EFFICIENT & ECOLOGICALLY-FRIENDLY PIG AND POULTRY PRODUCTION.

ECO-FCE

A WHOLE-SYSTEMS APPROACH TO OPTIMISING FEED EFFICIENCY AND REDUCING THE ECOLOGICAL FOOTPRINT OF MONOGASTRICS.

BASIC DATA

Funding:
EU-FP7
(€ 6 million)

Start date:
1 February 2013

Duration:
48 months
(2013 to 2016)

The ECO-FCE project is funded by the European Union Seventh Framework Programme (FP7 2007/2013) under grant agreement No. 311794.

COOPERATION

ECO-FCE: Lifetime performance of low birth weight piglets from hyperprolific sows is affected by peri-natal nutrition

Work package title (WP2): *Identification and optimization of feed strategies*

Task 2.3: *Peri-natal nutritional effects on lifetime performance of pigs*

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29.09.2016

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The ECO-FCE project is funded by the European Union Seventh Framework Programme (FP7 2007/2013) under grant agreement No. 311794.

Objectives

- Establish appropriate feeding strategies in the early postnatal (lactation) period to improve post natal growth efficiency of low birth weight pigs from hyperprolific sows
  - Task 2.3a: To compare the effect of daily L-carnitine or L-arginine administration on viability and muscle development of low birth weight pigs
  - Task 2.3b: To determine optimal inclusion level of most promising supplement during lactation on viability and muscle development of low birth weight pigs
  - Task 2.3c: To evaluate the long lasting effect of the dietary intervention during the lactation period on growth performance, carcass characteristics and meat quality

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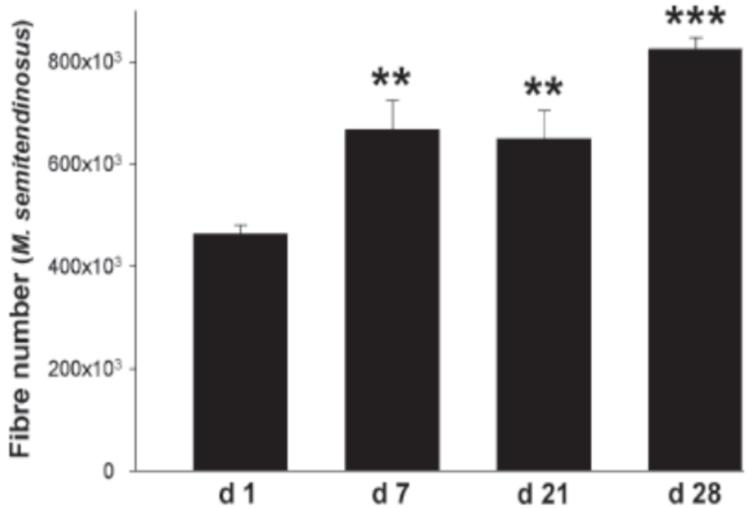
Background

- Low birth weight (L-BtW) pigs are a concern in modern pig production because of
  - lower pre-weaning survival rate
  - lower feed efficiency
  - impaired carcass and meat quality

Impaired myofiber hyperplasia

feeding strategies in early life



Berard et al., 2011

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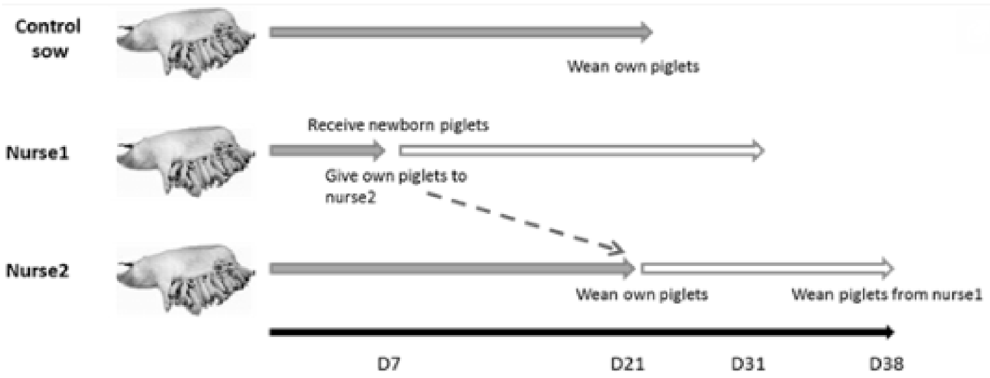
Study objectives

- **Objective**
  - Improve production efficiency by
    - Increasing survival
    - Enhancing post natal myofiber hyperplasia
    - Increasing growth rate

- **Alternative to conventional rearing**
  - Nursing sow strategies
  - Early artificial rearing in rescue decks
    - Large littermates, whole litter or L-BtW piglets.



Modified from Amdi et al., 2015

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Choice of strategy

Task 2.3a: to compare the effect of daily L-carnitine or L-arginine administration on viability and muscle development of new born piglets

- **Survival, growth and myofiber hyperplasia is impaired in L-BtW piglets**
  - Consequence of increased litter size resulting in intra-uterine growth restriction (IUGR)

- **Choice of supplementation based on previous studies.**
  - L-arginine (Kim and Wu, 2004, Yao et al, 2008).
    - Promotes: Survival, growth and protein synthesis.
  - L-carnitine (Lösel et al, 2009; Keller et al., 2009).
    - Promotes: Post natal myofiber hyperplasia in L-BtW piglets.

