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Optimal gut function in monogastric livestock

Pre- and post-weaning liquid feeding of pigs

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 955374.

Weaning - a challenging time for the pig

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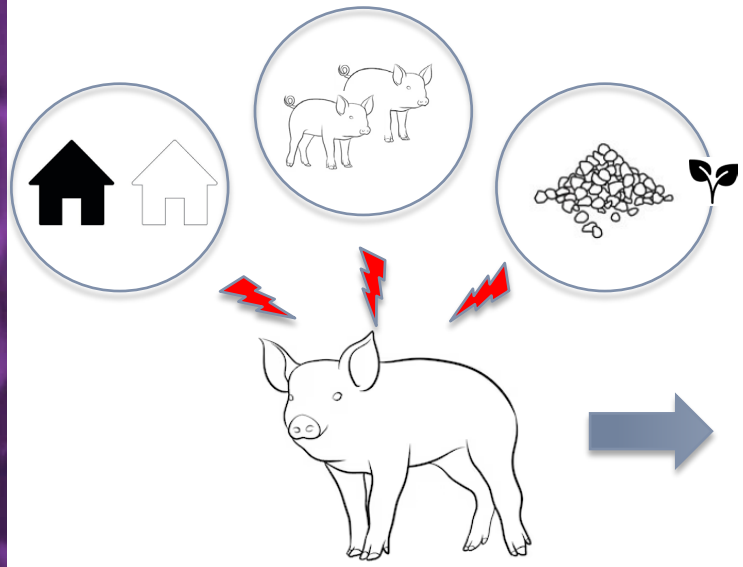
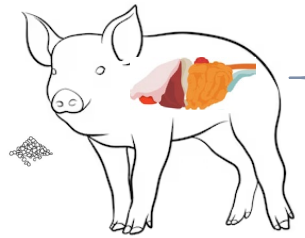
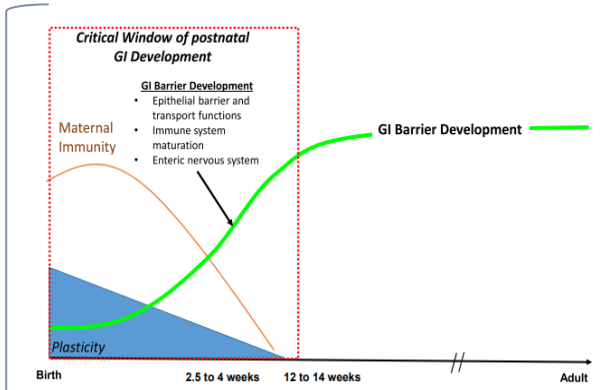
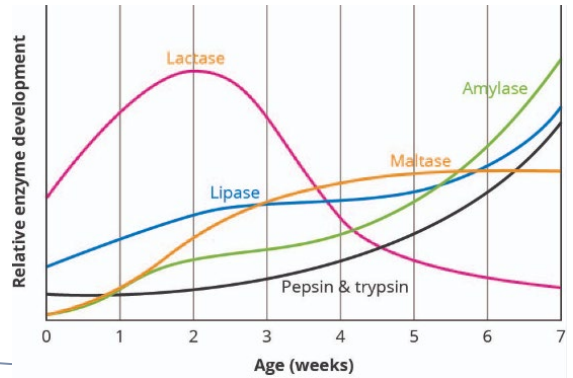


Wean at 3-4 wks



↓ Intake





↓ Growth & ↑ Diarrhoea

+ 3 pigs born alive since 2010

- ↓ access to teats
- ↓ milk intake = ↓wean wt.
- ↓ lifetime growth

2022 Bans

Prophylactic group antibiotic trt

Pharmacological levels of ZnO

<u>Overall objective:</u> Investigate liquid milk replacer and/or liquid feeding both pre- and post-weaning to achieve ↑ intake and growth in 1st days pw to ↑ lifetime growth and ↓ reliance on AMU

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 955374.

Sources: [1]Lawlor *et al.*, 2020; Moeser *at al.*, 2017; Kirchgessner, 1996; Teagasc, 2024

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Liquid feeding system

- **Automatic milk delivery system** (Babyfeed, Schauer)
- Milk replacer – Opticare, Swinco

- Trough feeder

- Feeding for ~18 hours/day

- Sensor check every ~25 min

Parameters: Individual BW, Dry matter disappearance, Antibiotic and Anti-inflammatory usage, Intestinal morphology, Intestinal microbiome, Enzyme activity, Gene expression

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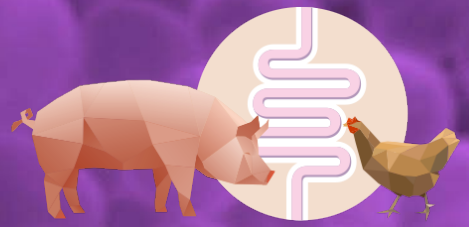

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01

Pre-weaning – milk and liquid creep feeding

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Introduction, Materials & Methods - Pre-weaning studies

- ↑ Litter size but not milk → limiting growth & weaning weight of piglets

Creep feeding

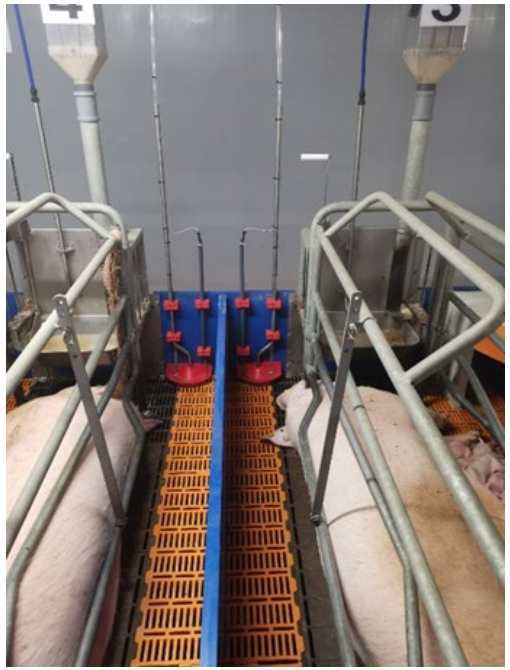
Commonly practiced with dry pelleted starter diet

- **↑ weaning weight**
- **Early exposure to plant ingredients**
- **↑ pw feed intake**

- Liquid creep feeding can ↑ feed intake (Byrgesen et al., 2021; Lyderik et al., 2023)

Nutrient & energy content of MR & starter diet

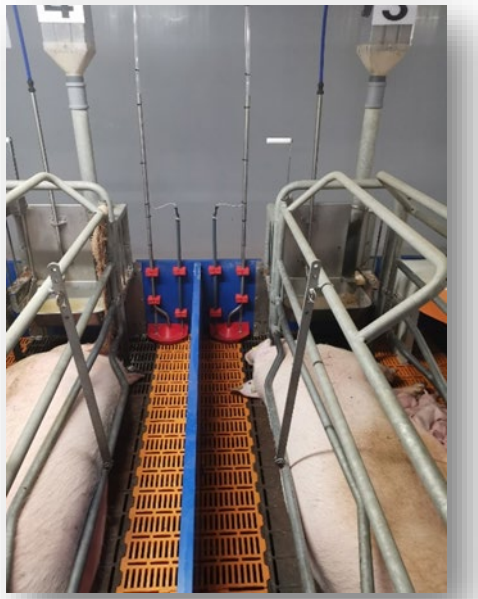
Calculated nutrient composition	Milk powder	Dry starter diet
Net energy (MJ/kg)	11.9	12.1
Fat (g/kg)	90	122
Protein (g/L)	215	200
Lysine (g/L)	18	16.2



20-25 sows/treatment
Blocked on litter size
(Large White x Landrace) x Duroc

Exp 1: Creep feeding pelleted starter diet, liquid milk replacer & liquid mixture of starter diet & milk replacer

Objective: Determine effect of creep-feeding dry pelleted starter diet, liquid milk replacer, & liquid mixture of milk replacer & starter diet to suckling pigs on lifetime growth & health



Arnaud et al (2024). Translational Animal Science. 8: txae04. https://doi.org/10.1093/tas/txae041

The PigNutriStrat project is funded by the Irish DAFM's Competitive Research Funding Programmes (Grant no: 2019R518).

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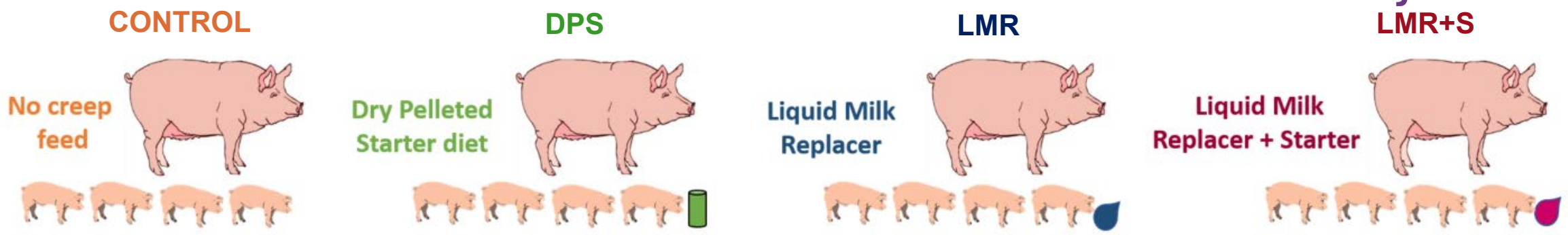
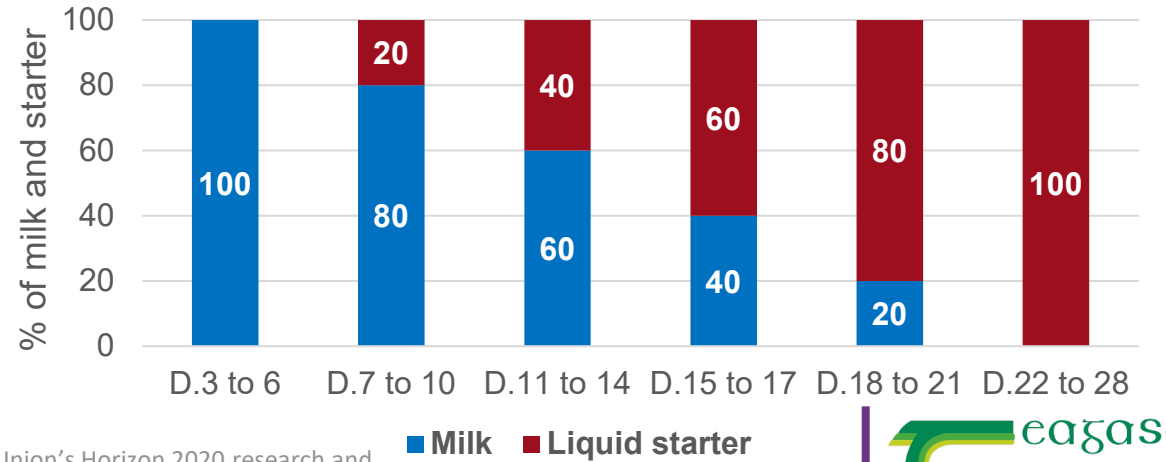
Materials & methods



- **Duration of creep feed supplementation:** Dry (DPS) D10 to weaning; Liquid (LMR; LMR+S) D3 to weaning
- **LMR:** ~15% DM
- **LMR+S:** mixture of milk powder with ↑ % of liquid starter → ~15% DM



