Gas emissions according to different pig housing systems

Summary of 10 experimental designs

Dr Jean-François CABARAUX
Dr François-Xavier PHILIPPE
Pr Baudouin NICKS

Université de Liège

Fundamental and Applied Research for Animals & Health

Faculté de médecine étérinaire

Introduction

- Pork: most consumed meat in the world (38%)

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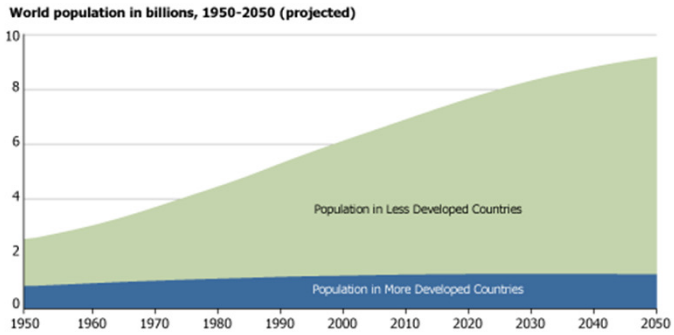
- By 2050: pig consumption ↗+ 40%



Gas emissions according to different pig housing systems

Introduction

- Pork: most consumed meat in the world (38%)
- By 2050: pig consumption ↗+ 40%
- Livestock emissions
  - 64% of global NH3 emissions
  - 18% of global GHG emissions (CO2, N2O, CH4)

Introduction

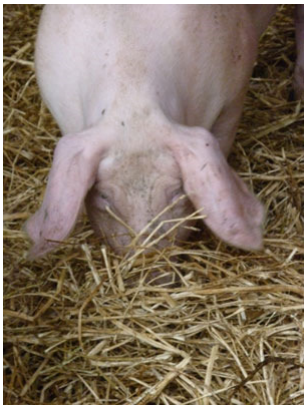
- Factors influencing the level of gas emissions

Introduction

- Factors influencing the level of gas emissions
  - Climatic conditions
    - Ambient temperature
    - Ventilation

Introduction

- Factors influencing the level of gas emissions
  - Climatic conditions
  - Animal behaviour

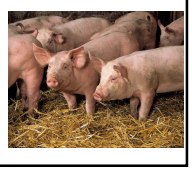


foraging behaviour

Gas emissions according to different pig housing systems

Introduction

- Factors influencing the level of gas emissions
  - Climatic conditions
  - Animal behaviour
  - Floor type and manure management
    - Slatted floor systems
      - Slat characteristics, Slurry emitting surface, Slurry removal strategy
    - Bedded floor systems
      - Type of substrate: straw, sawdust, woodshaving,…
      - Amount of substrate
      - Space allowance
      - Litter management
      - Combination of bedded, slatted and/or solid floor

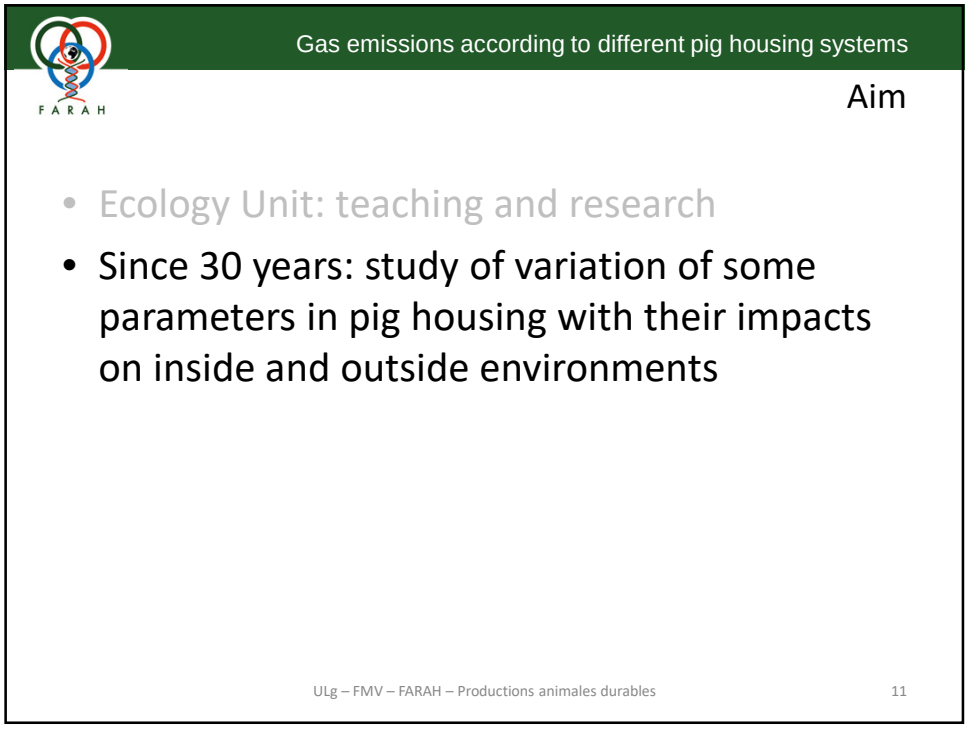


Introduction

- Factors influencing the level of gas emissions
  - Climatic conditions
  - Animal behavior
  - Floor type and manure management
  - Dietary factors
    - Reduced crude protein
    - Dietary fibers
    - …

Aim

- Ecology Unit: teaching and research
  - Οικοσ: house, environment
  - Λογοσ: study


Gas emissions according to different pig housing systems
Aim
• Ecology Unit: teaching and research
• Since 30 years: study of variation of some parameters in pig housing with their impacts on inside and outside environments
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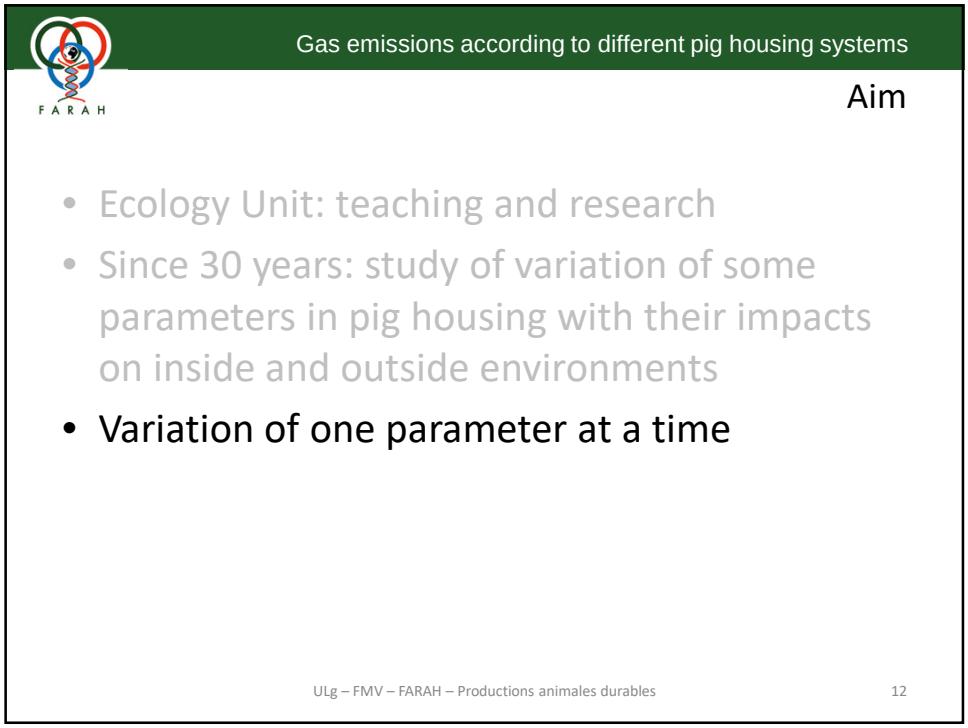
Gas emissions according to different pig housing systems
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• Ecology Unit: teaching and research
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• Variation of one parameter at a time
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Gas emissions according to different pig housing systems