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Exp. 1

- 3 week trial
- Born from hyperprolifc sows (>15 born/litter)
- Birth weight < 1.2 kg
- Restricted feeding
- Day 7 – 28
- Piglets weighed weekly and feed intake measured daily
- Slaughtered day 28

Ingredients, %	CTRL	CAR	ARG
Whey powder	61.6	61.6	61.6
Whole milk protein	28.0	28.0	28.0
Milk protein	6.2	6.2	6.2
L-arginine, g/kg BW · piglet^{-1} · d^{-1}	-	-	1.08
L-carnitine, g piglet · d^{-1}	-	0.40	-
Analyzed composition, % DM			
Gross energy, MJ/kg DM	17.9	17.9	17.9
Crude protein	21.1	21.1	21.1
Crude fat	7.8	7.8	7.8

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Materials and Methods

- Traits of interest:
  - Growth perfomance
  - Blood metabolites
  - Carcass composition
  - Organ weights
  - Semitendinosus muscle:
    - Myofiber number and size (histology)
    - Energy metabolism in muscle (enzym activity)
    - Gene expression analysis of myogenic- and proteasome related genes.

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Results Exp. 1

	Dietary treatment			Sow*
	CTRL	CAR	ARG	
Birth weight, kg	1.050	1.028	1.036	-
BW d 7, kg	1715	1821	1693	-
BW d 28, kg	4.298	4.854	4.729	-
ADG d 7-28, g	124	144	141	195
ADFI d 7-28, g DM	140	158	158	168
Energy intake, MJ/d	2.51	2.84	2.84	4.31
G:F d 7-28	0.88	0.91	0.89	1.15

*Suckling pigs (BW d 10: 3.32 kg) average of d 10-13 and 17-20 of age (Theil et al., 2007)

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Results Exp. 1

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Key enzyme for following pathways

Citric acid cycle activity

- Citrate synthase (**CS**)

Lipid oxidation

- β-hydroxyacyl-CoA dehydrogenase (**HAD**)

Glycolytic capacity

- Lactate dehydrogenase (**LDH**)

- LDH:CS and LDH:HAD = markers for muscle maturity

- Reflect the relative importance of **glycolytic** compared to **oxidative** metabolism in muscle.

	Treatment		
Item	CTRL	CAR	ARG
Dark portion			
CS (× 10^{-2})	0.428^{y}	0.393^{xy}	0.357^{x}
LDH	0.930^{a}	2.088^{b}	1.617^{b}
LDH:HAD	3.63^{a}	**9.09^{b}**	**6.29^{ab}**
LDH:CS	228.84^{a}	**552.95^{b}**	**462.14^{b}**
Light portion			
CS (× 10^{-2})	0.405^{b}	0.384^{b}	0.290^{a}
LDH	1.255^{a}	1.950^{ab}	2.471^{b}
LDH:HAD	7.33^{a}	**11.56^{ab}**	**14.62^{b}**
LDH:CS	321.33^{a}	**529.38^{b}**	**904.22^{b}**

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Conclusion Exp. 1 -> Changes for Exp. 2

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- **Both supplements positively affect muscle maturation in early life**
- **No effects of supplements on growth performance and carcass composition**
  - Low weaning weight
    - Restricted intake?

***Ad libitum* feeding**

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Results Exp. 2

ECOFCE

	Dietary treatment			Sow*
	CTRL	CAR	ARG	
Birth weight, kg	1.166	1.173	1.185	-
BW d 7, kg	1.958	2.051	2.158	-
BW d 28, kg	5.975	5.872	6.425	-
ADG d 7-28, g	191	181	196	195
ADFI d 7-28, g DM	218	199	236	168
Energy intake, MJ/d	3.91	3.56	4.24	4.31
G:F d 7-28	0.88	0.91	0.83	1.15

*Suckling pigs (BW d 10: 3.32 kg) average of d 10-13 and 17-20 of age (Theil et al., 2007)