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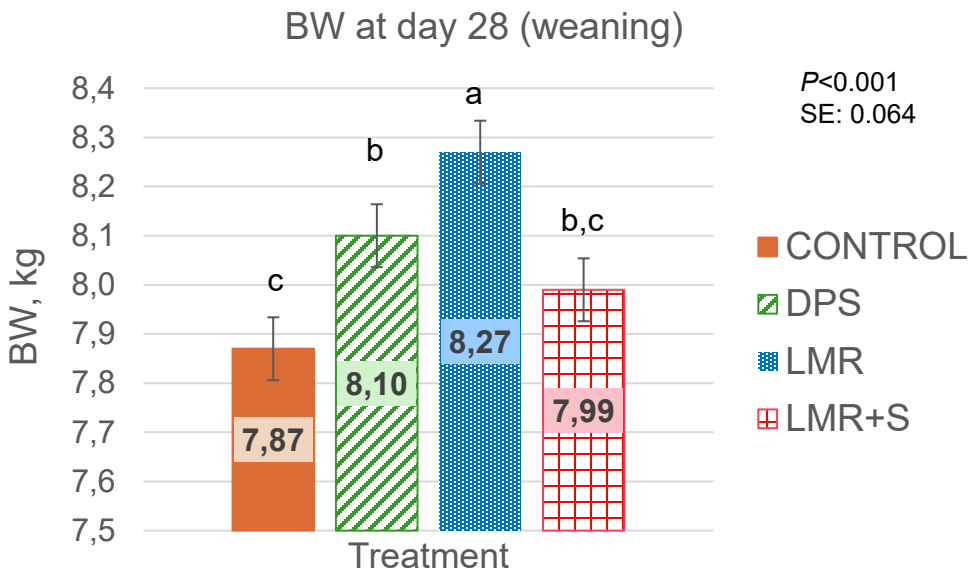
Pre- & post-weaning growth performance

Treatment	Control	DPS	LMR	LMR+S	SEM	*P*-value
Dry matter intake						
Pre-weaning creep feed (g/pig)	0 ^{c}	565 ^{a}	471 ^{ab}	353 ^{b}	45.1	<0.001
Feed cost(€/pig)	0	0.59	1.41	0.71		



Post-weaning

- LMR ↓ ADG and G:F from weaning to D6 pw
- No effect on BW pw or carcass weight at slaughter

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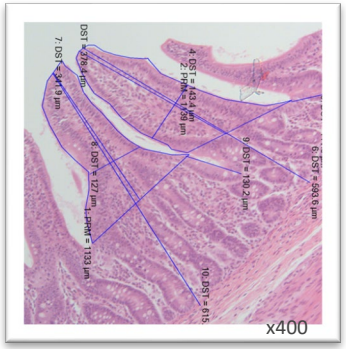
Intestinal morphology D5 post-weaning & health



No treatment difference on VH, CD and VH:CD in the duodenum and jejunum (*P*>0.05)

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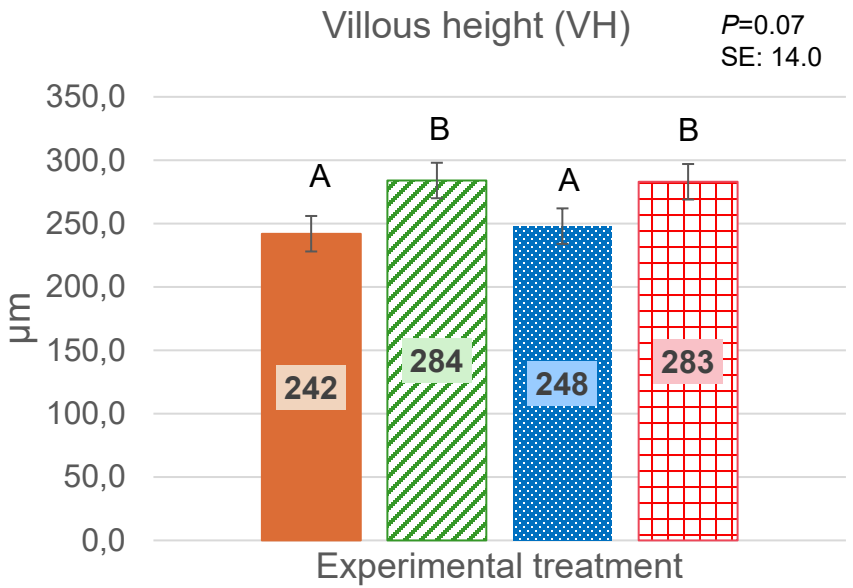

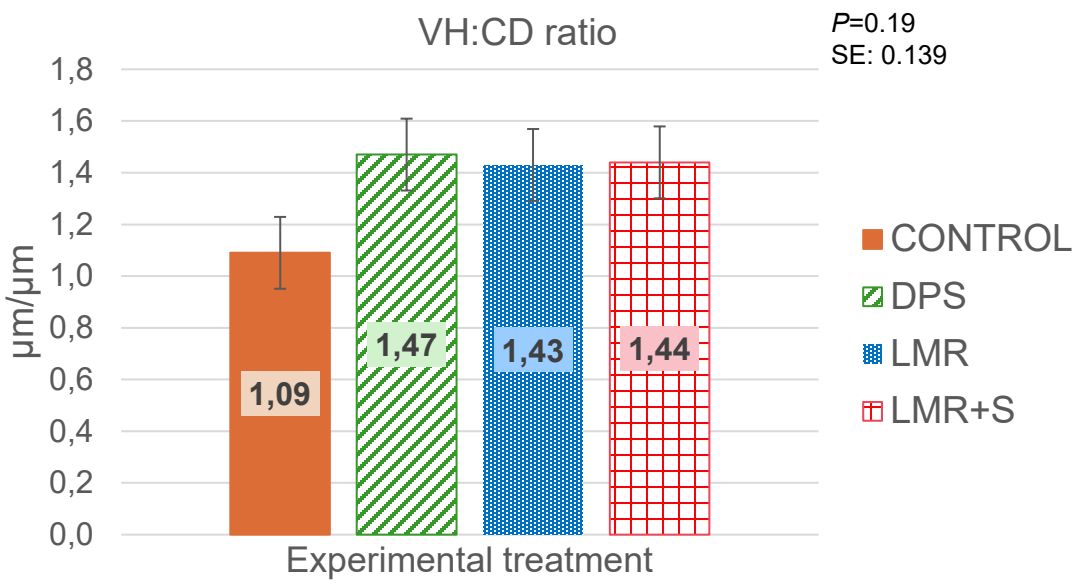

- No effect on no. of clinical cases of disease, antibiotic and anti-inflammatory usage

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Lessons learned (Exp. 1)

- Feeding milk replacer to weaning
  - ↑ weaning weight but ↓ pw growth and efficiency
- Feeding a liquid mixture of milk replacer & starter diet improved intestinal morphology
  - ↓ feed cost
- Dry feeding too liberal and liquid feeding restrictive in first experiment
  - ↑ no. of sensor checks in last week (↑ feeding frequency)
  - ↑ DMI in piglets - may benefit lifetime growth, especially with LMR+S

- Question: Will environmental hygiene affect response to pre-weaning liquid feeding?

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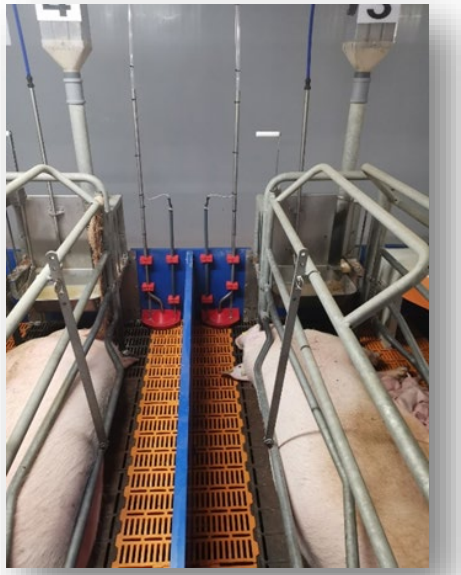
Exp 2: Creep feeding (dry or liquid) and pen hygiene (standard or optimal)

Objective: Determine effect of creep feeding a liquid mixture of milk replacer & starter diet in standard or optimal hygiene environments on creep feed DMI, pre- & post-weaning growth & post-weaning small intestinal morphology



Vasa et al (2024). Journal of Animal Science. (submitted)

Hypothesis: Liquid creep feeding & optimal pen hygiene environment will increase feed intake & growth of suckling piglets while reducing the need to medicate pigs leading to increased post-weaning intake & growth

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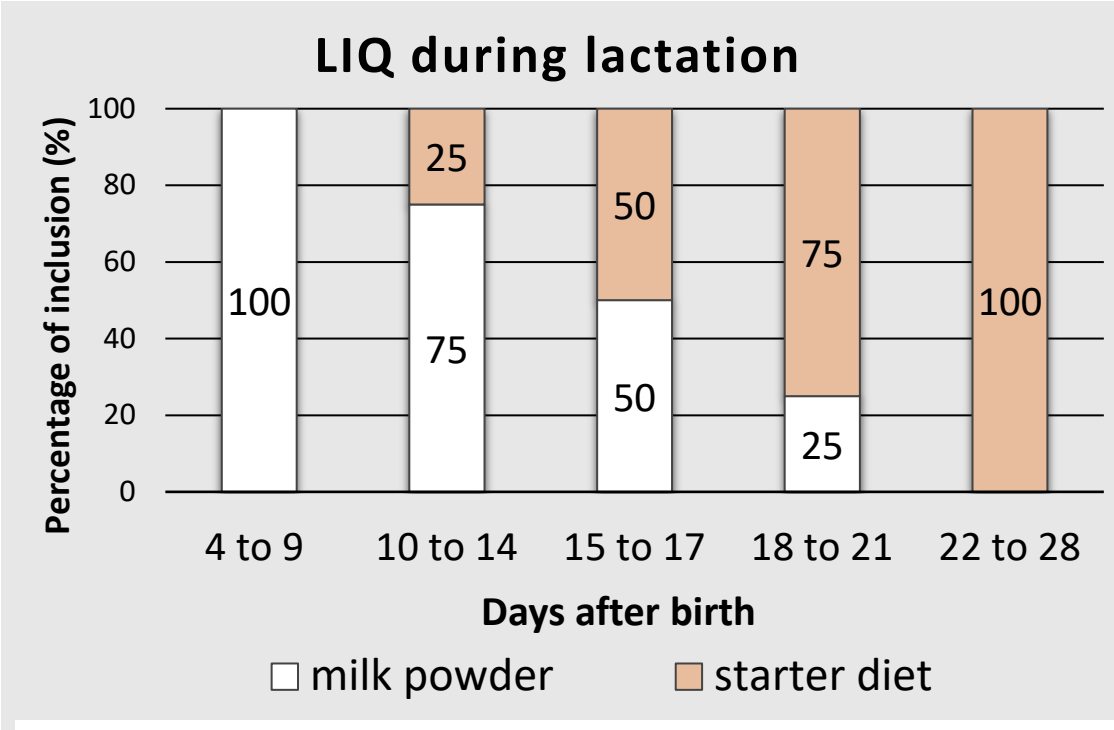
Material & Methods

Pre-weaning treatments		
Pen Hygiene \ Creep Feed	**Dry pelleted starter diet from D10 (DRY)**	**Liquid creep feed from D4 (LIQ)***
OPTI (Optimal)	OPTI-DRY	OPTI-LIQ
STAN (Standard)	STAN-DRY	STAN-LIQ

