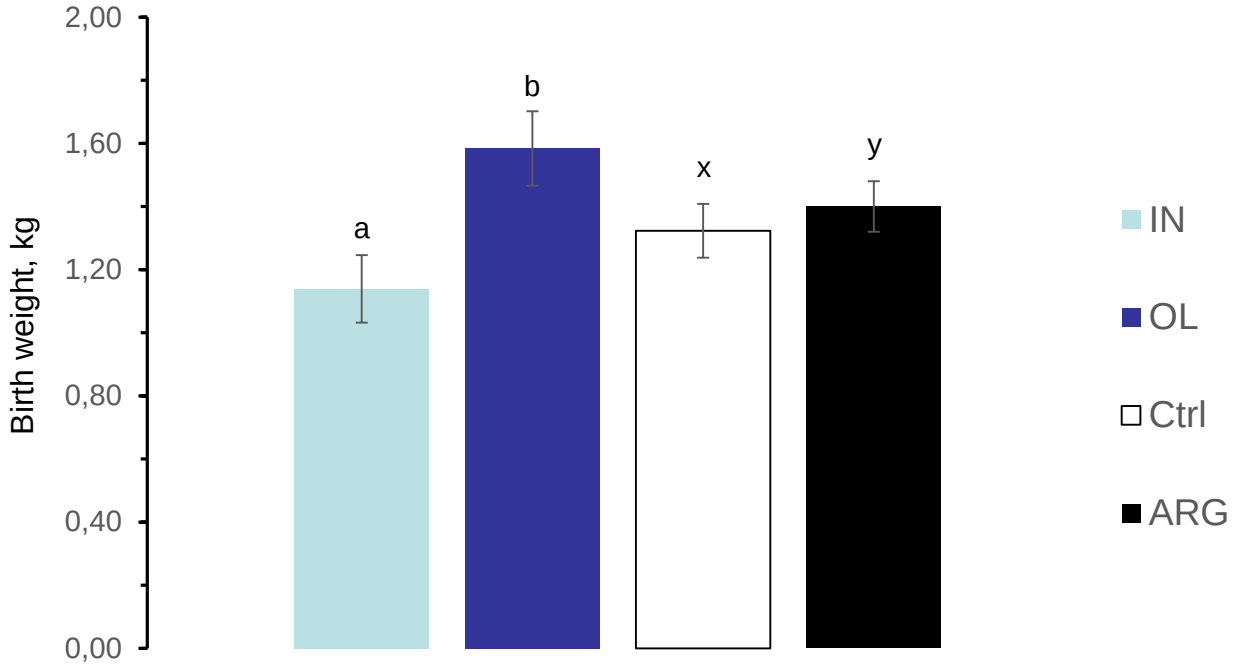
Birth weight of selected pigs



[a,b] LSM without a common superscript differ ($P < 0.05$)
[x,y] LSM without a common superscript differ ($0.05 \leq P < 0.10$)