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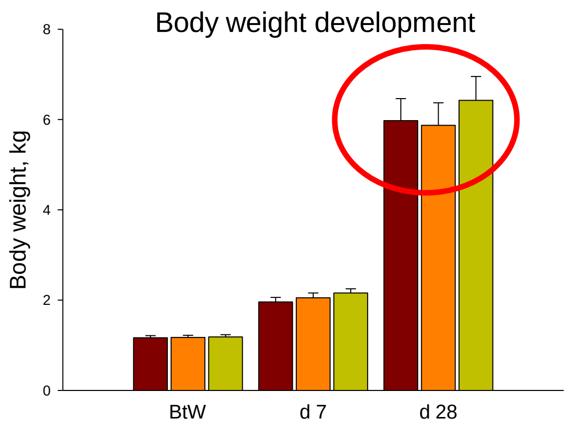
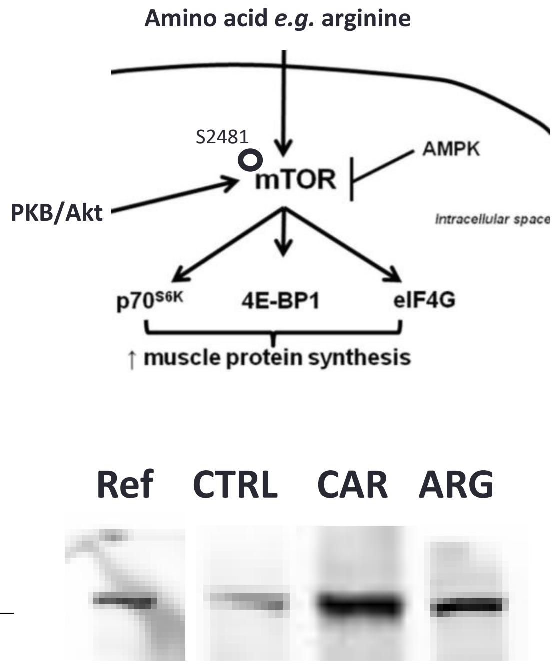
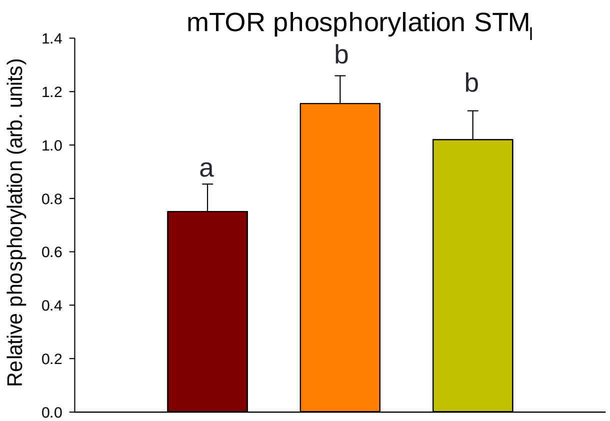
Results Exp. 2

Increase by 30% compared to Exp. 1







[a,b] bars with different superscripts differ ($P < 0.05$)

Control Carnitine Arginine

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Conclusion Exp. 2

- **Compared to Exp. 1, *ad libitum* feeding improves growth and weaning weight**

- **Molecular effect of supplementation**
  - Increased activation of protein synthesis pathway.

- **No clear indication that one of the two supplements has an advantage over the other (CAR ⇔ ARG)**

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Exp. 3

- **Optimize milk replacer**

		Milk replacer	
Ingredients, %	Sow milk	Exp. 1 & 2	Optimized
Whey powder	-	61.6	-
Whole milk protein	-	28.0	-
Milk protein	-	6.2	26.5
Butter powder, 75% fat	-	-	51.0
Glucose	-	1.0	20.0
Analyzed composition, as fed			
Dry matter, %	~ 20.0	20.0	20.0
Gross energy, MJ	5.5	3.6	5.5
Crude protein	56.0	42.2	63.2
Crude fat	83.2	15.6	81.2

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Exp. 3

- **Rearing with optimized milk replacer**
  - Massive diarrhea, low growth -> terminated experiment

- **Speculations regarding diarrhea**
  - DM, protein and/or fat content too high

- **Too early artificial rearing**
  - Day 3 might be too early for L-BtW

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Experimental design of Exp. 4

Task 2.3c: to evaluate the long lasting effect of the dietary intervention during the lactation period on growth performance, carcass characteristics and meat quality

All piglets born from hyperprolific sows (>15 born/litter) with a BtW < 1.2 kg

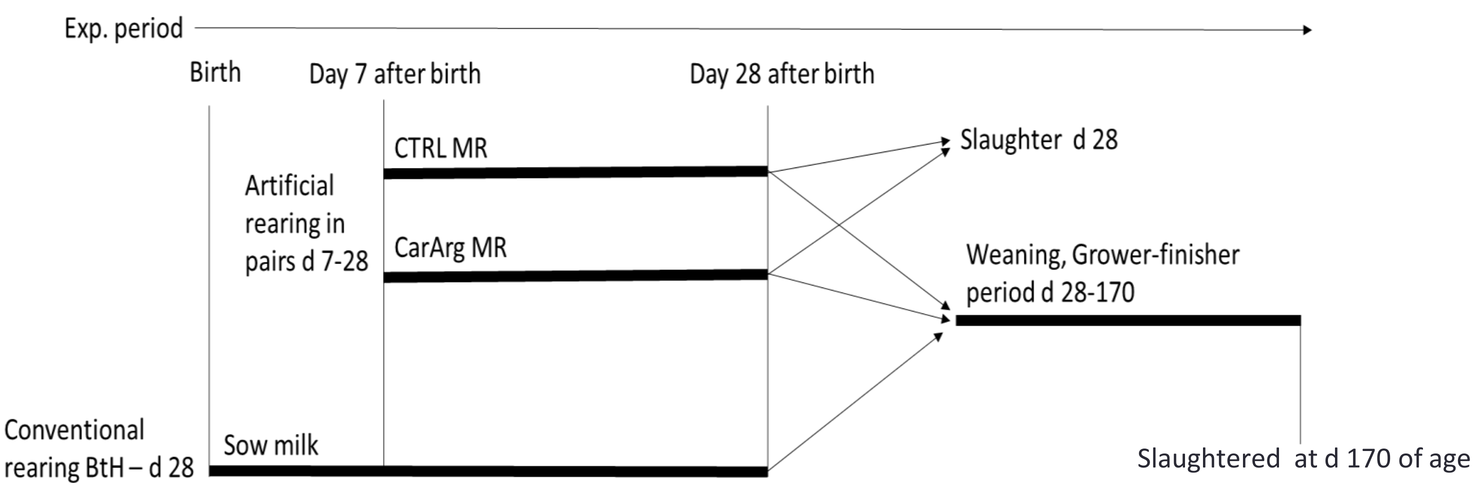
- 48 piglets were artificially reared from d 7-28 of age
- 24 piglets were conventionally reared piglets by their dam for 28 d (**SOW**)