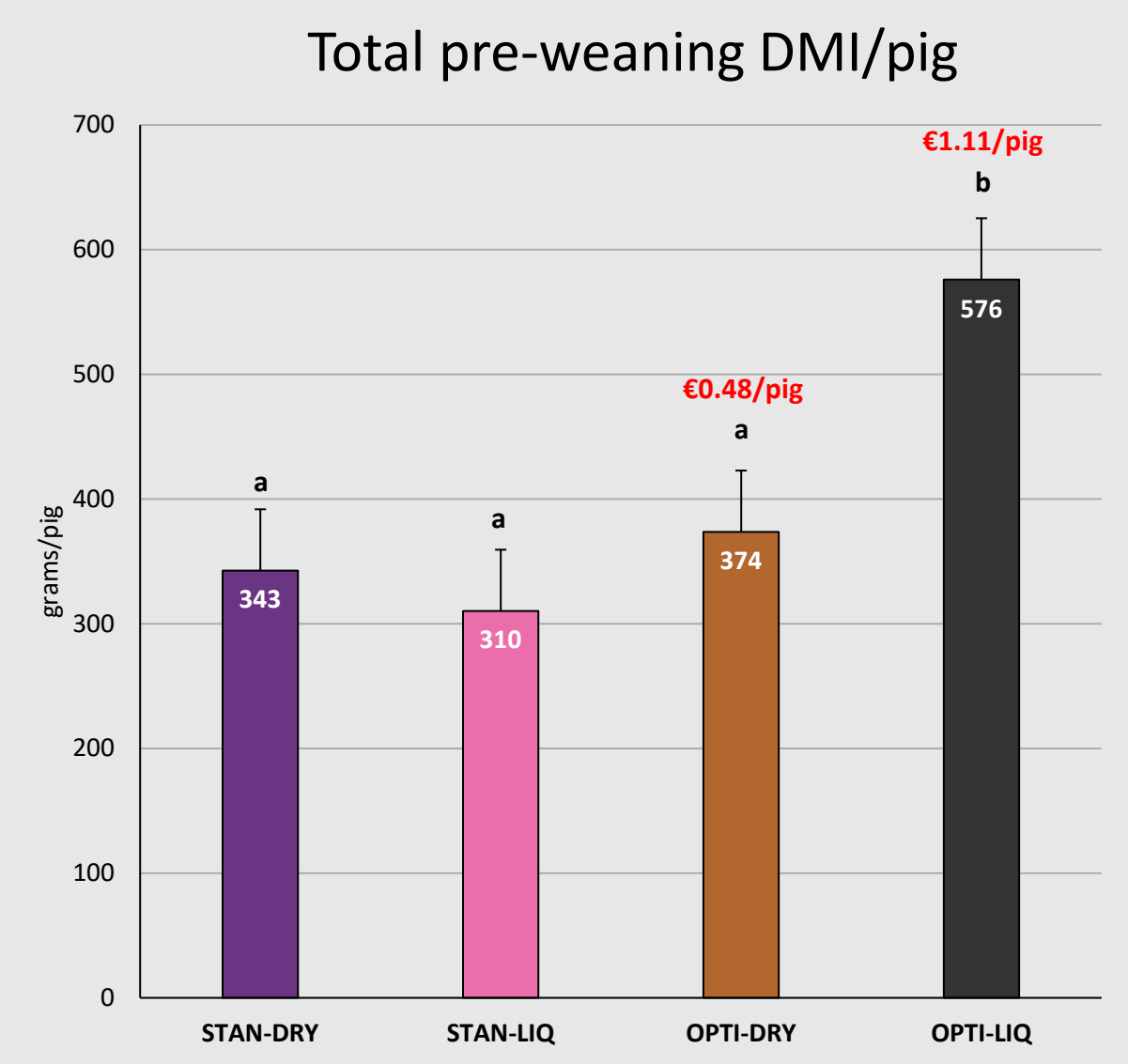


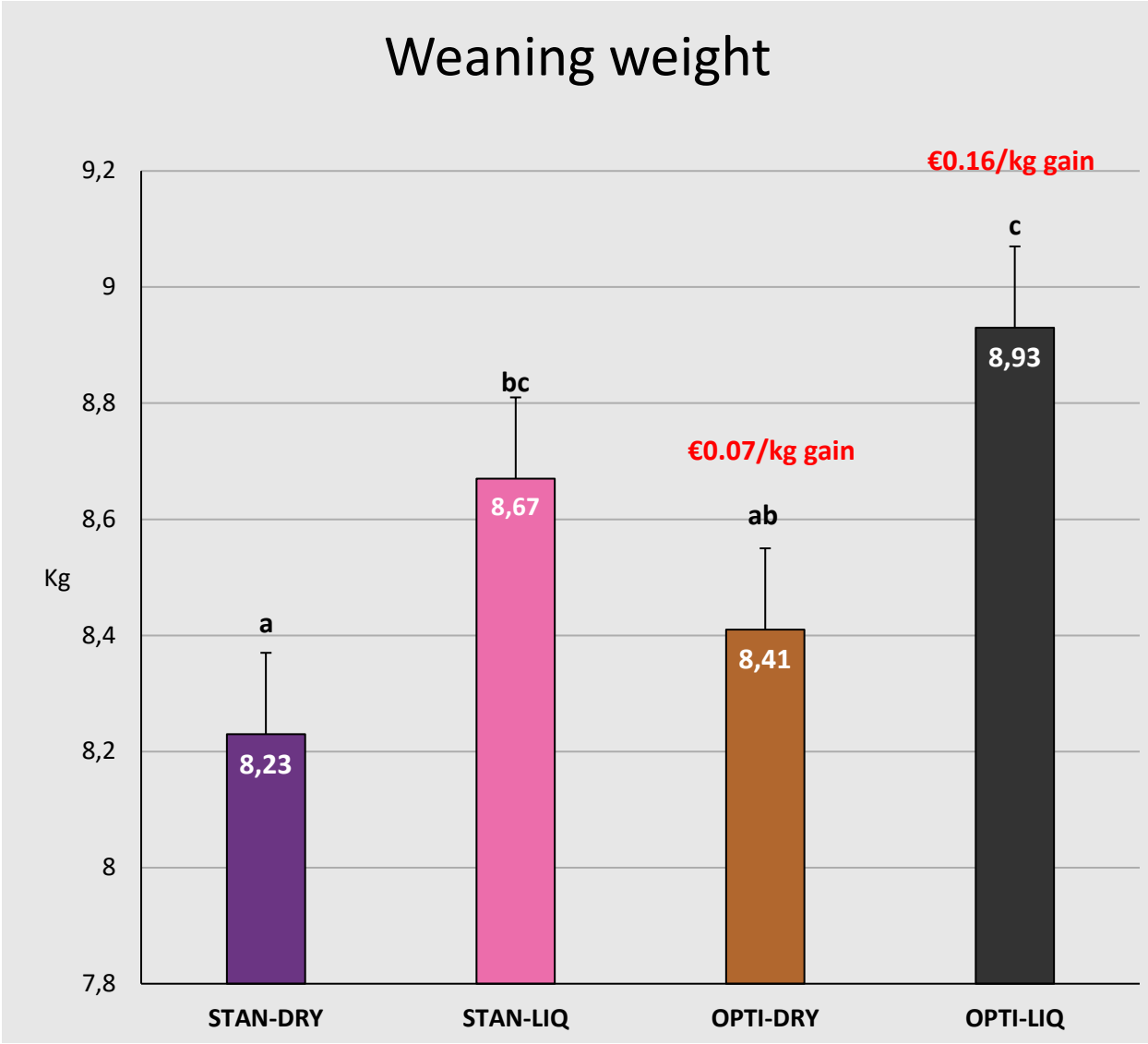
Farrowing room hygiene**	STAN	OPTI
Pre-soaking with water	×	✓
Power-washing with water	✓	✓
Detergent & disinfectant	×	✓
Drying time	≤ 18 hrs	6 days
Sows washed & disinfected	×	✓

* Liquid mixture of milk replacer & starter diet (14-15% DM)

**Halpin et al. (2024). Translational Animal Science, txae095

Dry matter intake (DMI) & weaning weight





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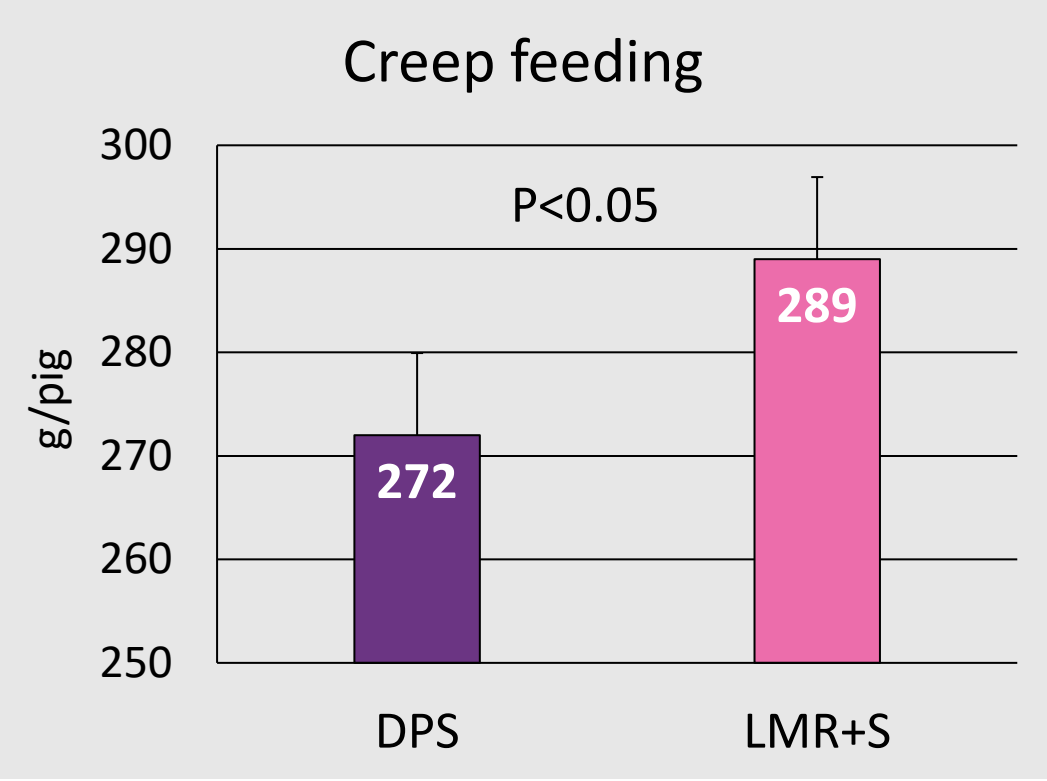
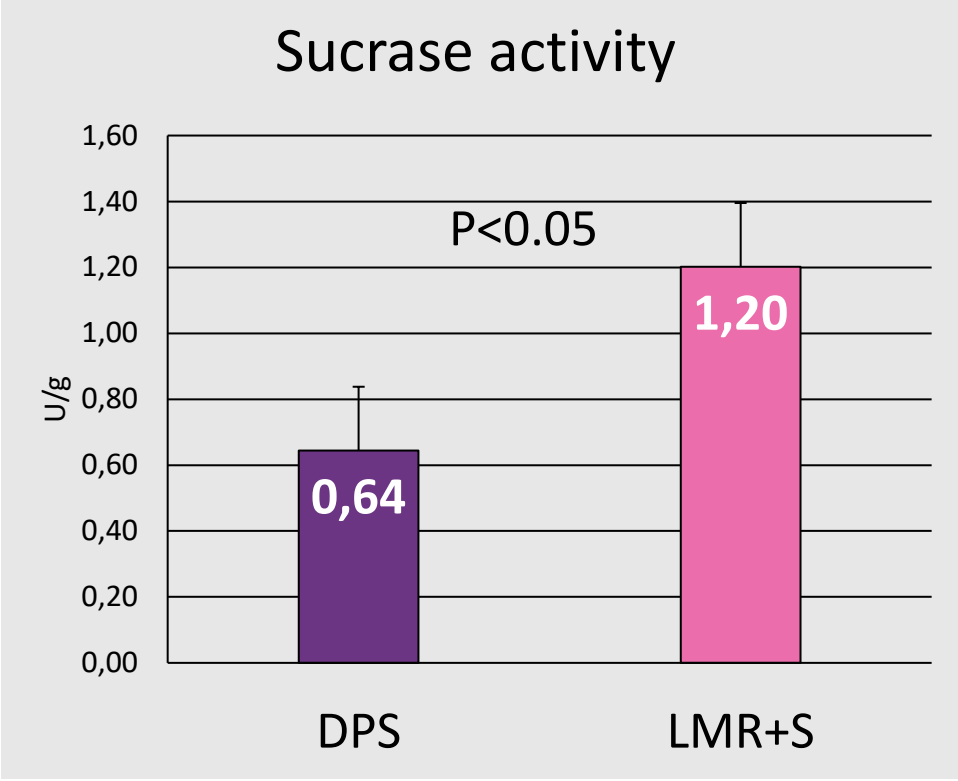
a-c Bars that do not share a common superscript differ significantly at P<0.05