Aim

- Ecology Unit: teaching and research
- Since 30 years: study of variation of some parameters in pig housing with their impacts on inside and outside environments
- Variation of one parameter at a time
- Experimental but “field-like” conditions

Gas emissions according to different pig housing systems

Methods

- ➔ 3 similar experimental rooms
  - Adaptable according to the experimental design




Gas emissions according to different pig housing systems

Methods

- ➔ 3 similar experimental rooms
  - Adaptable according to the experimental design
  - volume (103 m³) and surface (30.2 m²)




Gas emissions according to different pig housing systems

Methods

- ➔ 3 similar experimental rooms
  - Adaptable according to the experimental design
  - volume (103 m³) and surface (30.2 m²)
  - artificially ventilated with an exhaust fan: ventilation rate is adapted automatically to maintain a constant ambient temperature




Gas emissions according to different pig housing systems

Methods

- ➔ 3 similar experimental rooms
  - Adaptable according to the experimental design
  - volume (103 m^3) and surface (30.2 m^2)
  - artificially ventilated with an exhaust fan: ventilation rate is adapted automatically to maintain a constant ambient temperature
  - fresh air enters from the service corridor of the building: the outside air is preheated before entering the experimental rooms

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Gas emissions according to different pig housing systems

Methods

- ➔ 3 similar experimental rooms
  - equipped with a video camera

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Gas emissions according to different pig housing systems

Methods

- ➔ 3 similar experimental rooms
  - equipped with a video camera
  - automatically measurements
    - air temperatures (experimental rooms, corridor and outside)
    - ventilation rates
    - gas concentrations (experimental rooms and corridor)
      - » NH3, N2O, CH4 and CO2
      - » INNOVA 1312
      - » 3 or 4 times during 6 consecutive days

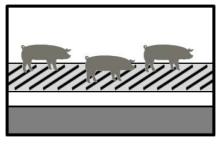
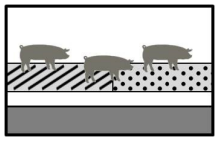



Gas emissions according to different pig housing systems

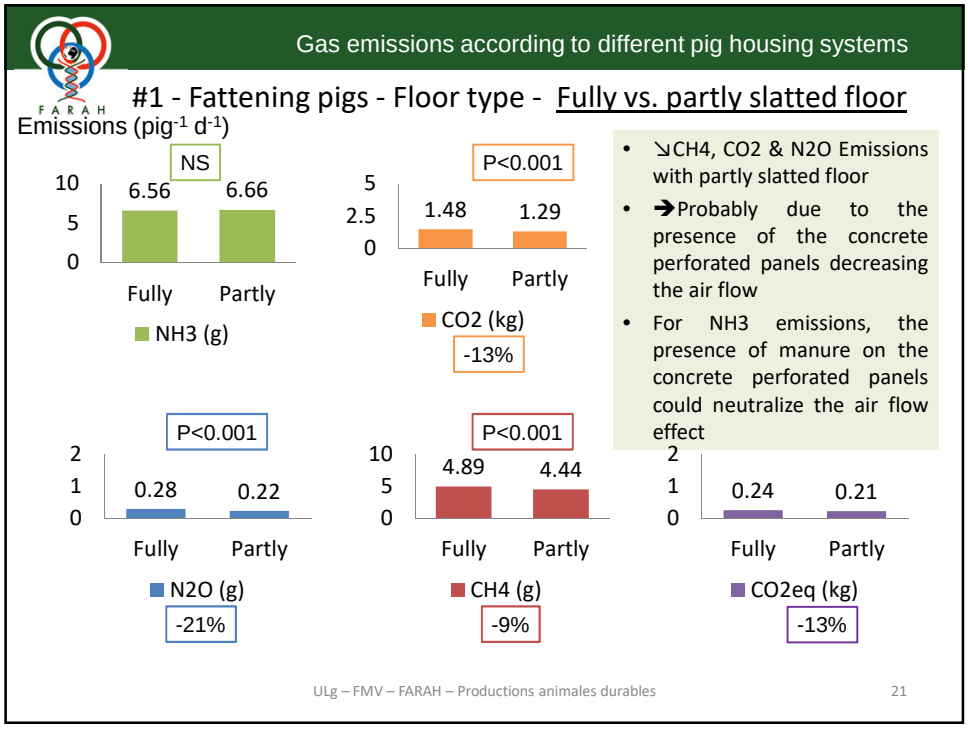
#1 - Fattening pigs - Floor type - Fully vs. partly slatted floor

- 4 batches of 24 pigs divided in 2 groups
- 40 kg → 110 kg
- 0.75 m²/pig
- Ad libitum diet