Artificial rearing:

- **CTRL**: Commercial milk replacer (20.5% protein, 9.5% fat, 18.6 GE MJ/kg DM)
- **CarArg**: Commercial milk replacer supplemented with **0.05% L-carnitine + 1.67% L-arginine**

After weaning:

- CTRL, CarArg and SOW pigs were fed standard weaning, grower and finisher diet till slaughter at 170 d of age



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Materials and Methods

- Traits of interest:
  - Pre-weaning growth
  - Organ weight and enzyme activity in STM
  - Post-weaning growth
    - BW at slaughter (d 170)
    - Daily gain (ADG), feed intake (ADFI), feed efficiency (G:F)
  - Carcass traits
    - Hot and cold carcass weight
    - Lean meat percentage
  - Meat quality traits
    - Drip loss, 24 h

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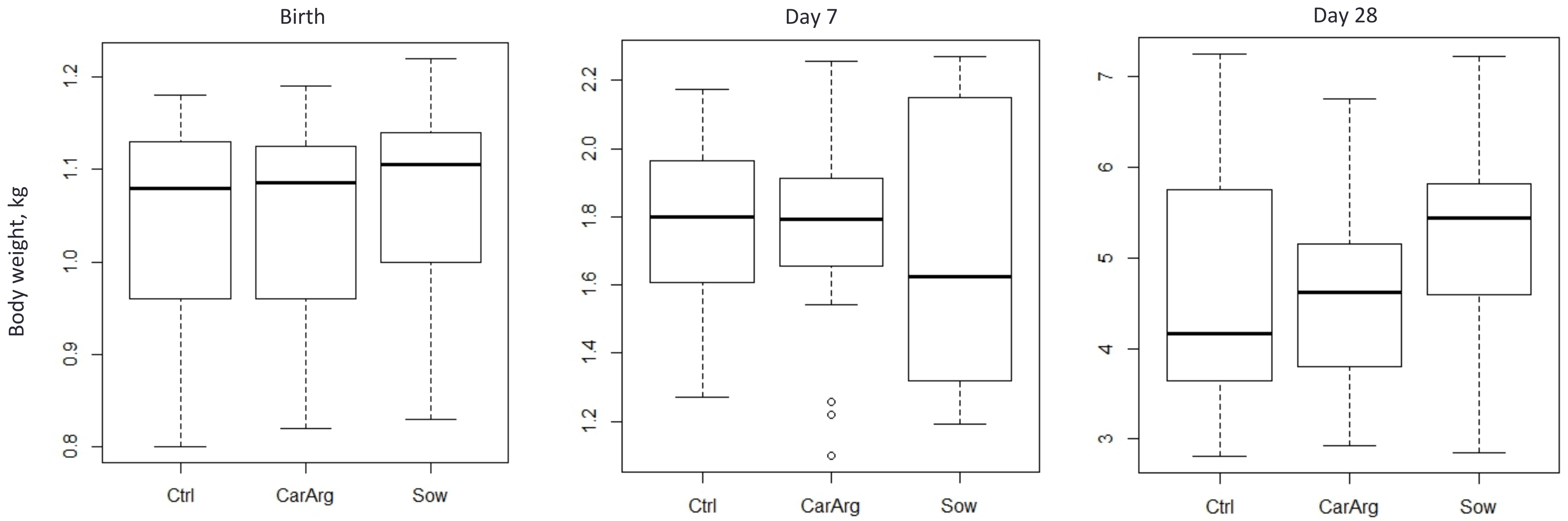
Results Exp. 4: Pre-weaning survival and growth



- Low weaning weight -> low DM content of milk replacer
- All piglets survived the experimental period
- 8% mortality rate d 7-28 from herd (loose-housed system)

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Results Exp. 4: Pre-weaning survival and growth

	Dietary treatment		Sow*
	CTRL	CarArg	
Birth weight, kg	1.038	1.039	-
BW d 7, kg	1.794	1.735	-
BW d 28, kg	4.652	4.465	-
ADG d 7-28, g	138	136	195
ADFI d 7-28, g DM	153	148	168
Energy intake, MJ/d	2.74	2.65	4.31
G:F d 7-28	0.90	0.92	1.15

*Suckling pigs (BW d 10: 3.32 kg) average of d 10-13 and 17-20 of age (Theil et al., 2007)