ADG and mortality from D4 to 28

No interaction effect (P>0.05)





Pre-weaning mortality

LMR+S ↓ pre-weaning mortality from 4.0 to 2.4% (P<0.05) compared to DPS

40% ↓ in mortality between D4 and D28

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Conclusions from pre-weaning work

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Experiment 1:

- Liquid milk replacer ↑ wean weight vs. dry pelleted starter But ↓ **ADG and G:F** early pw
- Liquid milk replacer and starter mix tended to ↑ PW ileal villous height
- Milk replacer powder: 3x the cost of starter diet

Experiment 2:

- Liquid creep ↑ wean wt. (+0.6kg), ↓ pre-wean mortality & ↑ gut maturity vs. dry starter diet
- Benefit: €0.39 /pig or €10.78 /sow/yr

Overall: Liquid creep ↑ wean weight & ↓ pre-wean mortality - no effect on residual PW growth

Recommendation: Milk replacer for ~10 days & follow up with dry pelleted diet to weaning to:

- ↓ pre-weaning mortality
- ↑ weaning weight
- ↓ feed cost

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monogut health

Optimal gut function in monogastric livestock

02

Post-weaning – milk and liquid feeding

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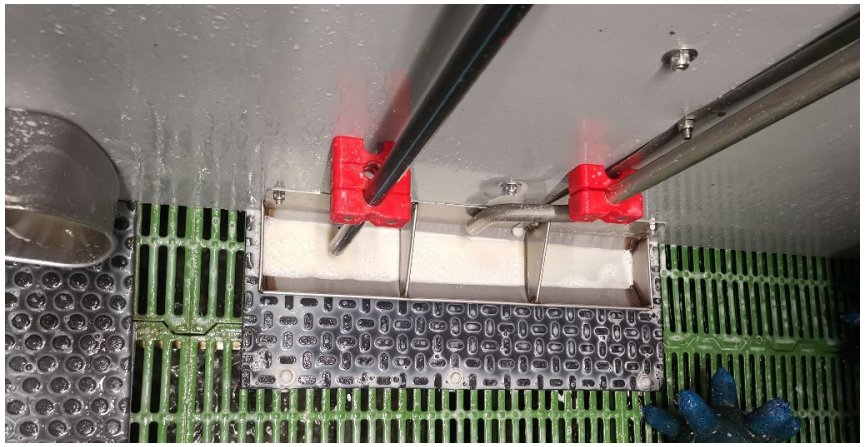
Materials & Methods – post-weaning experiments

- (Large White x Landrace) x Duroc
- Weaned at ~28 days
- N=12 pens/treatment (10 pigs/pen)
- Pens blocked by sex and weaning weight

Calculated nutrient composition	Liquid milk	Liquid starter
DM (%)	13	13
Net energy (MJ/L)	1.6	1.7
Fat (g/L)	11.7	17.3
Protein (g/L)	28.1	28.4
Lysine (g/L)	2.35	2.33



Supplementary to dry pelleted starter diet

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Exp 3: Supplementing milk replacer and liquid starter diet for 4 and 11 days post-weaning

Objective: Compare effect of supplementing liquid milk replacer & liquid starter diet, in addition to dry pelleted starter diet, for 4 & 11 days to weaned piglets on intestinal structure & function, growth & carcass parameters

Treatment	CON	S4	M4	S11	M11
Diet	Dry pelleted starter diet (DPS)	CON + liquid starter diet	CON + liquid milk replacer	CON + liquid starter diet	CON + liquid milk replacer
Duration	11 days pw	4 days pw	4 days pw	11 days pw	11 days pw

Vasa et al (2024) Animal. doi: https://doi.org/10.1016/j.animal.2024.101271

Conclusions from Exp. 3

- Supplementing liquid milk replacer for 11 days ↑ feed intake & ADG
- Milk replacer for >4 days pw ↑ Ileal enzyme activity and jejunal villous height
- Liquid starter diet for >4 days pw ↑ ileal villous height but no growth benefit
- Duration of supplementation: >4 days required
  - 'Second weaning' at end of supplementation (Zijlstra et al., 2009)
- Numerical ↑ in carcass weight at slaughter ?

Future:

- Liquid milk replacer for >4 days; can high intakes be used to supplement bioactives?
- Can slaughter/carcass weight be increased by liquid supplementation?

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Exp 4: Effect of post-weaning L-glutamine and/or liquid milk replacer supplementation

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Objective: Determine effect of post-weaning supplementary liquid milk replacer and/or dietary inclusion of 1% L-glutamine on lifetime growth & health of pigs

480 pigs (10/pen)

No supplementary milk / no L-glutamine	No supplementary milk / L-glutamine	Supplementary milk / No L-glutamine	Supplementary milk / L-glutamine
N= 12 pens	N= 12 pens	N= 12 pens	N= 12 pens

- **Supplementary liquid milk replacer:** to D10 pw → 14.3% DM
- **L-glutamine:** added at 1% in the starter diet and milk powder

Results:

- No glutamine x liquid milk replacer interaction
- No effect of glutamine on growth, diarrhoea, medication, D7 pw intestinal structure

The PigNutriStrat project is funded by the Irish DAFM's Competitive Research Funding Programmes (Grant no: 2019R518)

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Supplemental milk replacer for 10 days pw

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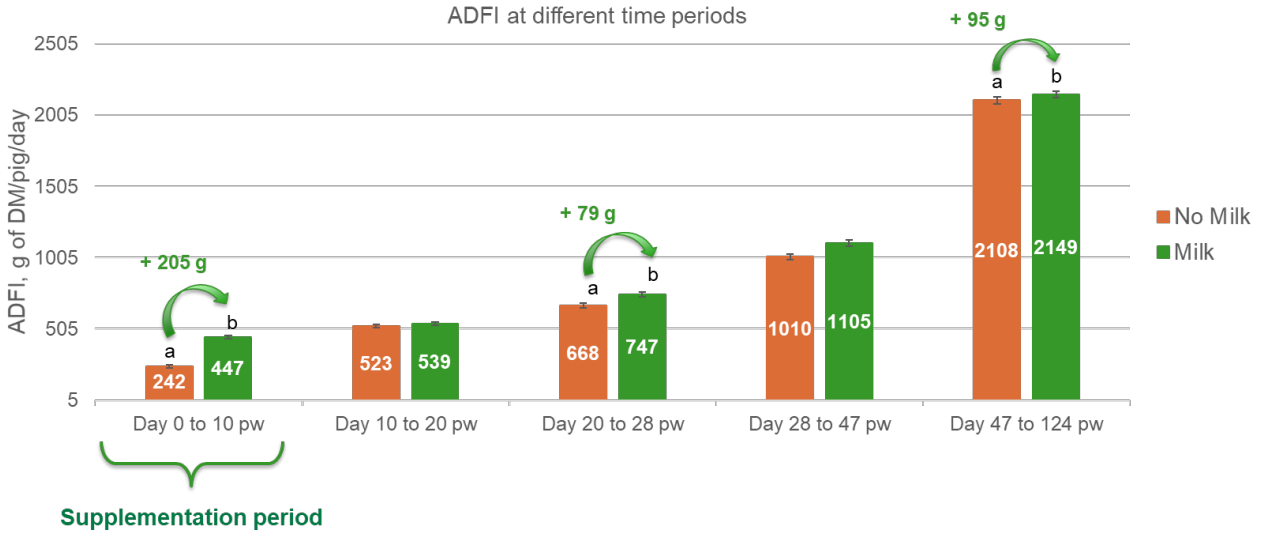