concrete perforated panels


Gas emissions according to different pig housing systems
#1 - Fattening pigs - Floor type - Fully vs. partly slatted floor
Emissions (pig-1 d-1)
NS
6.56
6.66
Fully
Partly
NH3 (g)
P<0.001
1.48
1.29
CO2 (kg)
-13%
P<0.001
0.28
0.22
N2O (g)
-21%
P<0.001
4.89
4.44
CH4 (g)
-9%
0.24
0.21
CO2eq (kg)
-13%
↘CH4, CO2 & N2O Emissions with partly slatted floor
➔Probably due to the presence of the concrete perforated panels decreasing the air flow
For NH3 emissions, the presence of manure on the concrete perforated panels could neutralize the air flow effect
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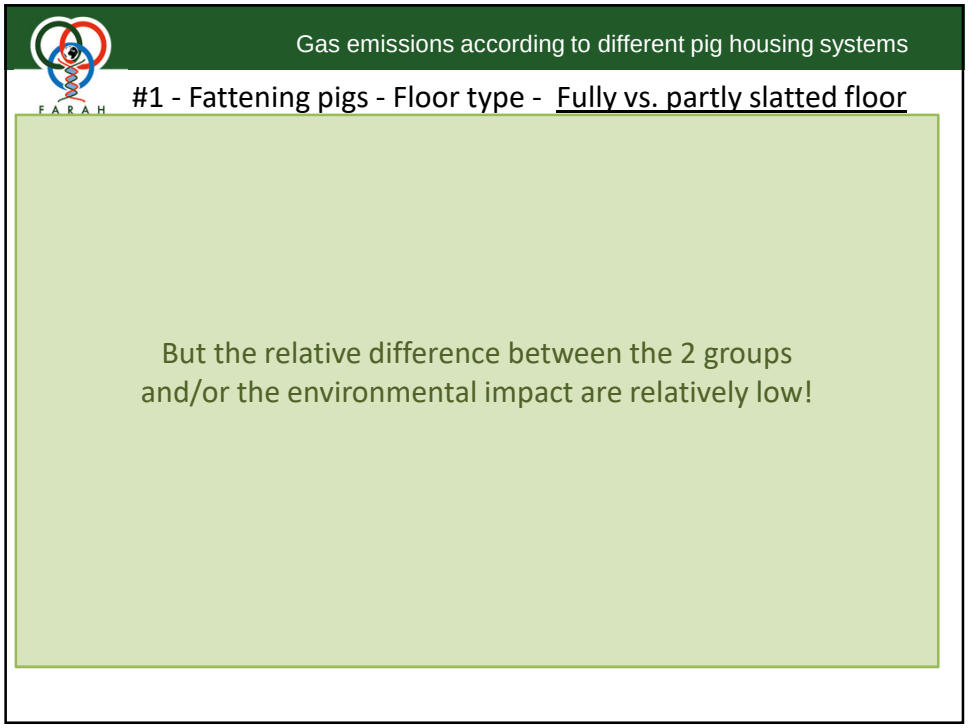

Gas emissions according to different pig housing systems
#1 - Fattening pigs - Floor type - Fully vs. partly slatted floor
But the relative difference between the 2 groups and/or the environmental impact are relatively low!

Gas emissions according to different pig housing systems

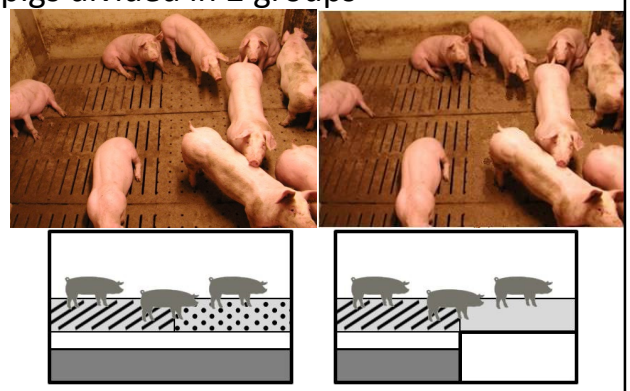
#1 - Fattening pigs - Floor type - Fully vs. partly slatted floor

What is the effect of a reduction of the emitting surface?

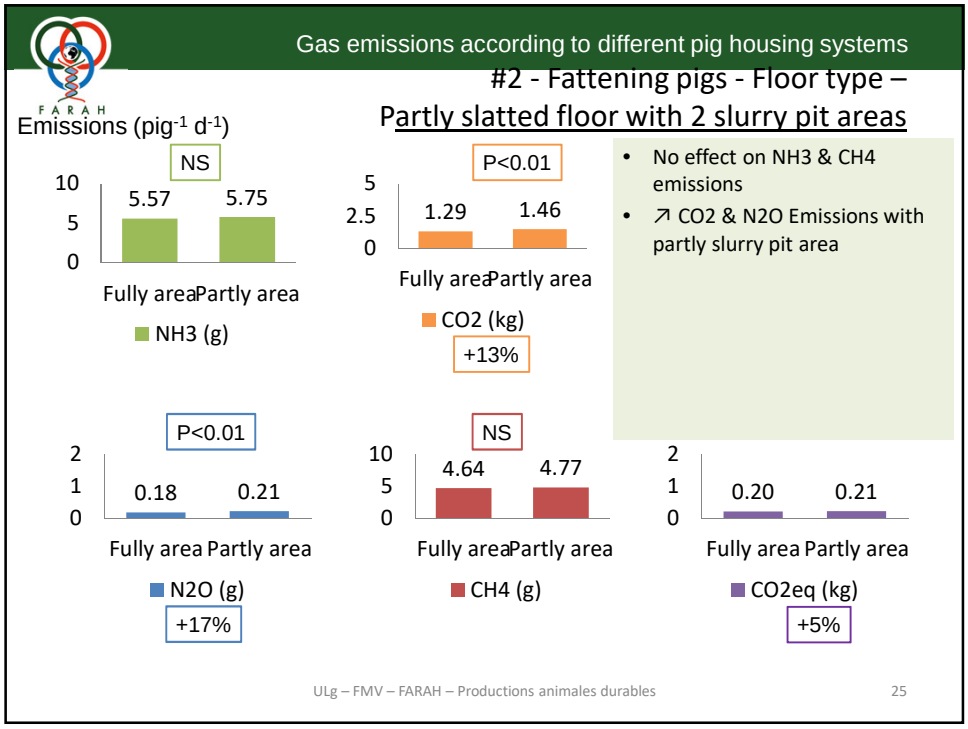
Gas emissions according to different pig housing systems

#2 - Fattening pigs - Floor type –
Partly slatted floor with 2 slurry pit areas

- 2 batches of 24 pigs divided in 2 groups
- 40 kg → 100 kg
- 0.75 m²/pig
- Ad libitum diet