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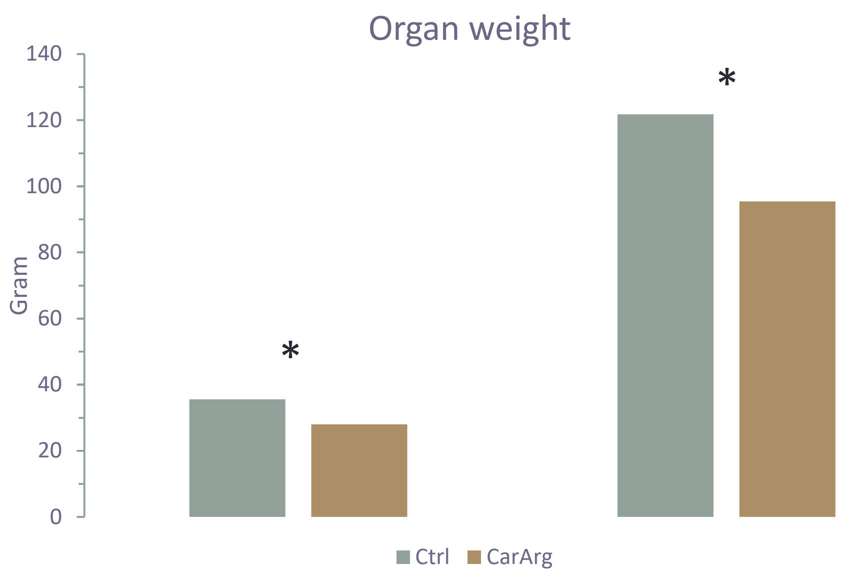
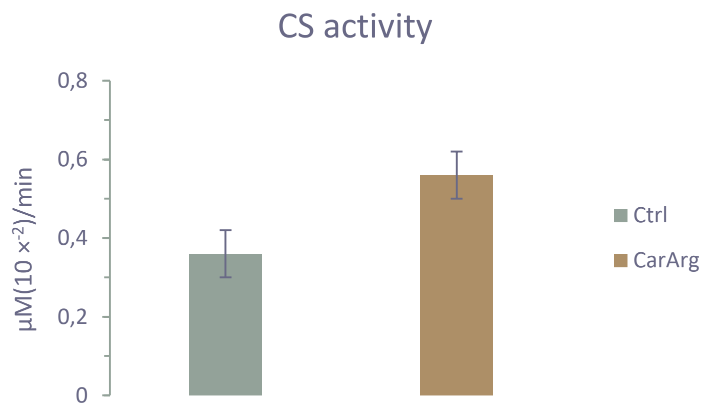
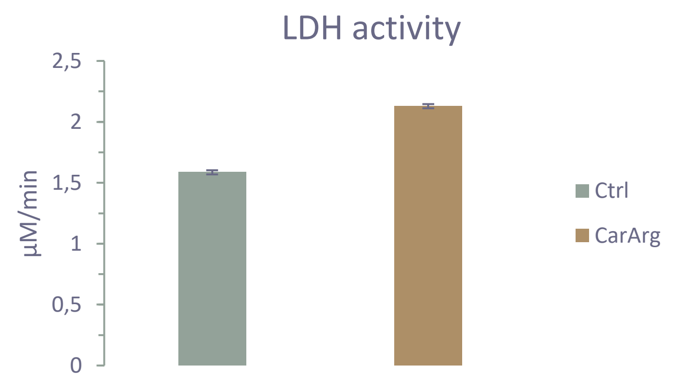
Results of Exp. 4: Organ weight and enzyme activity







- Stomach and liver weight greater in Ctrl piglets *($P < 0.05$)
- Greater CS and LDH activity in white portion of STM of CarArg piglets ($P < 0.05$)

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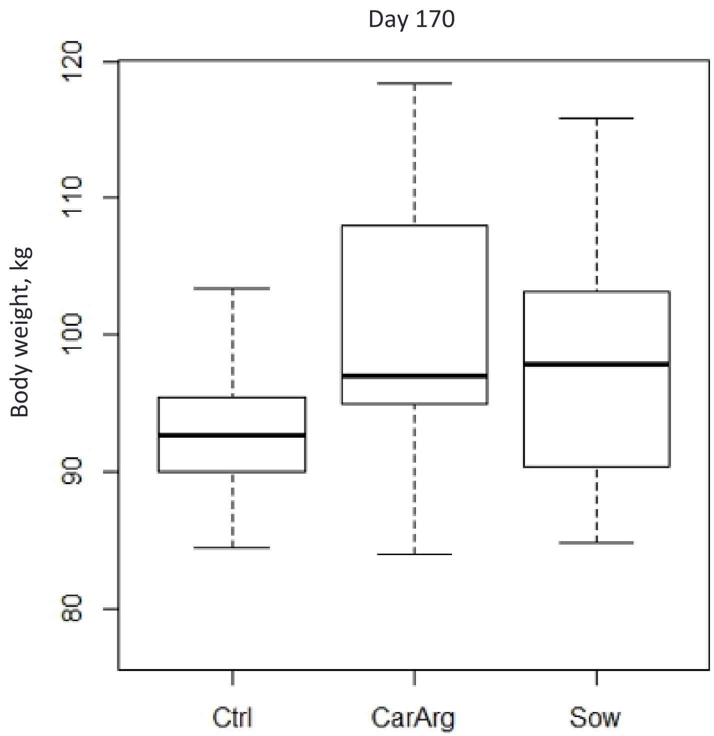
Results of Exp. 4: Post-weaning performance



- No difference in slaughter weight (6 kg diff. Ctrl vs. CarArg and Sow)
- Large variation within groups

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Results of Exp. 4: Post-weaning performance