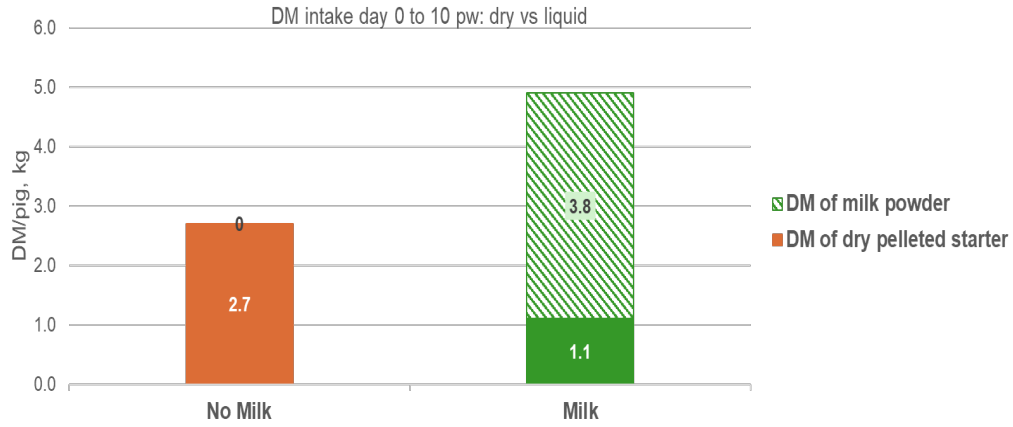

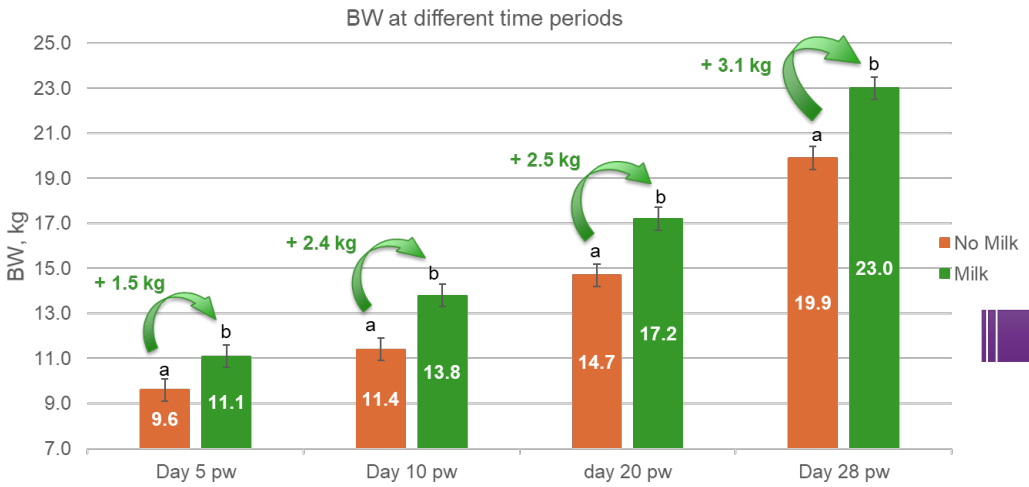

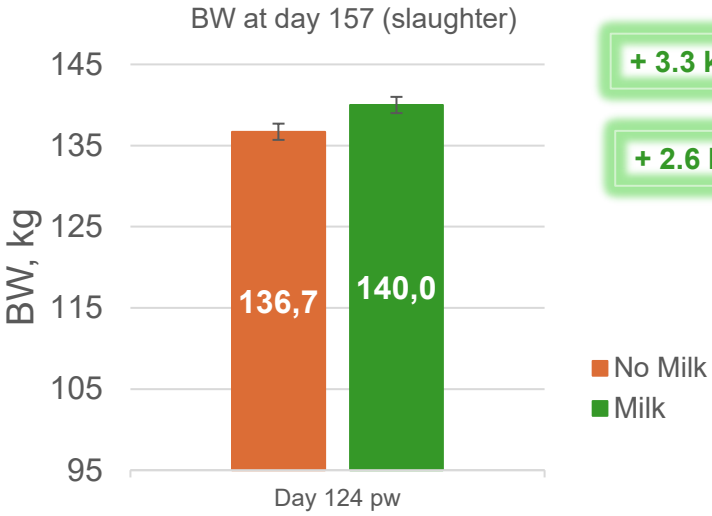

+ 3.3 kg live weight

+ 2.6 kg carcass weight

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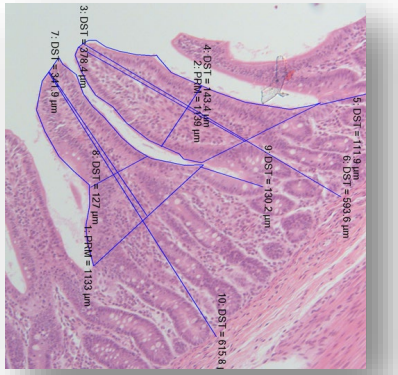
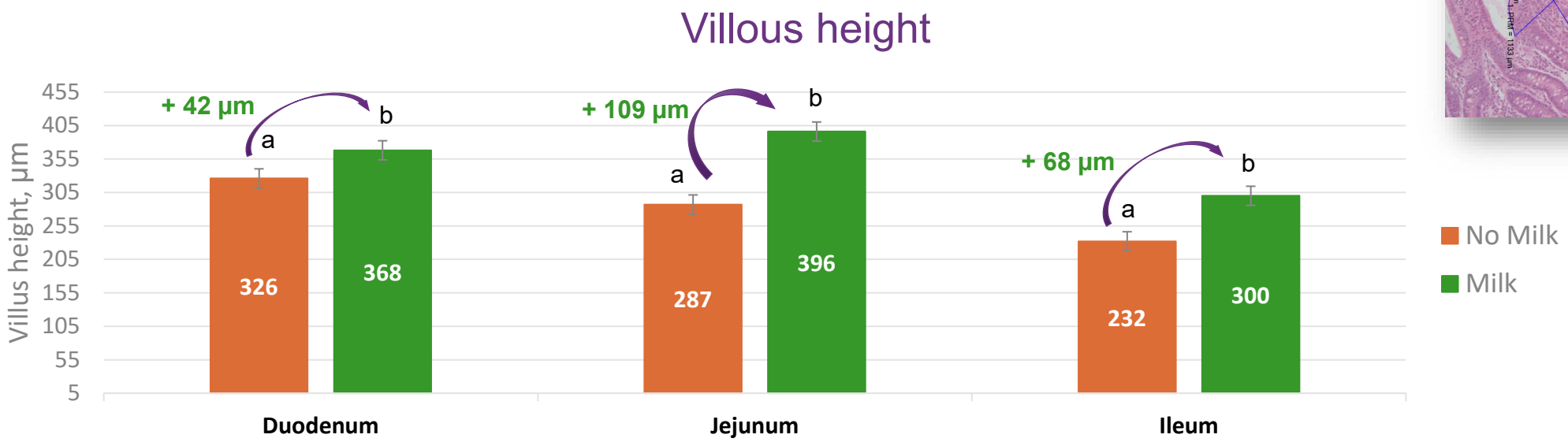
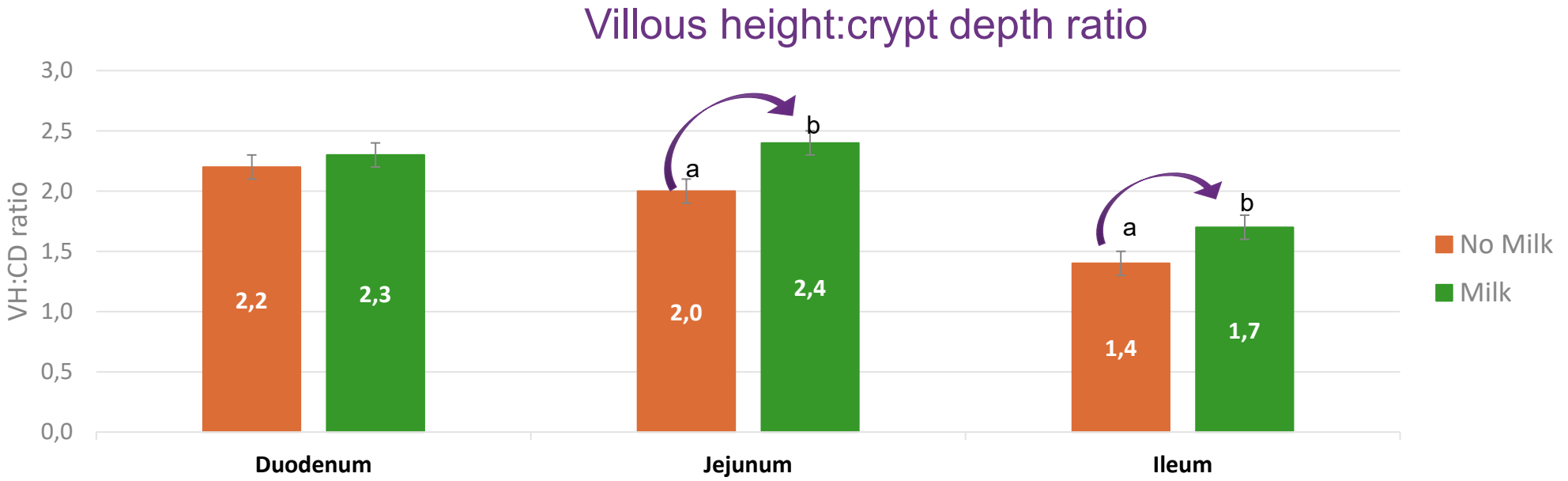
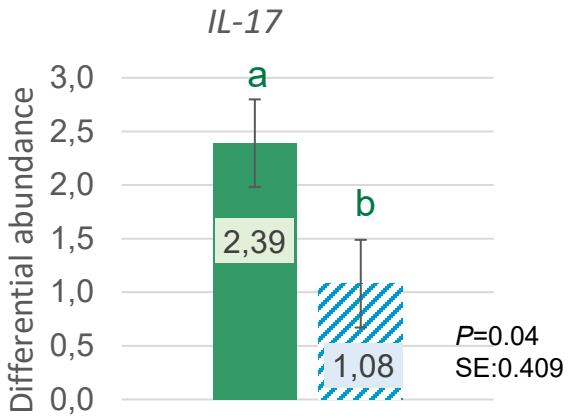
Intestinal morphology at D7 pw

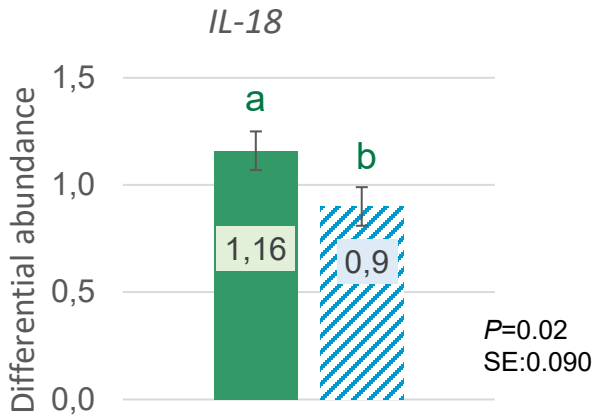


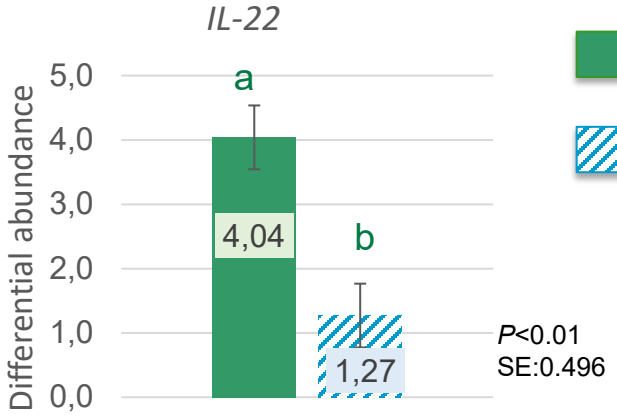


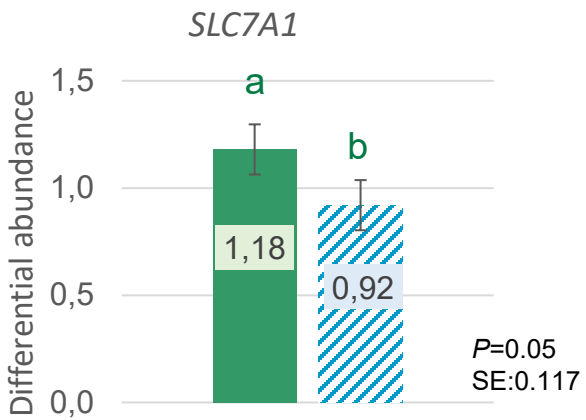


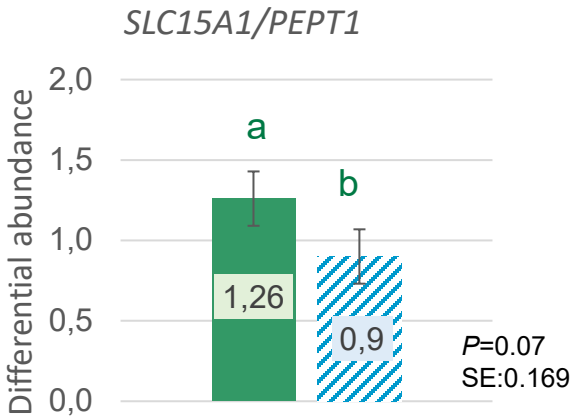
Gene expression in jejunum - D7 pw

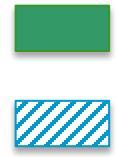












- ↓ expression of pro-inflammatory cytokines
- ↓ expression of peptide transporters
- **↓ intestinal inflammation**

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Conclusions - Post-weaning

- Supplementing liquid milk replacer for 10 days pw:
  - ↑ ADFI by ~85% and ADG by ~94% during supplementation and BW at D10 pw by ~21%
  - ↑ intestinal villous height & BBM enzyme activity, ↓ jejunal pro-inflammatory marker expression at D7 pw and ↑ faecal abundance of VFA-producing bacteria at D11 pw
  - ↑ carcass weight at slaughter by ~2.6 - 3.2kg

- **However:** milk replacer is expensive and its use must be economically justified
  - €4/pig reduced margin over feed with milk supplementation for 10 days pw

- Future: Mixture of milk replacer and starter diet/reduced period of feeding to ↓ feed cost

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THANK YOU

Do you have any questions?