Slurry pit area 0.75 vs. 0.375 m²/pig


Gas emissions according to different pig housing systems
#2 - Fattening pigs - Floor type –
Partly slatted floor with 2 slurry pit areas
Emissions (pig-1 d-1)
NS
10
5
0
5.57
5.75
Fully area
Partly area
NH3 (g)
P<0.01
5
2.5
0
1.29
1.46
Fully area
Partly area
CO2 (kg)
+13%
• No effect on NH3 & CH4 emissions
• ↗ CO2 & N2O Emissions with partly slurry pit area
P<0.01
2
1
0
0.18
0.21
Fully area
Partly area
N2O (g)
+17%
NS
10
5
0
4.64
4.77
Fully area
Partly area
CH4 (g)
2
1
0
0.20
0.21
Fully area
Partly area
CO2eq (kg)
+5%
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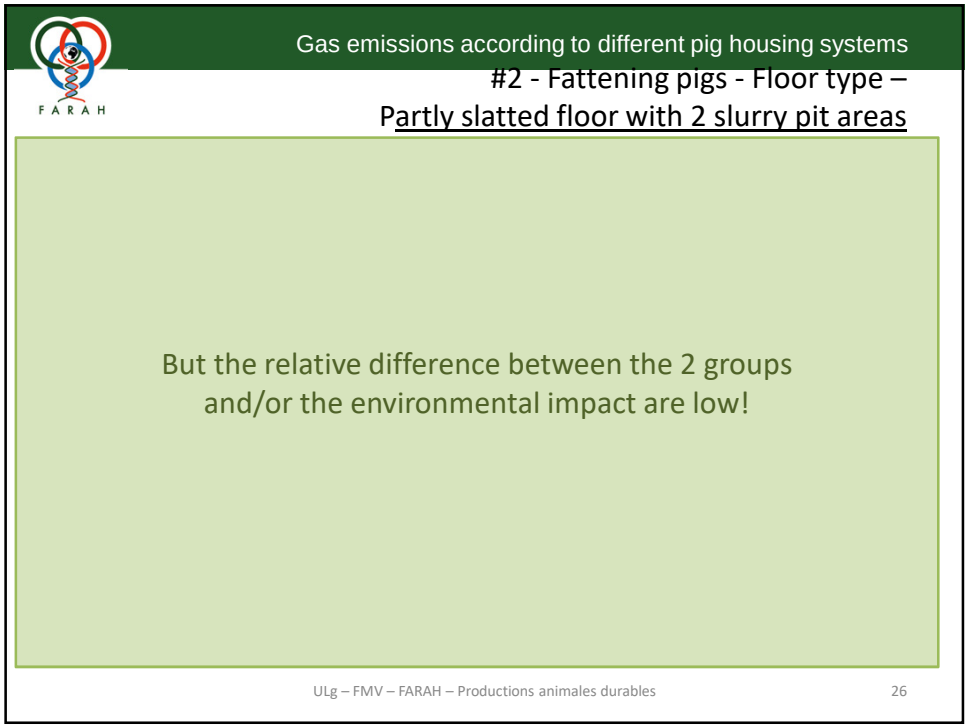
Gas emissions according to different pig housing systems
#2 - Fattening pigs - Floor type –
Partly slatted floor with 2 slurry pit areas
But the relative difference between the 2 groups
and/or the environmental impact are low!
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Gas emissions according to different pig housing systems

#2 - Fattening pigs - Floor type –
Partly slatted floor with 2 slurry pit areas

Reduction of emissions provided the soiling of the solid floor is prevented

≠

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Gas emissions according to different pig housing systems

#2 - Fattening pigs - Floor type –
Partly slatted floor with 2 slurry pit areas

What is the effect of a bedded floor system?

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Gas emissions according to different pig housing systems

#3 - Fattening pigs - Floor type – Fully slatted floor vs. straw-based deep litter

- 5 batches of 32 pigs divided in 2 groups
- 25 kg → 110 kg
- Available floor space
  - 0.75 m²/pig on slatted floor
  - 1.20m²/pig on deep litter
- 46 kg straw/pig
- Ad libitum diet

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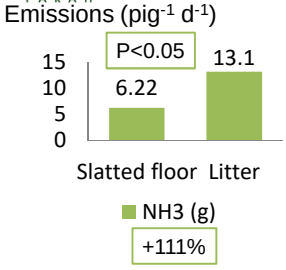
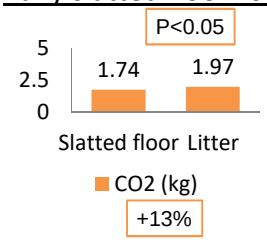
Gas emissions according to different pig housing systems

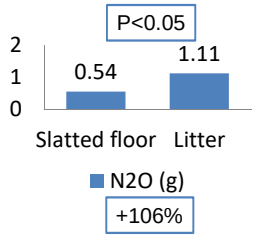
#3 - Fattening pigs - Floor type – Fully slatted floor vs. straw-based deep litter

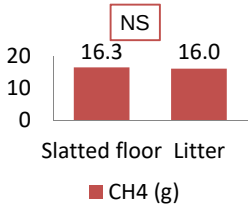
Emissions (pig^{-1} d^{-1})

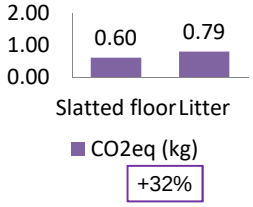




- With litter
  - NH3 & NO2 emissions are doubled
  - ↗ CO2emissions with litter
  - No significant difference for CH4







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Gas emissions according to different pig housing systems

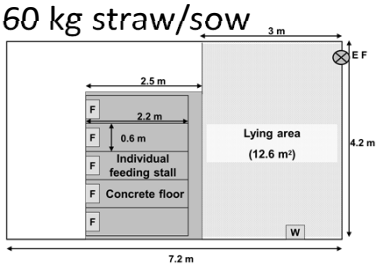
#3 - Fattening pigs - Floor type – Fully slatted floor vs. straw-based deep litter

We realised the same comparison with gestating sows…

Gas emissions according to different pig housing systems

#4 – Gestating sows- Floor type – Fully slatted floor vs. straw-based deep litter

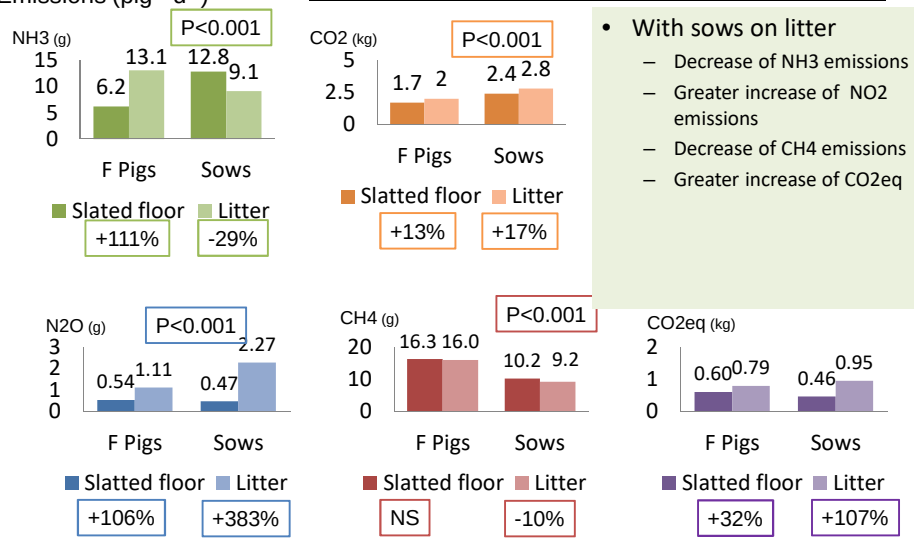
- 3 batches of 10 gestating sows divided in 2 groups
- 2.5 m²/sow
- Individual feeding stalls
- Restricted diet supplied once a day at 08:00 am
- 9 weeks
- *60 kg straw/sow*