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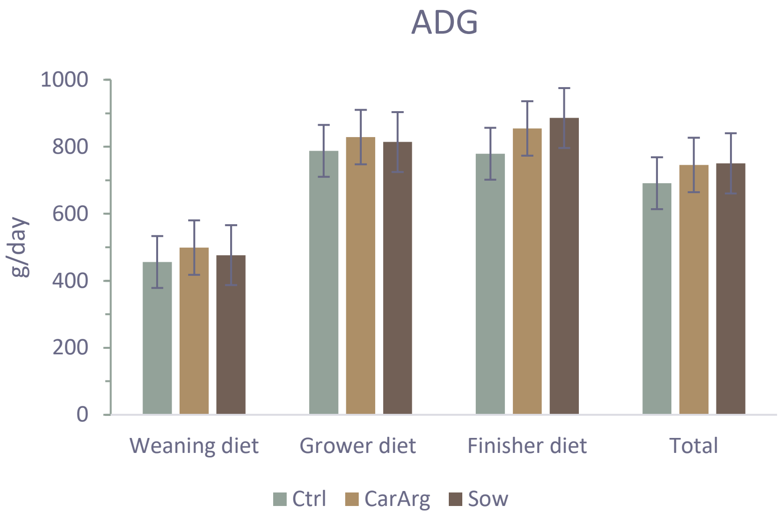
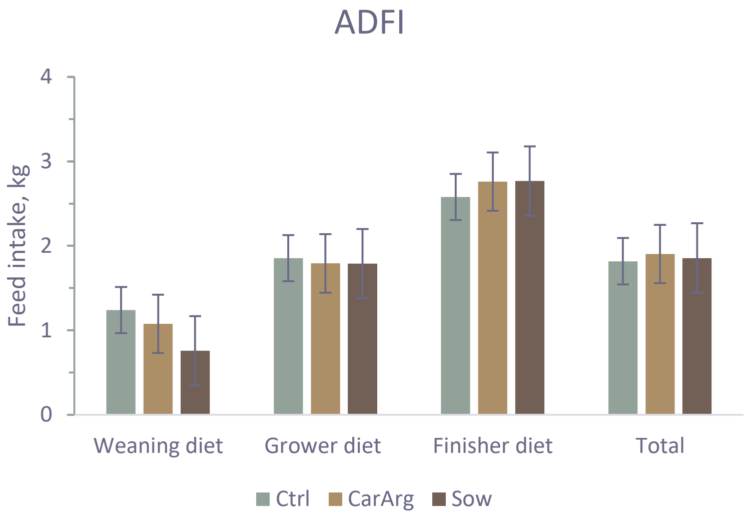
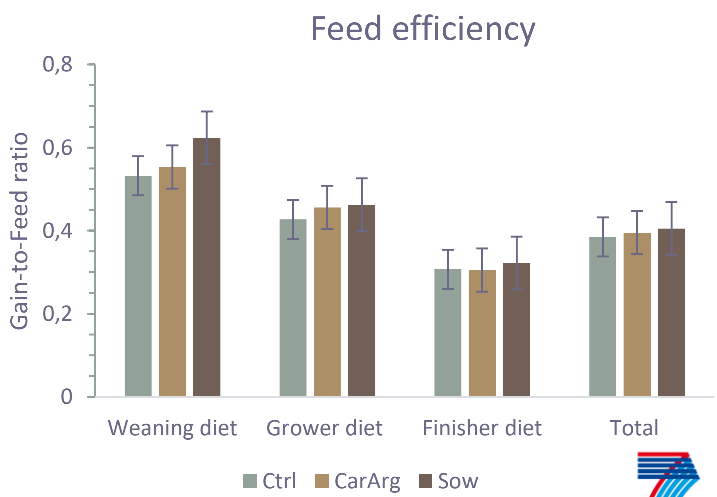