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 955374.

Materials and methods

480 pigs (10/pen)

N= 12 pens

N= 12 pens

N= 12 pens

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- **Supplementary liquid milk replacer:** to day 10 post-weaning → 14.3% DM
- **L-glutamine:** added at 1% in the starter diet and milk powder

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Conclusions – Feed costs

Treatments (10 days pw)	Dry pelleted starter	Dry pelleted starter + liquid milk replacer
DM intake (g/pig/day)	270	490
Feed cost (€/pig/day)	0.28	1.17
Total feed cost for 10 days (€/pig)	2.82	11.69
Total feed cost for 4 days (€/pig)	1.13	4.68
Carcass weight increase (kg/pig)†	-	2.6
Increased price/pig sold (€/pig)*	-	4.76

Liquid milk replacer for 10 days:
(11.69-2.82)-4.76 = €4.11 of extra cost

Liquid milk replacer for 4 days:
4.68-1.13 = €3.55 of extra cost

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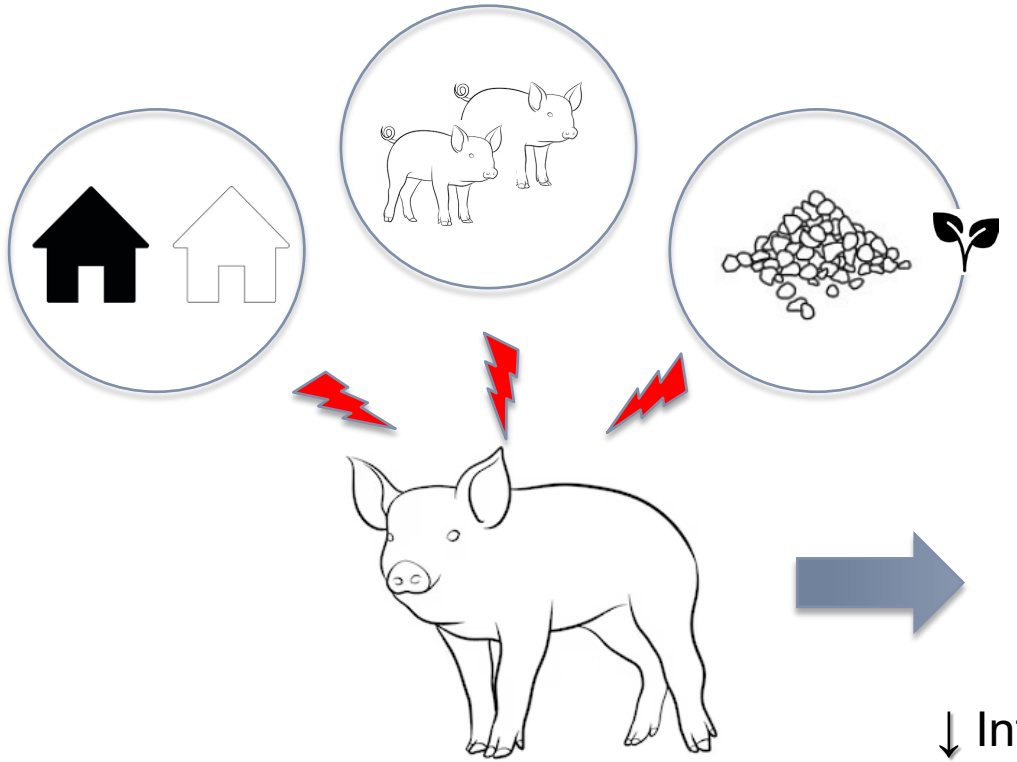
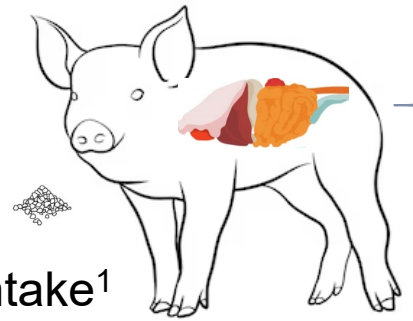
Weaning a challenging time for the pig

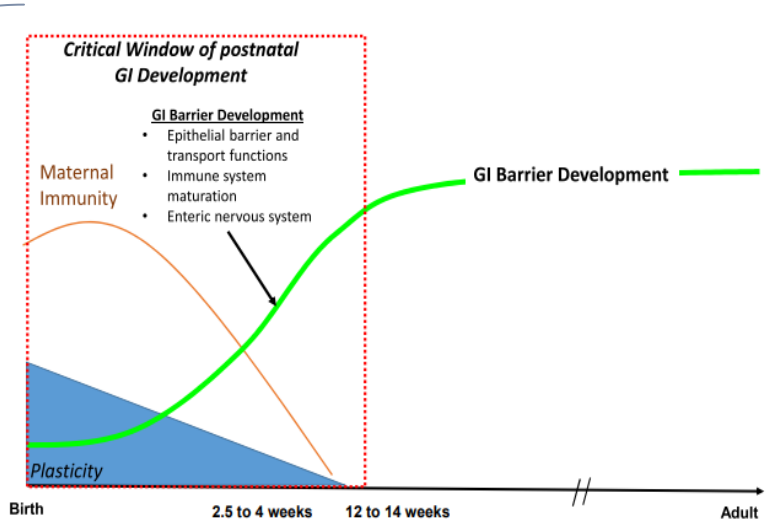


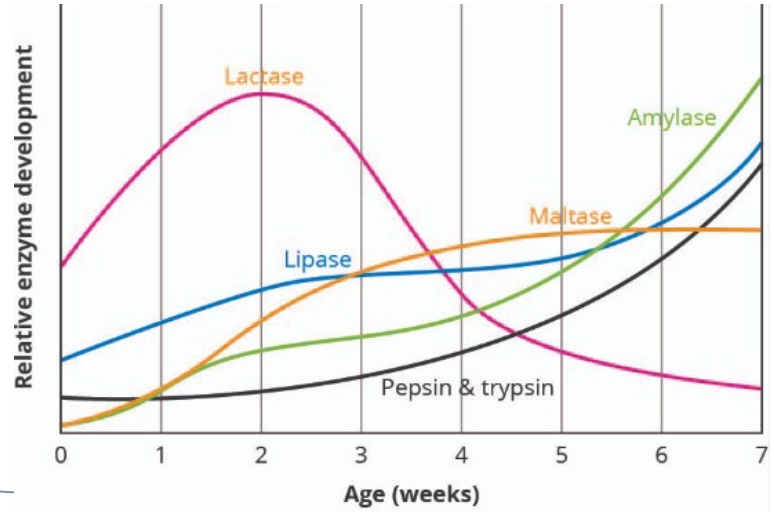
Weaning at 3 - 4 weeks

↓ Intake[1]



↓ Growth & ↑ Diarrhoea





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Sources: 1, Lawlor *et al.*, 2020; Moeser *at al.*, 2017; Kirchgessner, 1996

Antibiotic and Zinc Oxide usage

Prevention of post-weaning diarrhoea up to 2022:

Pharmacological dose of ZnO (2500 ppm of zinc) during first 2 weeks post-weaning.
In feed antibiotics - prophylactic group treatment.

Emergence of antimicrobial resistance

Prohibition of prophylactic group treatment of pigs
Ban on use of pharmacological levels of ZnO in pigs

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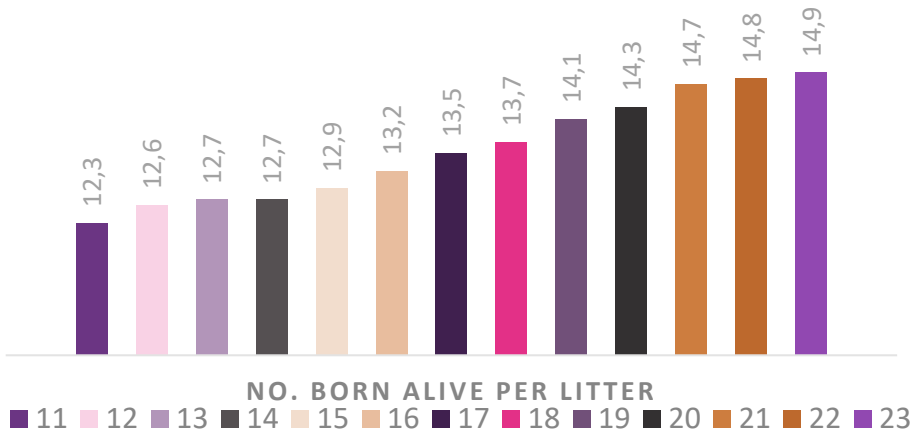
Weaning weight and lifetime performance



↓ milk intake negatively affects weight gain and weaning weight

Higher weaning weight = better lifetime growth

Solutions: ↑ weaning weight and facilitate weaning transition

Overall objective:

↑ intake and growth of pigs 1st few days pw with a view to ↑ lifetime growth in pigs and ↓ reliance on AMU

To achieve this: Liquid milk replacer and/or Liquid feeding both pre- and post-weaning

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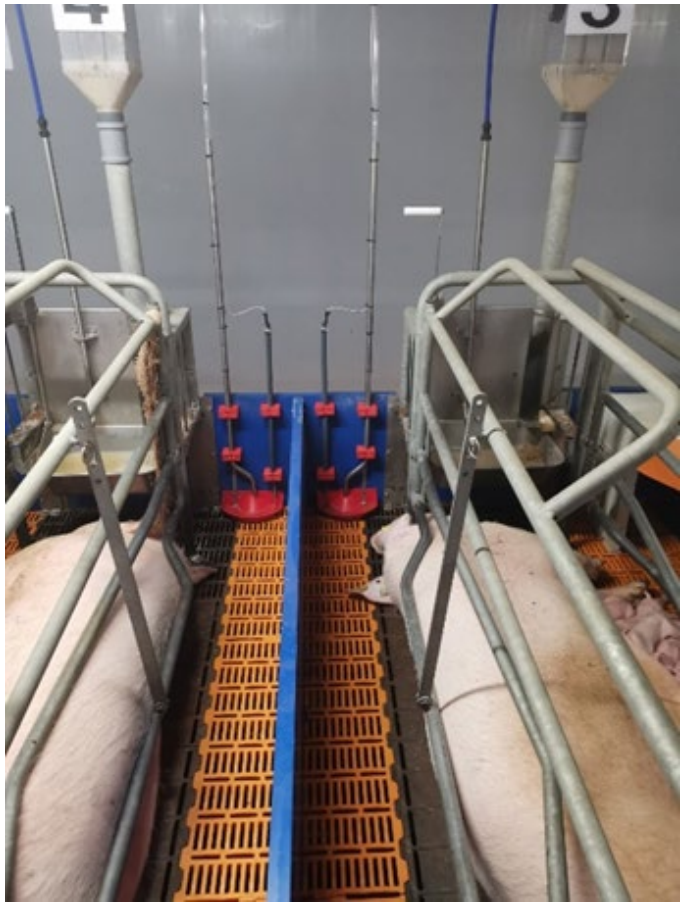
Sources: [1]Devillers et al., 2011; Graph, Teagasc PigSys Records for Ireland