IN vs. OL: Intra-uterine crowding lowered birth weight of selected pigs

ARG vs. Ctrl: Arginine tended to increase birth weight of selected pigs

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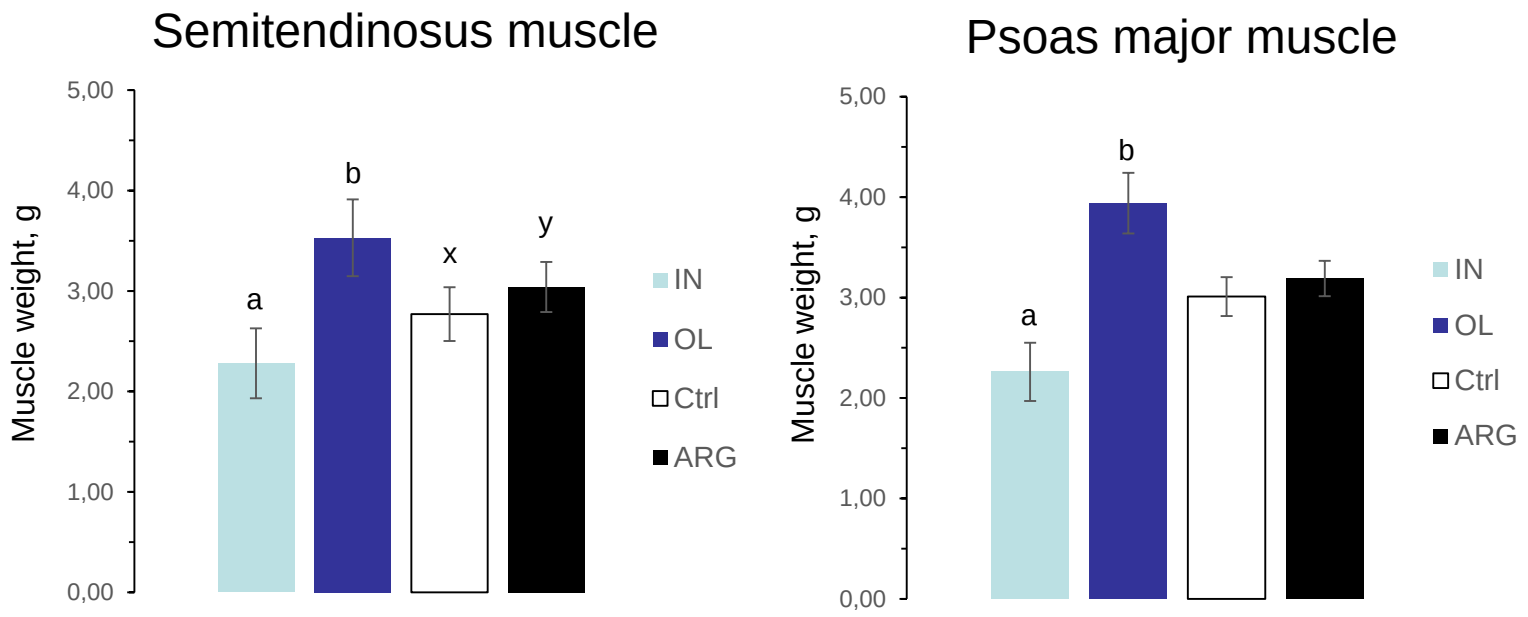
Offspring traits: Muscle weight