No difference between groups



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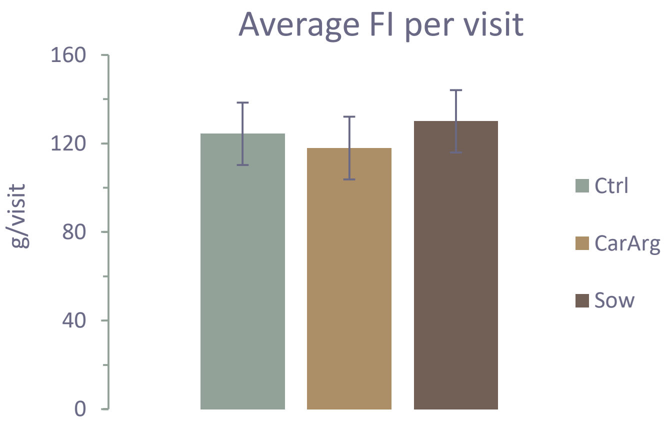
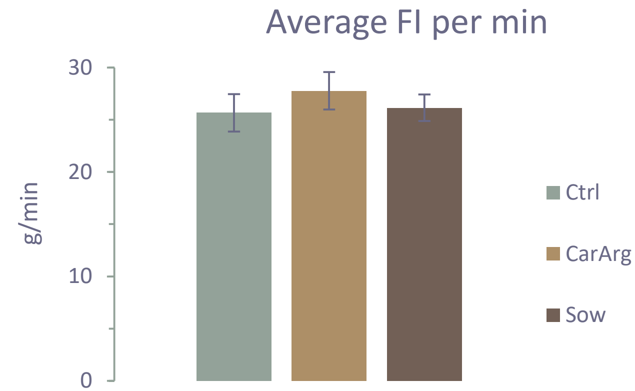
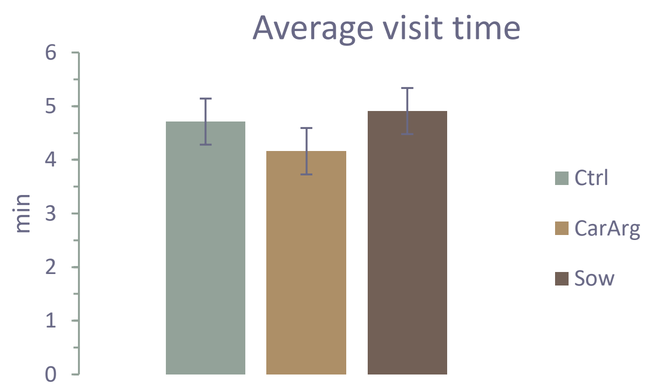
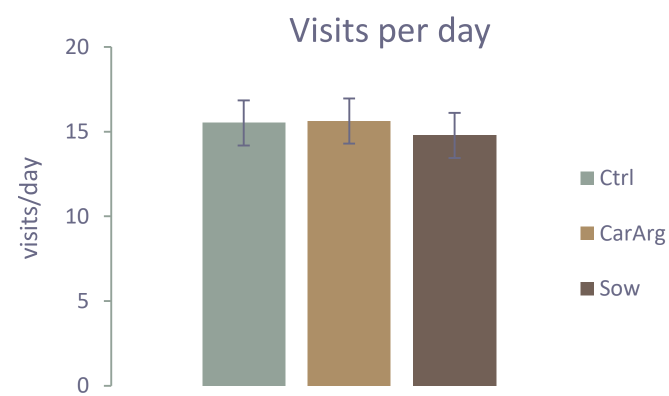
Results of Exp. 4: Post-weaning performance

ECO FCE









Eating behaviour does not explain the difference in final slaughter weight

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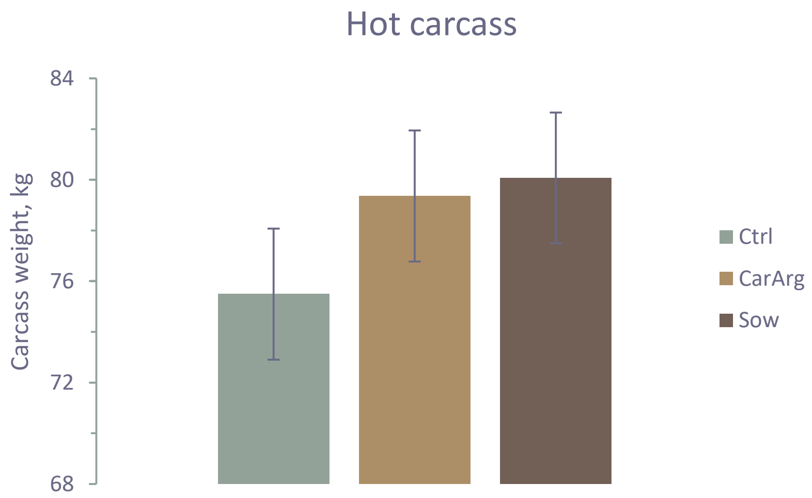
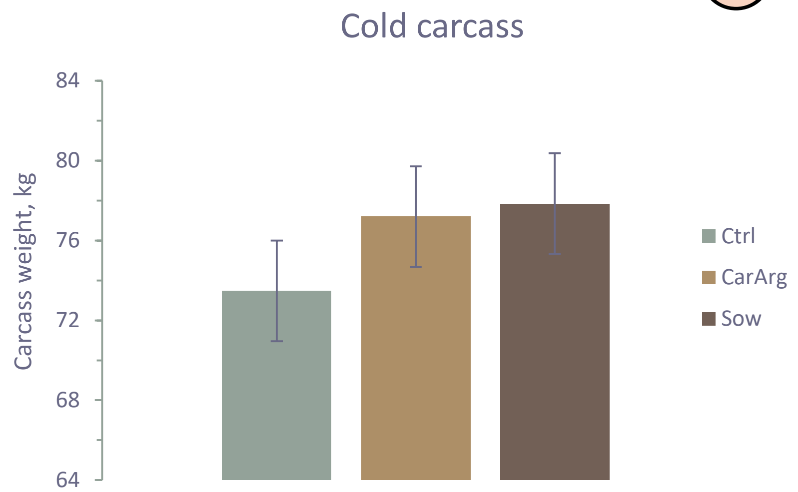
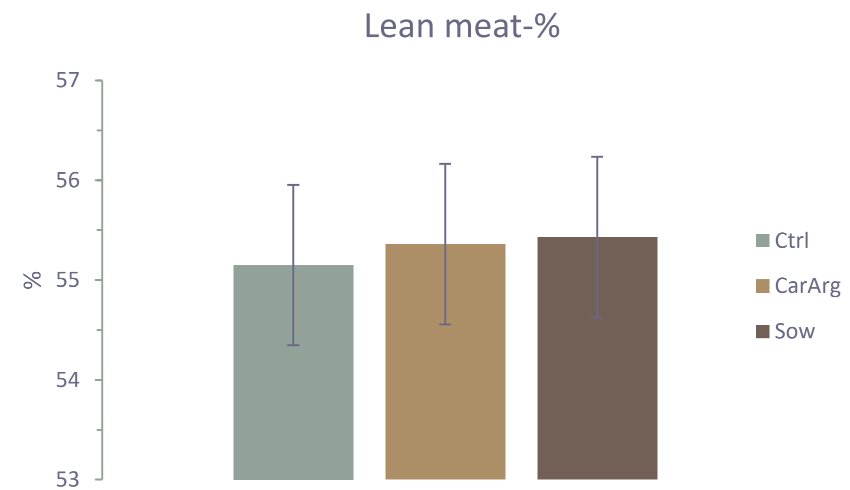
Results of Exp. 4: Carcass traits