Materials & Methods for Pre-weaning studies

Nutrient & energy content of milk powder & starter diet

Calculated nutrient composition	Milk powder	Dry starter diet
Net energy (MJ/kg)	11.9	12.1
Fat (g/kg)	90	122
Protein (g/L)	215	200
Lysine (g/L)	18	16.2



20-25 sows/treat
Blocked on litter size
Piglets –
(Large White x Landrace) x Duroc

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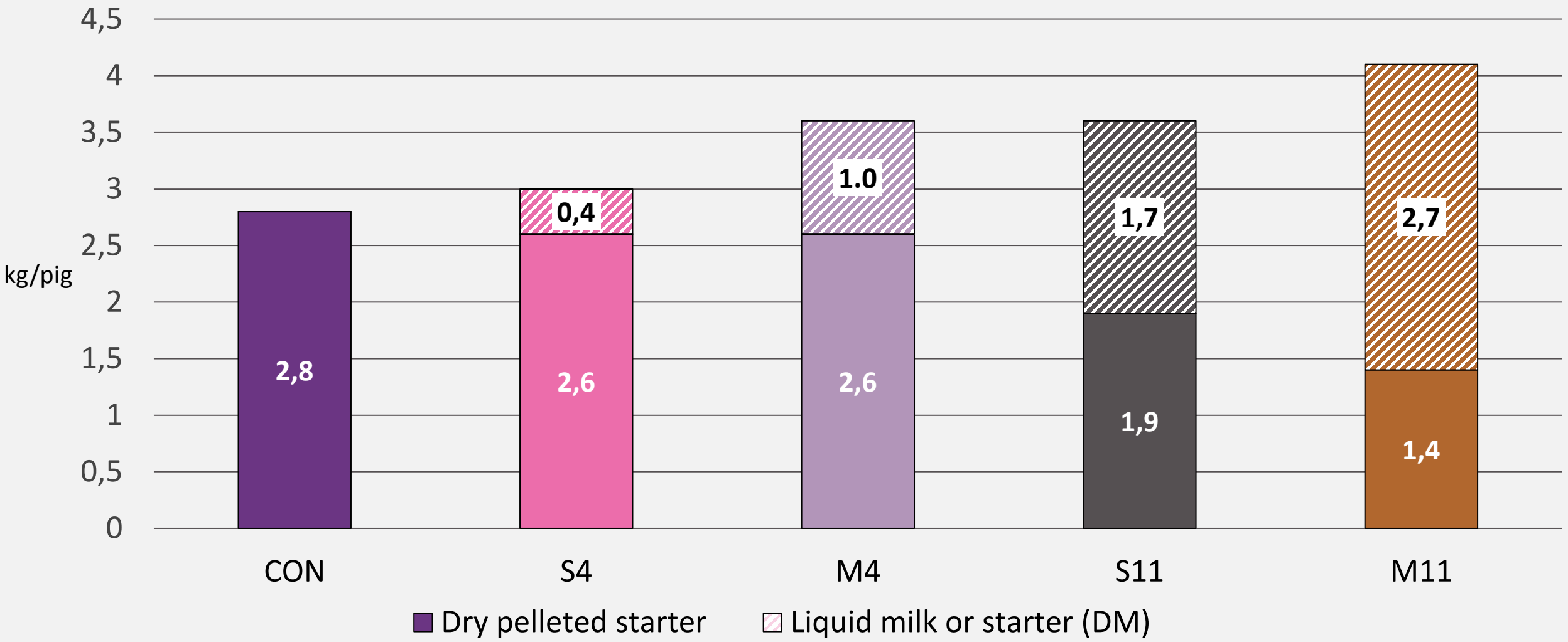
Total feed intake (DM basis) - dry vs liquid from D0-11 pw



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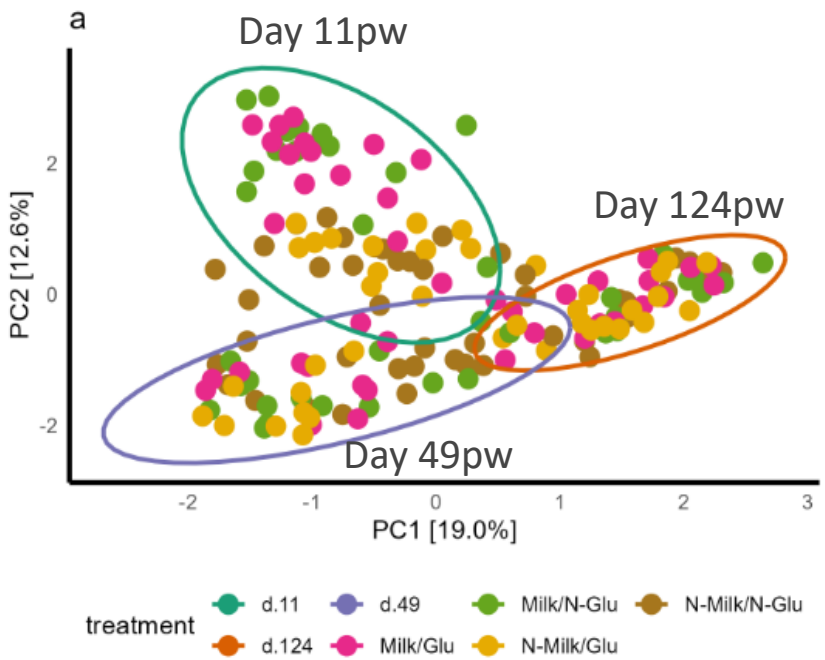
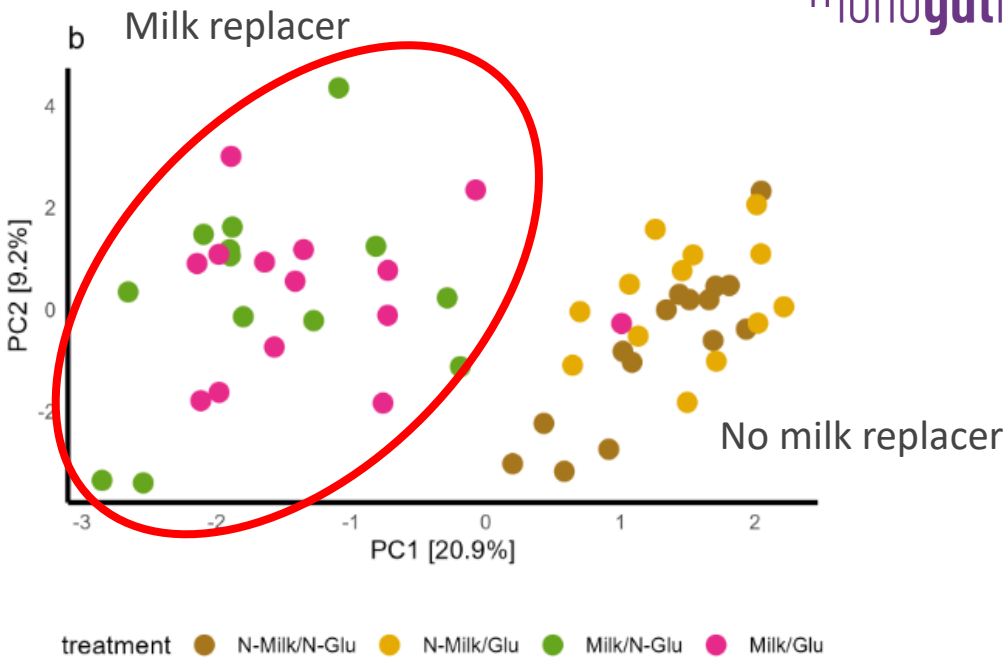
Faecal microbiome

- No effect on α-diversity



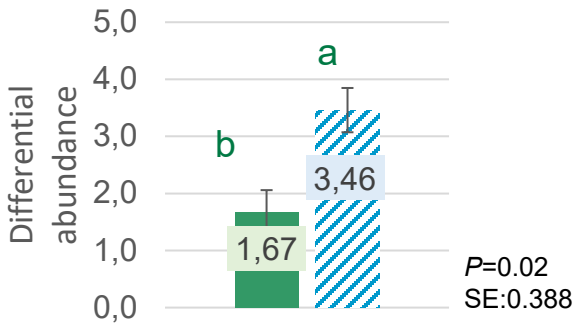
Day 11 post-weaning



N-Milk/N-Glu

Milk/N-Glu

Oscillospiraceae UCG-002



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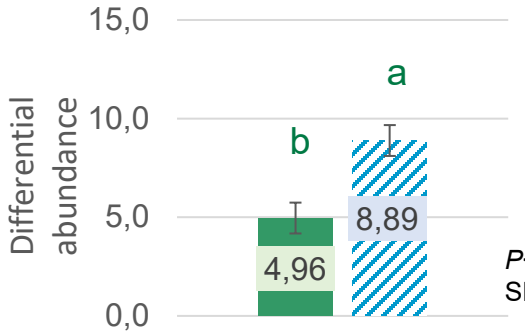
SE:0.388

Rikenellaceae RC9



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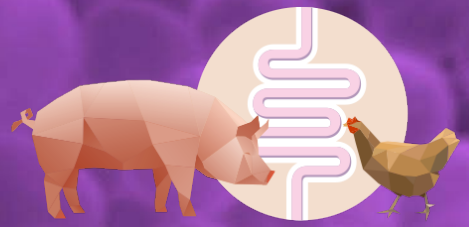