Gas emissions according to different pig housing systems

#4 – Gestating sows- Floor type – Fully slatted floor vs. straw-based deep litter

Emissions (pig^{-1} d^{-1})



- With sows on litter
  - Decrease of NH3 emissions
  - Greater increase of NO2 emissions
  - Decrease of CH4 emissions
  - Greater increase of CO2eq

Gas emissions according to different pig housing systems

#4 – Gestating sows- Floor type – Fully slatted floor vs. straw-based deep litter

NH3

- The amounts of supplied straw could explain the different results:
  - The Excreted N was quite similar (around 40gN/d per fattening pig or sow)
  - The straw supply was greater with the sows than with the fattening pigs
    - 900g/d per sow
    - 400g/d per pig
- More straw increased the C/N ratio of the litter which favors bacterial growth and promotes the N assimilation into stable microbial protein with lower NH3-emissions as a consequence…

Gas emissions according to different pig housing systems

#4 – Gestating sows- Floor type – Fully slatted floor vs. straw-based deep litter

N2O

- The formation of N_2O occurs during incomplete Nitrification/denitrification processes that normally convert NH_3 into N_2, a non polluting gas. N_2O-synthesis needs close combination of aerobic and anaerobic areas, heterogeneous conditions met within the litter.
- These particular conditions explain greater N_2O-emissions usually observed with bedded systems in comparison with slurry systems where the environment is largely anaerobic.
- All parameters that modify the physicochemical properties of manure (temperature, density, moisture, pH, C / N) have an impact on N2O production
  ➔ In bedded systems, N_2O-formation may be reduced with a generous supply of straw and may be increased by the presence of numerous anaerobic areas.

Gas emissions according to different pig housing systems

#4 – Gestating sows- Floor type – Fully slatted floor vs. straw-based deep litter

We realised a comparison with different amounts of straw…

Gas emissions according to different pig housing systems

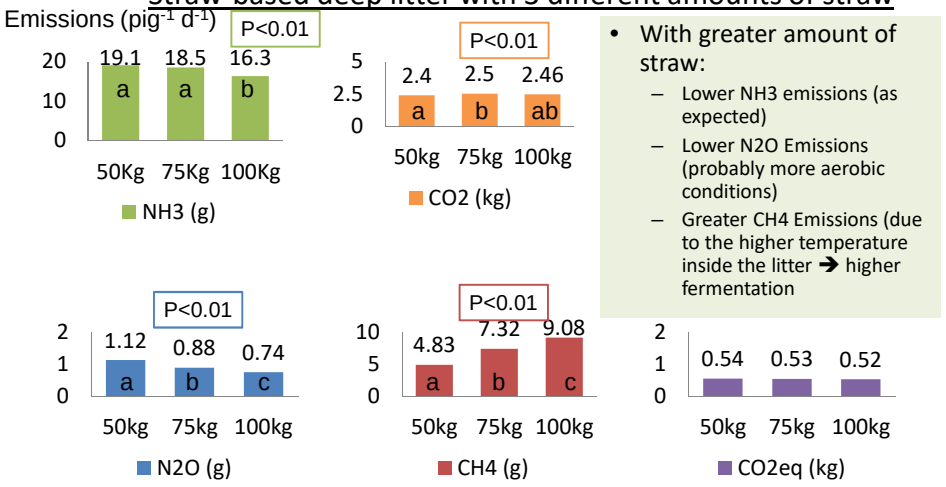
#5 - Fattening pigs - Floor type – Straw-based deep litter with 3 different amounts of straw

- 2 batches of 30 pigs divided in 3 groups
- 1.2 m²/pig
- 50 , 75 or 100 kg straw/pig
- Ad libitum diet
- 40 kg ➔ 115 kg



Gas emissions according to different pig housing systems

#5 - Fattening pigs - Floor type – Straw-based deep litter with 3 different amounts of straw



- With greater amount of straw:
  - Lower NH3 emissions (as expected)
  - Lower N2O Emissions (probably more aerobic conditions)
  - Greater CH4 Emissions (due to the higher temperature inside the litter ➔ higher fermentation

Gas emissions according to different pig housing systems

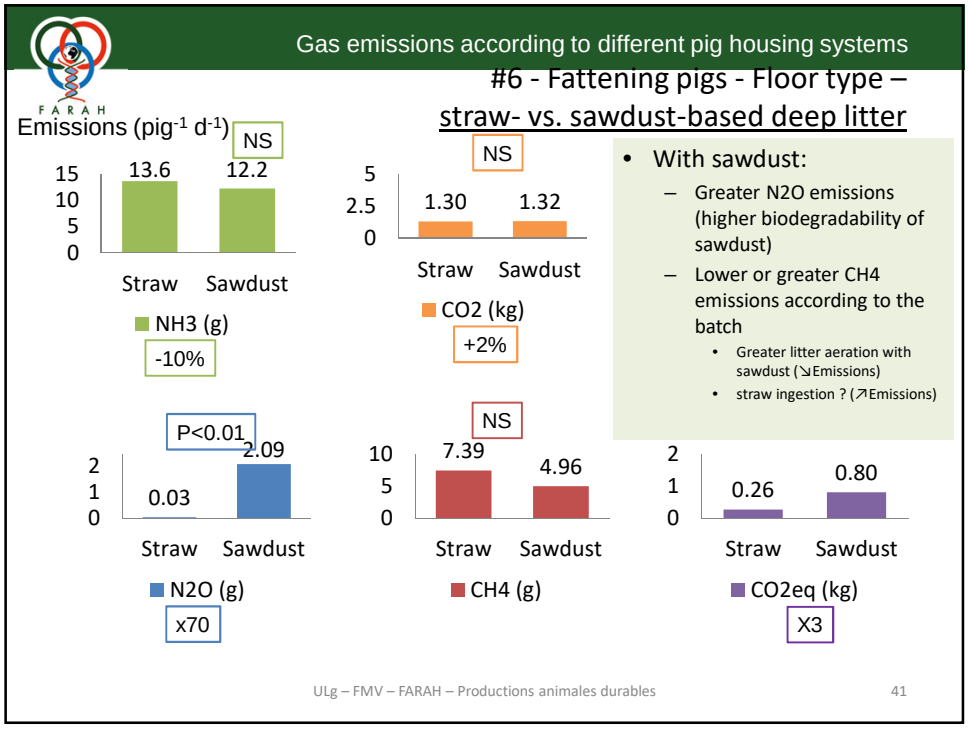
#5 - Fattening pigs - Floor type – Straw-based deep litter with 3 different amounts of straw

Effect of other type of litter…

Gas emissions according to different pig housing systems

#6 - Fattening pigs - Floor type – straw- vs. sawdust-based deep litter

- 3 batches of 36 fattening pigs divided in 2 groups
- 130 kg straw per pig and 105 kg sawdust per pig
- 1.2 m²/pig
- Ad libitum diet
- 22 kg ➔ 115 kg