- No difference between groups
- Within the artificially reared groups, CarArg tended to increase carcass weight



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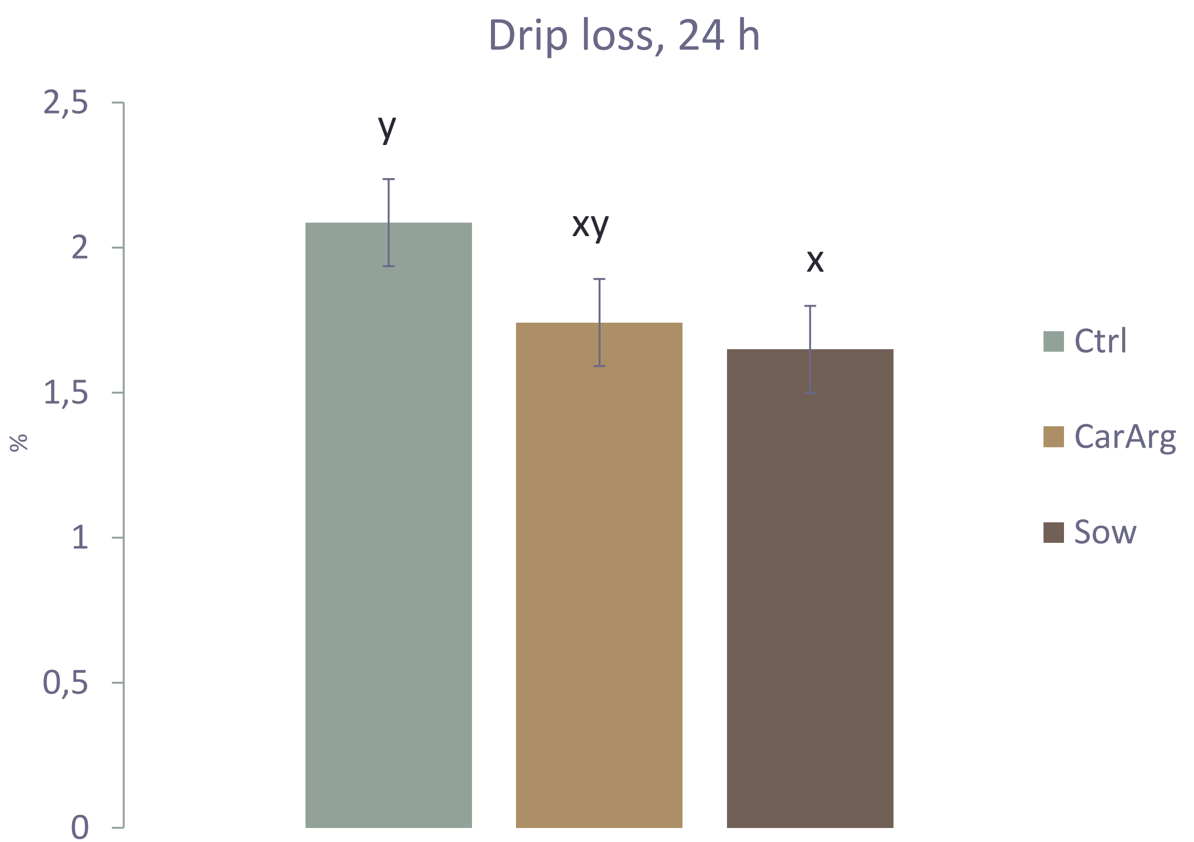
Results of Exp. 4: Meat quality traits



Tendency of less water holding capacity in Ctrl group ($0.05 \leq P < 0.10$)

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Conclusion

- L-arginine and L-carnitine act as bioactive components in L-BtW IUGR piglets (from large litters)
- Muscle maturation and increased protein synthesis
  - did not positively influence growth performance (inconclusive)
- No clear supplemental effect on growth
- Improved survival rate of L-BtW piglets from d 7-28
- Growth performance of L-BtW is not compromised by artificial rearing

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Perspectives

- **Milk replacer still needs optimization**
  - Dry matter, protein and fat content, plus amino acid and fatty acid composition needs adjustment
  - Is the assumption correct that sow milk is optimal for L-BtW piglets?

- **Considering earlier artificial rearing**
  - Survival rate lowest first three days after farrowing
  - Some countries rearing d 3 is allowed (mainly larger littermates)
  - L-BtW piglets most vulnerable

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Thank you for your attention

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