monogut health

Optimal gut function in monogastric livestock

02

Exp 2

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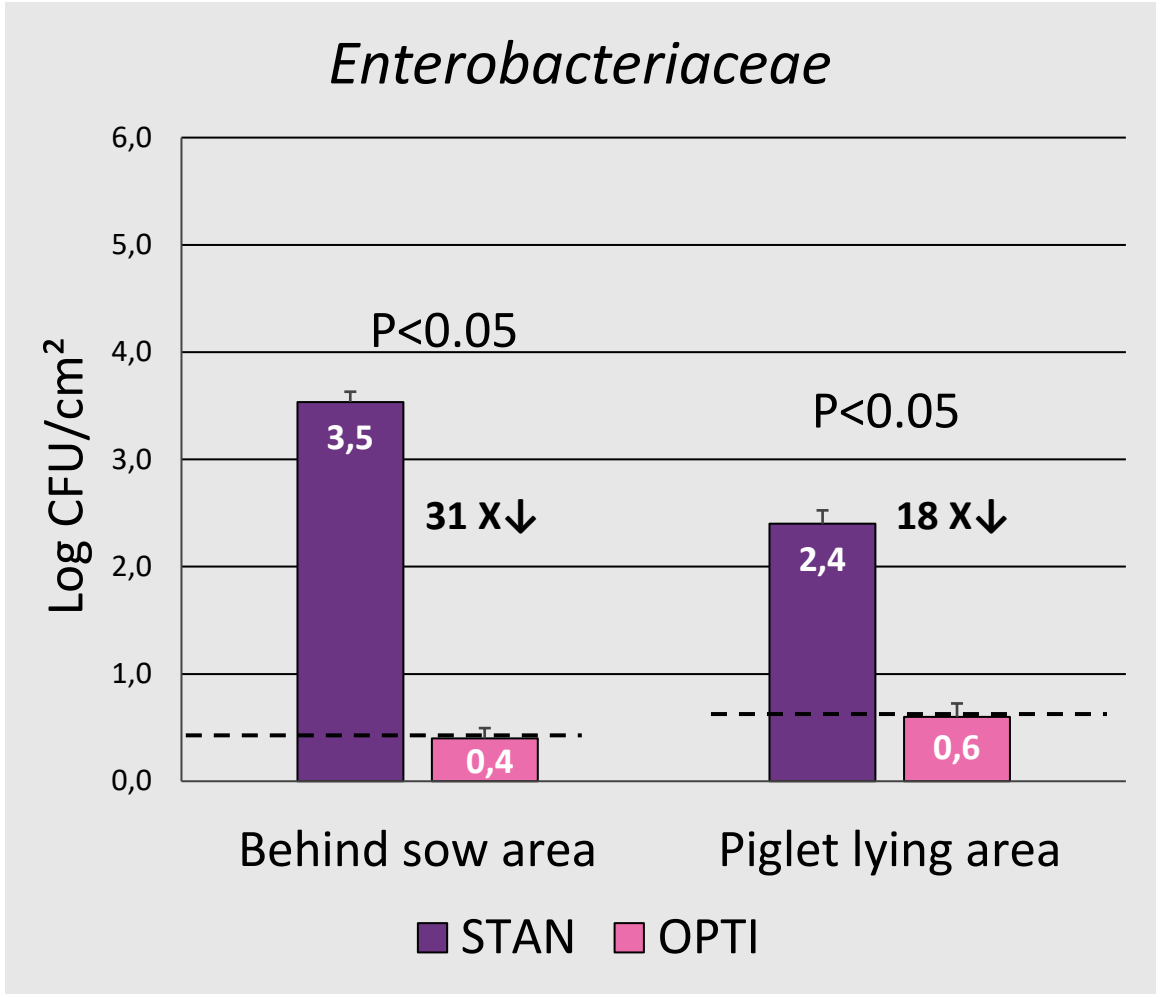
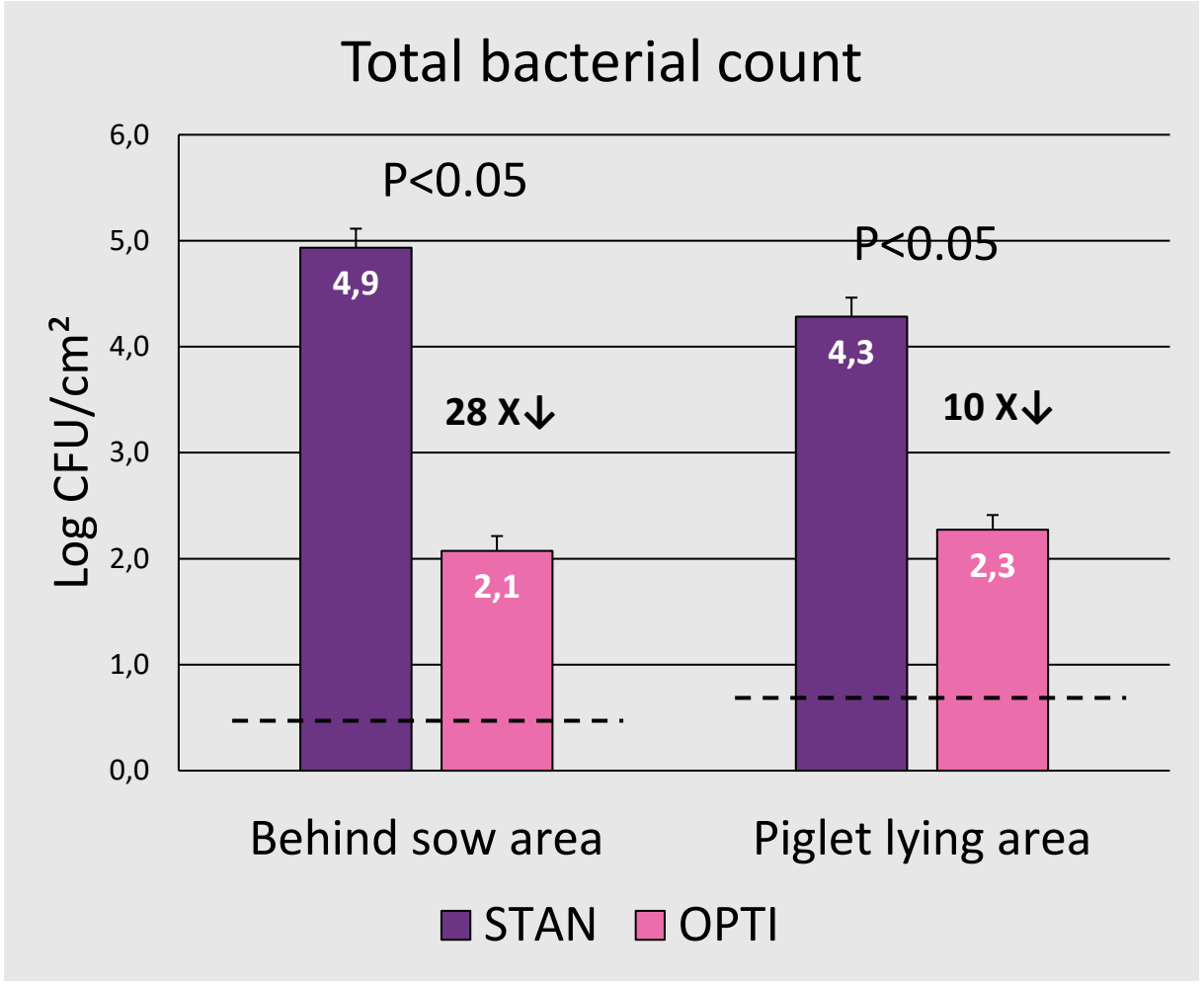
Microbial counts - pen floor swabs after cleaning





- - - - **Limit of detection**

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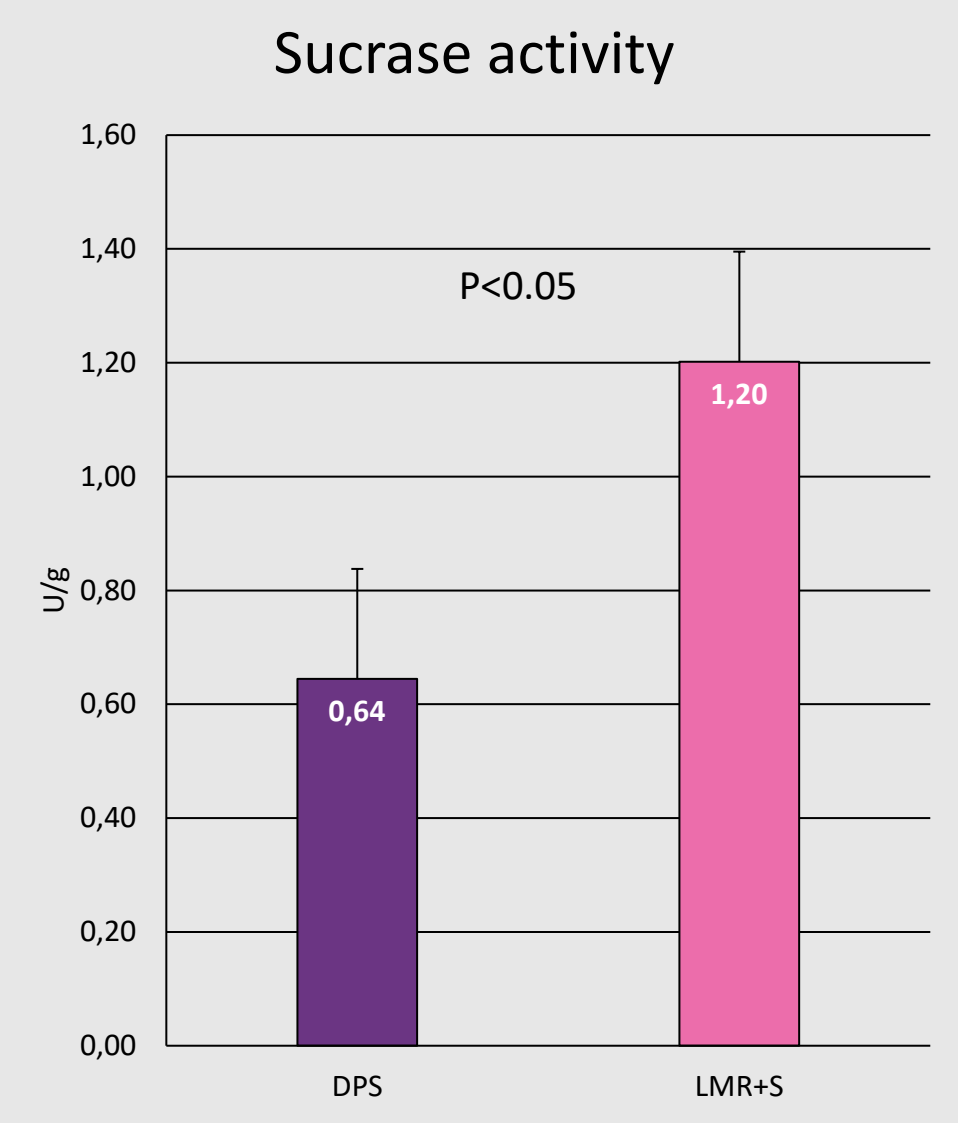
Sucrase activity at day 4 pw



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Conclusions from Exp. 2

Liquid creep feeding

- With optimal hygiene – best pre-weaning feed intake & growth
- With standard hygiene ↑ weaning weight
- ↑ weaning weight and intestinal maturity and ↓ pre-weaning mortality

Optimal pen hygiene

- ↑ pre-weaning feed intake, ↓ clinical cases of disease & ↓ diarrhoea, ↓medication usage, improved intestinal structure and ↓ the days to slaughter

Economic impact

- Liquid creep: ↑ weaning weight + ↓ mortality → €0.39 /pig or €10.78 /sow/yr
- Optimal hygiene: Reach target slaughter weight earlier → €2 /pig or €55 /sow/yr

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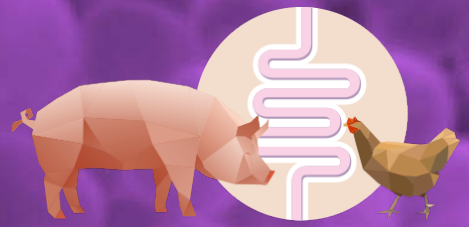

monogut health

Optimal gut function in monogastric livestock

03

Exp 3

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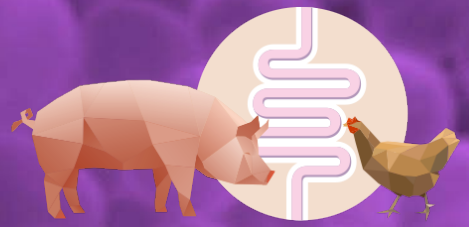

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04

Exp 4

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Results

- No glutamine x liquid milk replacer interaction

Glutamine:

- No effect on growth, diarrhoea, medication usage, D7 pw intestinal structure

Liquid milk replacer:

- ↑ DMI from D0 to 10 post-weaning **(242 *vs.* 447 g/day)**
- ↑ VH in the duodenum, jejunum and ileum at D7 post-weaning
- ↑ growth up to slaughter and carcass weight by **2.6 kg**
- No effect on medication usage

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Conclusions from Exp. 4

1% L-glutamine supplementation

→ No interaction or main effect of 1% L-glutamine supplementation

Supplementary milk replacer

- Supplementary milk replacer ↑ VH in duodenum, jejunum and ileum & VH:CD ratio in the jejunum and ileum, ↓ expression of genes encoding pro-inflammatory markers in jejunum of pigs at D7 pw
- Supplementary milk ↑ abundance of beneficial bacteria in faeces at D11 pw
- + 2.6 kg in carcass weight in pigs supplemented with milk for 10 days pw

Economics

- €4/pig reduced margin over feed with milk supplementation for 10 days post-weaning

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