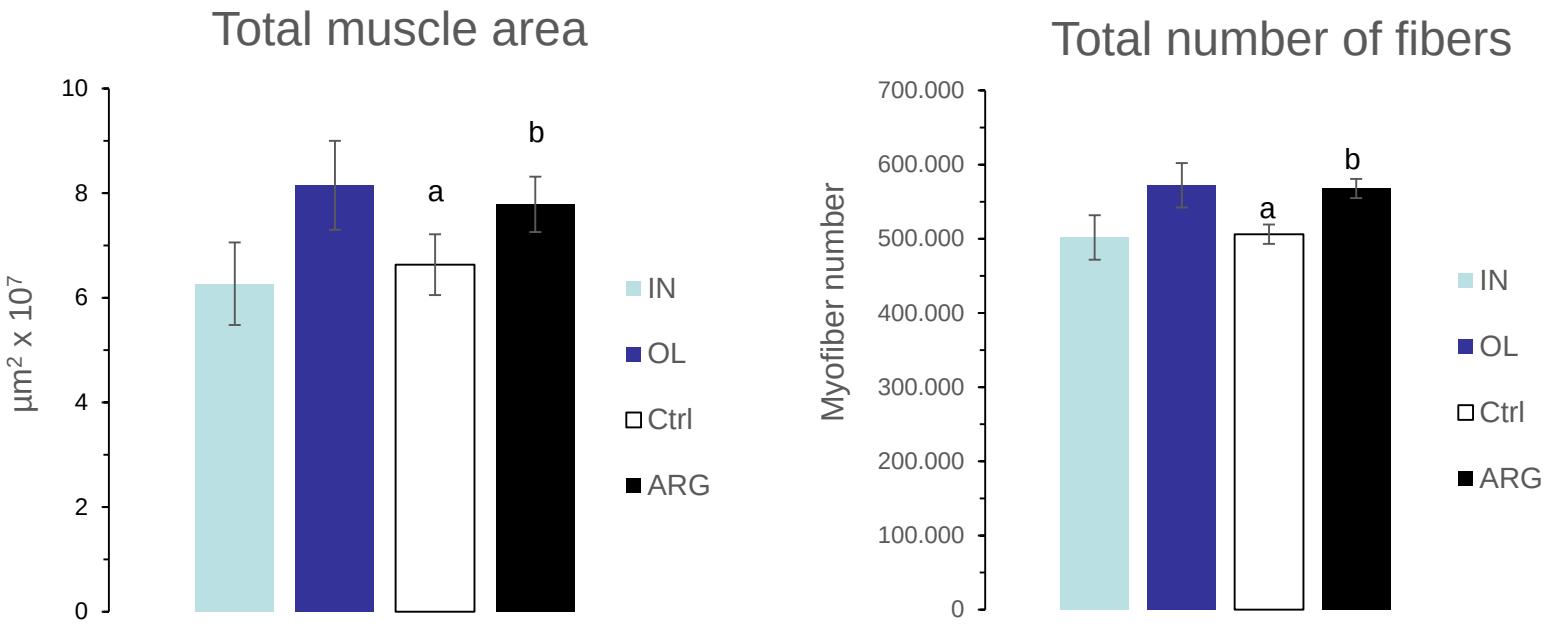


[a,b] LSM without a common superscript differ ($P < 0.05$)
[x,y] LSM without a common superscript differ ($0.05 \leq P < 0.10$)

IN vs. OL: Intra-uterine crowding reduced absolute STM and PM weight

ARG vs. Ctrl: Arginine tended to increase STM but not PM weight

Myofiber characteristics

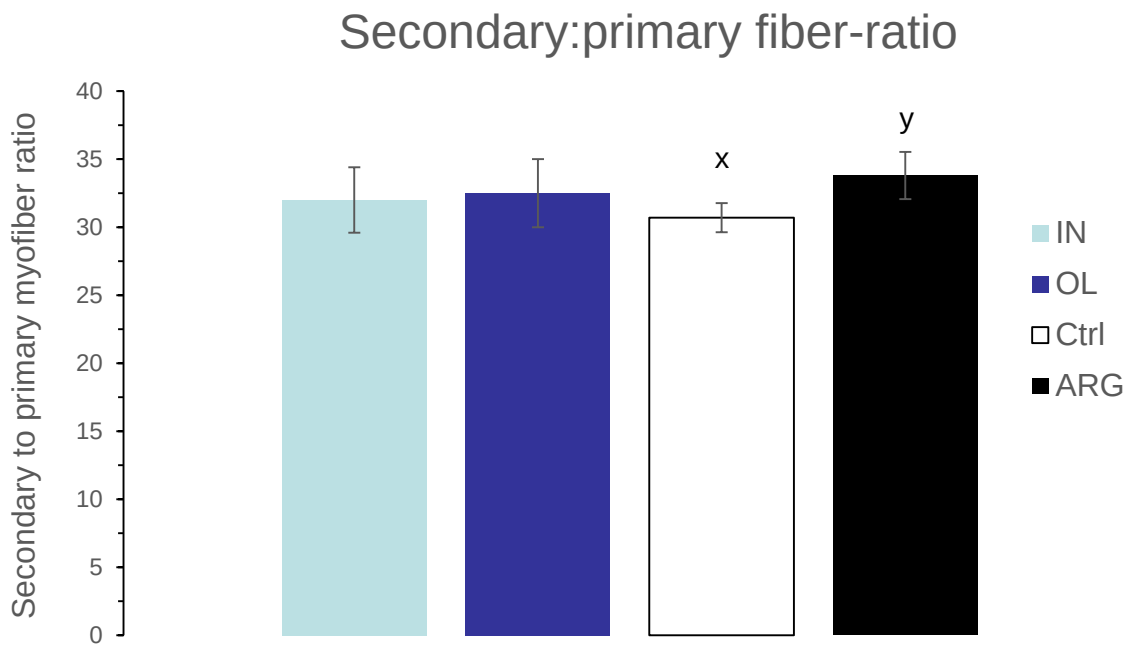


[a,b] LSM without a common superscript differ ($P < 0.05$)

IN vs. OL: Intra-uterine crowding had no effect on total muscle area and total myofiber number

ARG vs. Ctrl: Arginine increased muscle area and myofiber number

Myofiber characteristics



[x,y] LSM without a common superscript differ ($0.05 \leq P < 0.10$)