Gas emissions according to different pig housing systems
#6 - Fattening pigs - Floor type – straw- vs. sawdust-based deep litter
Emissions (pig-1 d-1)
NS
15
10
5
0
13.6
12.2
Straw
Sawdust
NH3 (g)
-10%
NS
5
2.5
0
1.30
1.32
Straw
Sawdust
CO2 (kg)
+2%
With sawdust:
– Greater N2O emissions (higher biodegradability of sawdust)
– Lower or greater CH4 emissions according to the batch
• Greater litter aeration with sawdust (↘Emissions)
• straw ingestion ? (↗Emissions)
P<0.01
2
1
0
0.03
2.09
Straw
Sawdust
N2O (g)
x70
NS
10
5
0
7.39
4.96
Straw
Sawdust
CH4 (g)
2
1
0
0.26
0.80
Straw
Sawdust
CO2eq (kg)
X3
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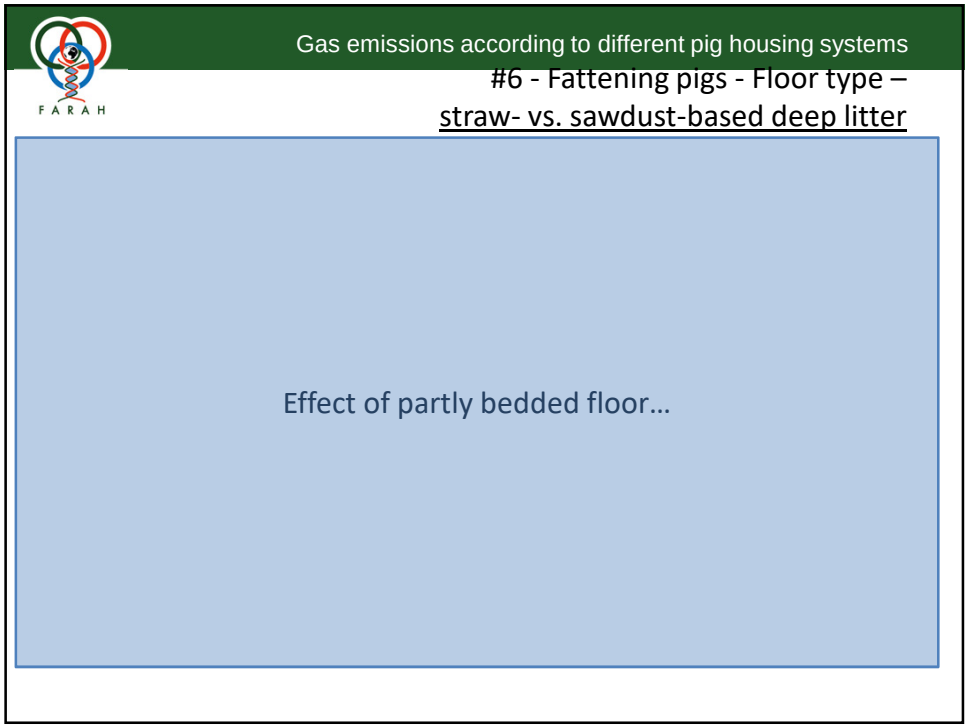
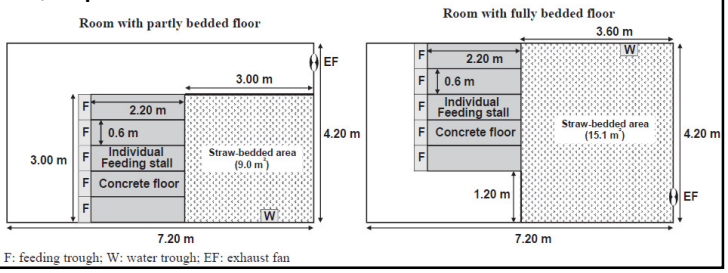

Gas emissions according to different pig housing systems
#6 - Fattening pigs - Floor type – straw- vs. sawdust-based deep litter
Effect of partly bedded floor…

Gas emissions according to different pig housing systems

#7 – Gestating sows- Floor type –

Deep litter - permanent use of feeding stalls as living area

- 3 batches of 10 gestating sows divided in 2 groups
  - 3m²/sow deep-litter (feeding stall: rear gates closed)
  - 1.8m²/sow deep-litter +1.2m²/sow concrete floor (feeding stall: rear gates open)
- Restricted diet supplied once a day at 08:00 am
- 0.9 kg straw/d per sow
- 9 weeks

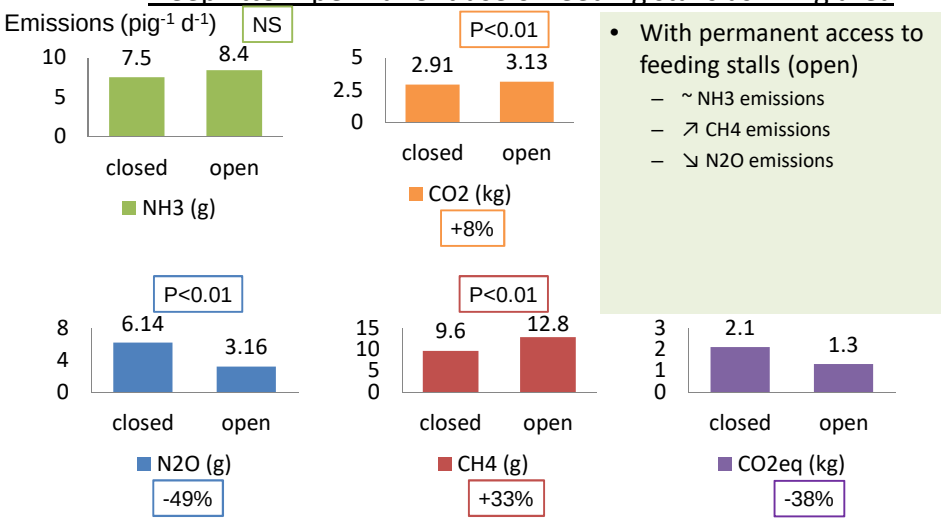


F: feeding trough; W: water trough; EF: exhaust fan

Gas emissions according to different pig housing systems

#7 – Gestating sows- Floor type –

Deep litter - permanent use of feeding stalls as living area



- With permanent access to feeding stalls (open)
  - ~ NH3 emissions
  - ↗ CH4 emissions
  - ↘ N2O emissions

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Gas emissions according to different pig housing systems

#7 – Gestating sows- Floor type – Deep litter - permanent use of feeding stalls as living area

NH3

- In this experiment, no significant difference was observed…
- The greater amount of urine and faeces on the concrete floor of the feeding stalls in the Partly Bedded Floor room, due to the permanent access of the sows to these stalls in that room, could have compensated for the greater emitting surface of the litter in the Fully Bedded Floor room and thus, could explain the results.

Gas emissions according to different pig housing systems

#7 – Gestating sows- Floor type – Deep litter - permanent use of feeding stalls as living area

CH4

- The higher CH4-emission reported from the PBF room could be related to greater compaction of the litter due to the higher animal density and thus by the presence of more anaerobic conditions in the litter resulting in an increase of fermentations.

N2O

- More favourable conditions in the FBF litter where close combination of aerobic and anaerobic areas was plausibly more present probably explained the greater N2O-emissions.

#7 – Gestating sows- Floor type – Deep litter - permanent use of feeding stalls as living area

What about the diet…

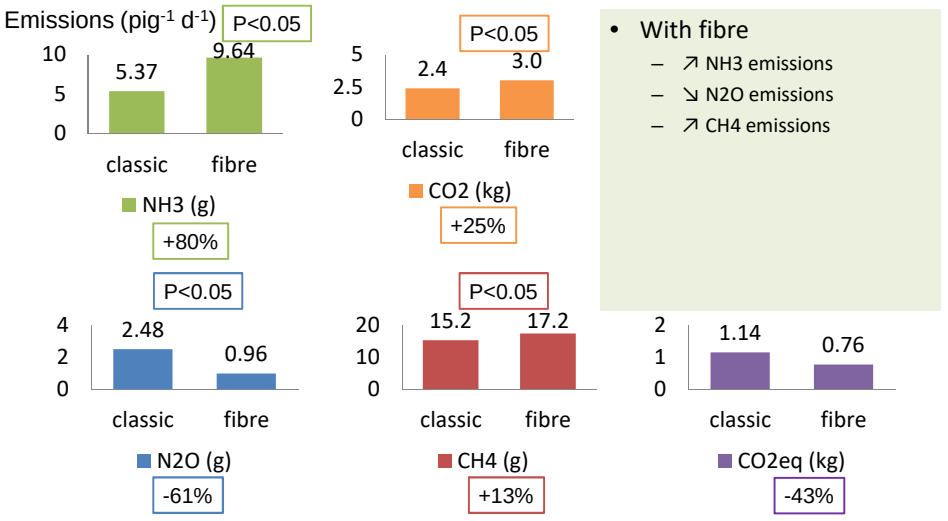
#8 – Gestating sows- Diet– use of fibres (SBP) – straw litter

- 4 batches of 10 gestating sows divided in 2 groups
  - Classic diet (Restricted diet)
  - Fibre diet (SBP - ad libitum)

  } Net energy intake similar
- 1.3 kg straw/d per sow
- 2.5 m²/sow

Gas emissions according to different pig housing systems

#8 – Gestating sows- Diet– use of fibres (SBP) – straw litter



- With fibre
  - ↗ NH3 emissions
  - ↘ N2O emissions
  - ↗ CH4 emissions

Gas emissions according to different pig housing systems

#8 – Gestating sows- Diet– use of fibres (SBP) – straw litter

NH3

- Canh et al. (1998) observed less NH3 emissions with SBP
  - Microbial fermentations
    - Lower faeces pH (VFA)
    - Less N in urine as urea (and more N in faeces as protein form)
- Present trial: field conditions with manure
  - Microbial fermentations
    - Large intestine
    - Manure

N2O

- Microbial fermentations ≠
- ➔ faeces composition ≠
- Maybe more resistant to nitrification/denitrification process leading to N2 formation ?

Gas emissions according to different pig housing systems

#8 – Gestating sows- Diet– use of fibres (SBP) – straw litter

CH4

- Greater enteric fermentations ← higher fibre content of diet
- Straw intake by all sows! Amount ???

Gas emissions according to different pig housing systems

#8 – Gestating sows- Diet– use of fibres (SBP) – straw litter

Without straw…

Gas emissions according to different pig housing systems

#9 – Gestating sows- Diet– use of fibres (SBP) – partly slatted floor

- 3 batches of 10 gestating sows divided in 2 groups
  - Classic diet (Restricted)
  - Fibre diet (SBP -Restricted)
- Partly slatted floor
- 3 m²/sow

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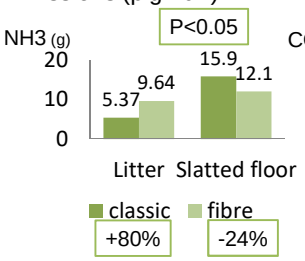
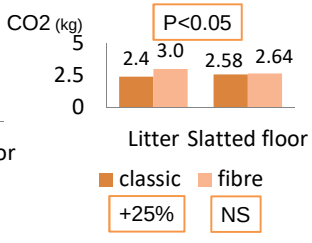
Gas emissions according to different pig housing systems

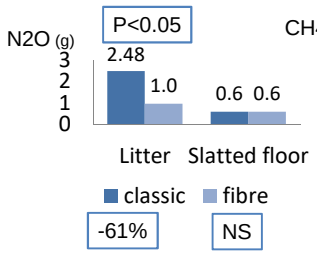
#9 – Gestating sows- Diet– use of fibres (SBP) – straw litter vs partly slatted floor

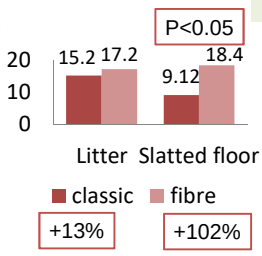
Emissions (pig^{-1} d^{-1})

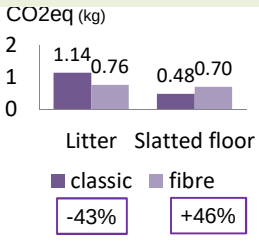




- With fibre and slatted floor
  - ↘ NH3 emissions
  - ~ N2O emissions
  - ↗ CH4 emissions
  - ↗ CO2 eq emissions







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Gas emissions according to different pig housing systems

#9 – Gestating sows- Diet– use of fibres (SBP) – straw litter vs partly slatted floor

NH3

- Canh et al. (1998) observed less NH3 emissions with SBP
  - Microbial fermentations
    - Lower faeces pH (VFA)
    - Less N in urine as urea (and more N in faeces as protein form)
- It was what we expected…

N2O

- No effect
- It was what we expected…

CH4

- Greater enteric fermentations ← higher fibre content of diet
- It was what we expected…

Gas emissions according to different pig housing systems

#9 – Gestating sows- Diet– use of fibres (SBP) – straw litter vs partly slatted floor