IN vs. OL : Intra-uterine crowding had no effect on secondary to primary myofiber ratio

ARG vs. Ctrl: Arginine tended to increase the secondary to primary myofiber ratio

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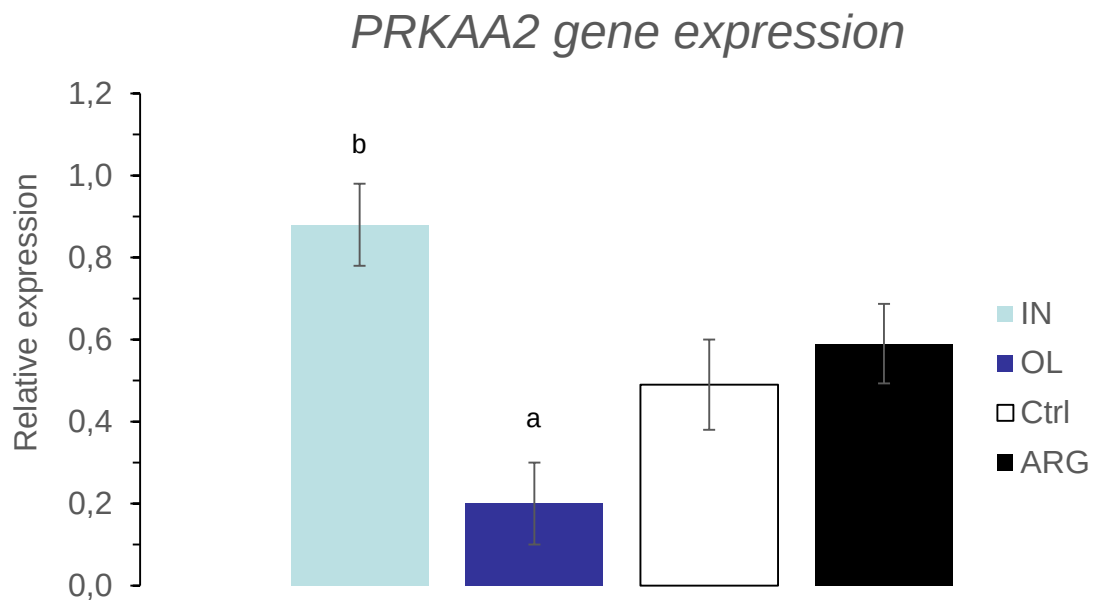
PRKAA2 gene expression



[a,b] LSM without a common superscript differ ($P < 0.05$)

Protein kinase AMP-activated catalytic subunit alpha 2 inhibitor of muscle protein synthesis

IN vs. OL: Intra-uterine crowding increased *PRKAA2* gene expression

ARG vs. Ctrl: Arginine had no effect on *PRKAA2* gene expression

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Conclusion

- Crowding critically affects offspring's phenotype

- Early gestational supplementation of L-arginine reduces negative impact of intra-uterine crowding by increasing:
  - Birth weight of lowest and medium birth weight piglets
  - Muscle area
  - Myofiber hyperplasia

- Effect of diet is independent of the extent of crowding

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Perspectives

- Further questions are: Does myofiber hyperplasia have positive effect on…

- viability and growth of L-BtW pigs in the nursery phase?
  - growth data of pigs during the nursery phase is available, but has yet to be analyzed.

- growth potential of L-BtW pigs?
  - improve weight gain in the weaning, grower and finisher phase

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Thank you for your interest!