Interactions between housing, behavior and diet…

Gas emissions according to different pig housing systems

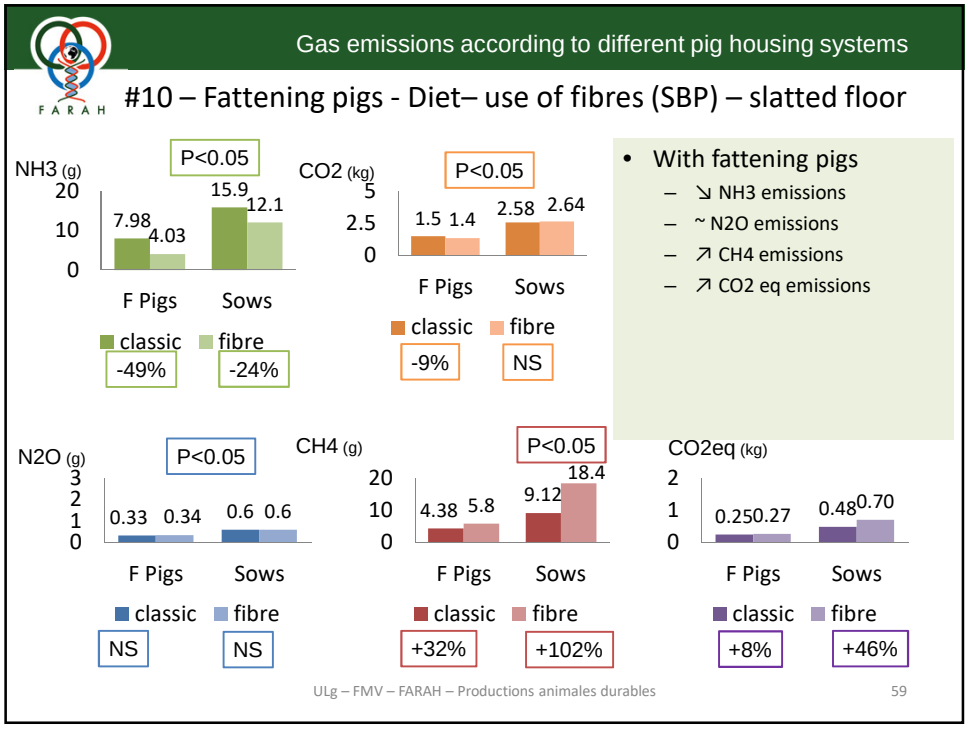
#9 – Gestating sows- Diet– use of fibres (SBP) – straw litter vs partly slatted floor

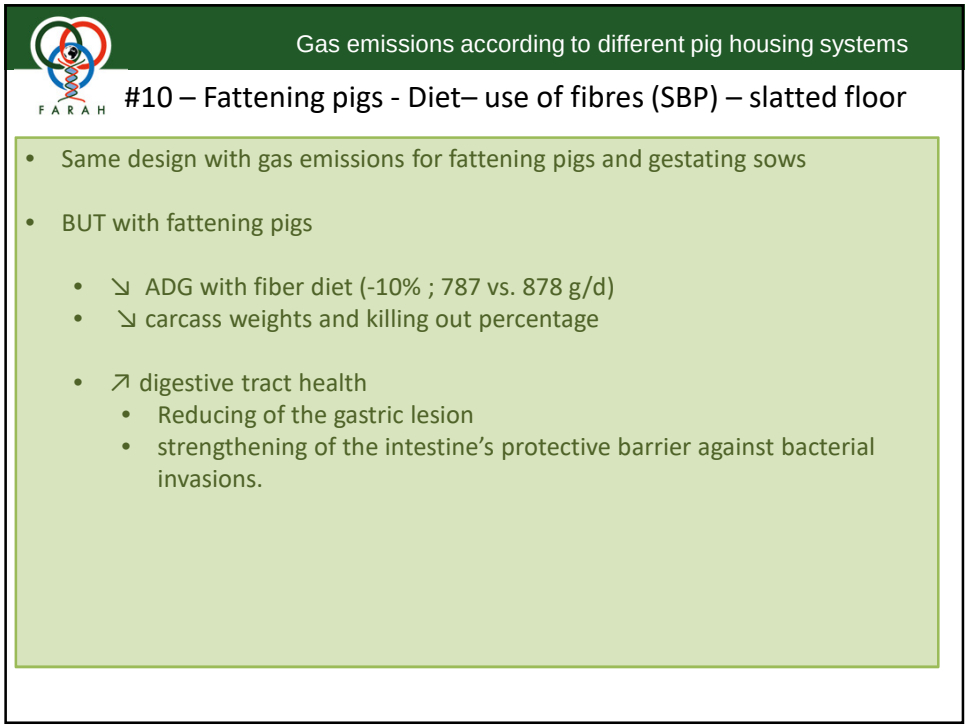
Confirmation with fattening pigs…

Gas emissions according to different pig housing systems

#10 – Fattening pigs - Diet– use of fibres (SBP) – slatted floor

- 2 batches of 24 pigs divided in 2 groups
  - Classic diet (18% NSP)
  - Fibre diet (30%NSP)
- Isoproteic and isoenergy
- Ad libitum
- 35 ➔ 110 kg
- 0.75 m²/pig
- Fully slatted floor


Gas emissions according to different pig housing systems
#10 – Fattening pigs - Diet– use of fibres (SBP) – slatted floor
NH3 (g)
P<0.05
7.98
4.03
15.9
12.1
F Pigs
Sows
classic
fibre
-49%
-24%
CO2 (kg)
P<0.05
1.5 1.4
2.58 2.64
F Pigs
Sows
classic
fibre
-9%
NS
With fattening pigs
↘ NH3 emissions
~ N2O emissions
↗ CH4 emissions
↗ CO2 eq emissions
N2O (g)
P<0.05
0.33 0.34
0.6 0.6
F Pigs
Sows
classic
fibre
NS
NS
CH4 (g)
P<0.05
4.38 5.8
9.12
18.4
F Pigs
Sows
classic
fibre
+32%
+102%
CO2eq (kg)
0.25 0.27
0.48 0.70
F Pigs
Sows
classic
fibre
+8%
+46%
ULg – FMV – FARAH – Productions animales durables
59


Gas emissions according to different pig housing systems
#10 – Fattening pigs - Diet– use of fibres (SBP) – slatted floor
Same design with gas emissions for fattening pigs and gestating sows
BUT with fattening pigs
↘ ADG with fiber diet (-10% ; 787 vs. 878 g/d)
↘ carcass weights and killing out percentage
↗ digestive tract health
Reducing of the gastric lesion
strengthening of the intestine's protective barrier against bacterial invasions.

Conclusions

- Numerous techniques to reduce emissions, whatever the floor type
- BUT contradictions depending on the circumstances and the gas
  - Bedded floor : Large range of rearing systems ➔ Environment inside the litter
    - Sawdust : (↘ CH4), ↗ N2O
    - Increasing straw supply : ↘ NH3, ↘ N2O, ↗ CH4
  - Partly slatted floor : Provided prevention of soiled solid floor
  - Dietary factors
    - Fibres : ↘ NH3 on slatted floor, ↗ NH3 on bedded floor, ↗ CH4 on both

Thank you for your attention