Item	Sow		Diet		SEM	*P*-value[2]				
	IN	OL	Ctrl	ARG		S	D	BtW	S × D	D × BtW
Birth weight	1.139	1.584	1.323	1.400	0.0992	0.008	0.068	0.564	0.137	< 0.001
Absolute muscle and organ weights (g)										
Semitendinosus muscle	2.28	3.53	2.77	3.04	0.318	0.025	0.074	0.571	0.426	0.009
Psoas major muscle	2.26	3.94	3.01	3.19	0.247	0.001	0.232	0.543	0.891	0.024
Heart	9.44	7.87	8.34	8.96	1.382	0.418	0.159	0.806	0.005	0.032
Liver	24.15	46.77	33.44	37.47	4.417	0.004	0.053	0.529	0.290	0.022
Spleen	1.02	1.48	1.25	1.25	0.118	0.063	0.938	0.918	0.537	0.052
Lung	17.36	19.26	18.17	18.45	2.037	0.576	0.750	0.459	0.152	0.010
Kidney	8.30	12.75	10.22	10.83	1.131	0.033	0.301	0.771	0.322	0.022
Brain	32.61	34.08	33.03	33.66	0.544	0.235	0.119	0.621	0.699	0.031
Brain:liver weight ratio	1.24	0.93	1.15	1.02	0.172	0.270	0.077	0.151	0.182	0.001
Relative muscle and organ weights (g/100 g BtW)										
Semitendinosus muscle	2.08	2.24	2.14	2.18	0.064	0.328	0.415	0.716	0.341	0.511
Psoas major muscle	2.10	2.35	2.18	2.27	0.093	0.277	0.276	0.314	0.987	0.483

[1] Results are presented as least squares means and pooled SEM.
[2] Probability values for the effects of surgical treatment (S), dietary treatment (D), birth weight (BtW), and interactions S × D and D × BtW.

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Heart	0.68	0.66	0.69	0.66	0.015	0.492	0.030	0.770	0.720	0.338
Liver	2.34	2.77	2.49	2.62	0.125	0.128	0.192	0.629	0.142	0.343
Spleen	0.093	0.088	0.093	0.088	0.0038	0.665	0.176	0.734	0.018	0.556
Lung	1.43	1.29	1.39	1.33	0.078	0.363	0.250	0.235	0.762	0.655
Kidney	0.73	0.81	0.77	0.77	0.029	0.270	0.764	0.613	0.396	0.627
Brain	2.70	2.50	2.67	2.53	0.251	0.616	0.169	0.204	0.114	< 0.001

Item	Sow		Diet		SEM	*P*-value[2]				
	IN	OL	Ctrl	ARG		S	D	BtW	S × D	D × BtW
Muscle area, $\mu m^2 \times 10^7$										
Total	6.270	8.150	6.633	7.787	0.7006	0.144	0.003	0.653	0.738	0.053
Dark portion	2.318	3.172	2.565	2.925	2.0161	0.078	0.025	0.233	0.007	0.573
Light portion	3.634	5.292	4.028	4.897	0.6138	0.143	0.011	0.910	0.786	0.061
Myofiber number, N										
Total muscle	501868	572189	506238	567819	23737.8	0.236	0.003	0.136	0.604	0.475
Dark portion										
Total myofibers	196091	201597	189259	208429	15306.2	0.884	0.131	0.002	0.231	0.560
Primary myofibers	5972	6012	5986	5998	427.0	0.970	0.974	0.069	0.422	0.575
Secondary myofibers	190118	195585	183272	202431	15011.1	0.883	0.124	0.002	0.231	0.559
S:P ratio	32.0	32.5	30.7	33.8	1.91	0.912	0.051	0.356	0.643	0.337
Light portion	305777	370592	316978	359390	21818.7	0.234	0.022	0.889	0.778	0.236

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Gene[3]	Sow		Diet		SEM	*P*-value[2]				
	IN	OL	Ctrl	ARG		S	D	BtW	S × D	D × BtW
IGF2	1.95	1.30	1.63	1.62	0.381	0.487	0.967	0.965	0.013	0.950
IGFBP5	5.64	3.47	3.97	5.13	1.693	0.489	0.233	0.275	0.290	0.297
MSTN[4]	1.62	0.67	0.86	1.26	0.166	0.351	0.232	0.105	0.241	0.110
MYF5[4]	0.38	0.26	0.29	0.34	0.143	0.631	0.531	0.895	0.974	0.159
MYF6	0.62	1.08	0.88	0.82	0.391	0.623	0.859	0.893	0.664	0.631
MYOD1[4]	2.08	0.57	1.27	0.94	0.250	0.223	0.340	0.056	0.885	0.418
MYOG	0.82	1.21	1.13	0.90	0.169	0.333	0.168	0.392	0.915	0.417
PRKAA2	0.88	0.20	0.49	0.59	0.141	0.024	0.264	0.298	0.034	0.091