Digestive efficiency: a new measure to include in breeding schemes?

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Context of the study

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A method for predicting individual digestive efficiency was developed in the H2020 Feed-a-Gene project

Familial structure of the experiment

1663 pigs
783 couples of full-sibs
from 171 sires

Fed a different diet from 30kg up to slaughter (115kg)

Standard diet (9.4 MJ/kg)
Wheat + Barley (53%)
Corn (25%), soybean meal (11%)

Fibre-rich diet (8.2 MJ/kg)
Wheat + Barley (53%)
Wheat bran (15%) + soybean hulls (10%)
soybean meal (5.5%), sugar beet pulp (5%)

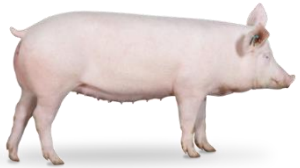
How to measure digestive efficiency?

Step 1: Collection of faeces

Step 2: Samples are frozen, freeze-dried and ground

Step 3: Analysis of faeces samples with NIRS

Step 4: Prediction of digestibility



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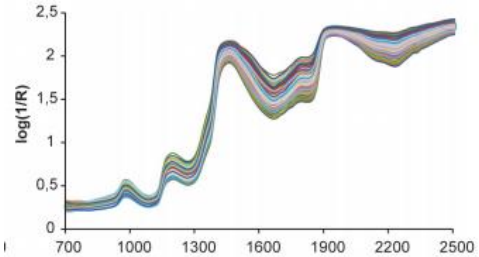

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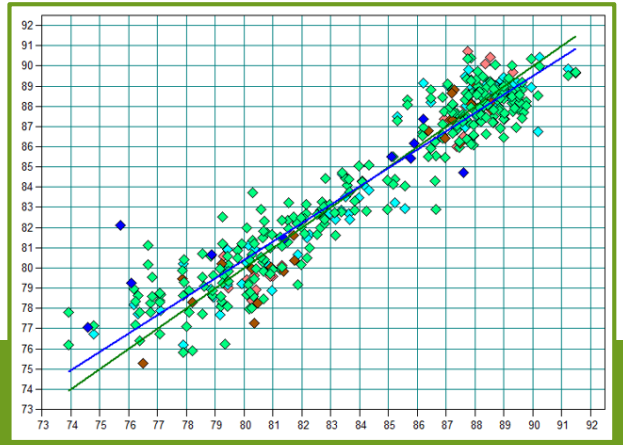

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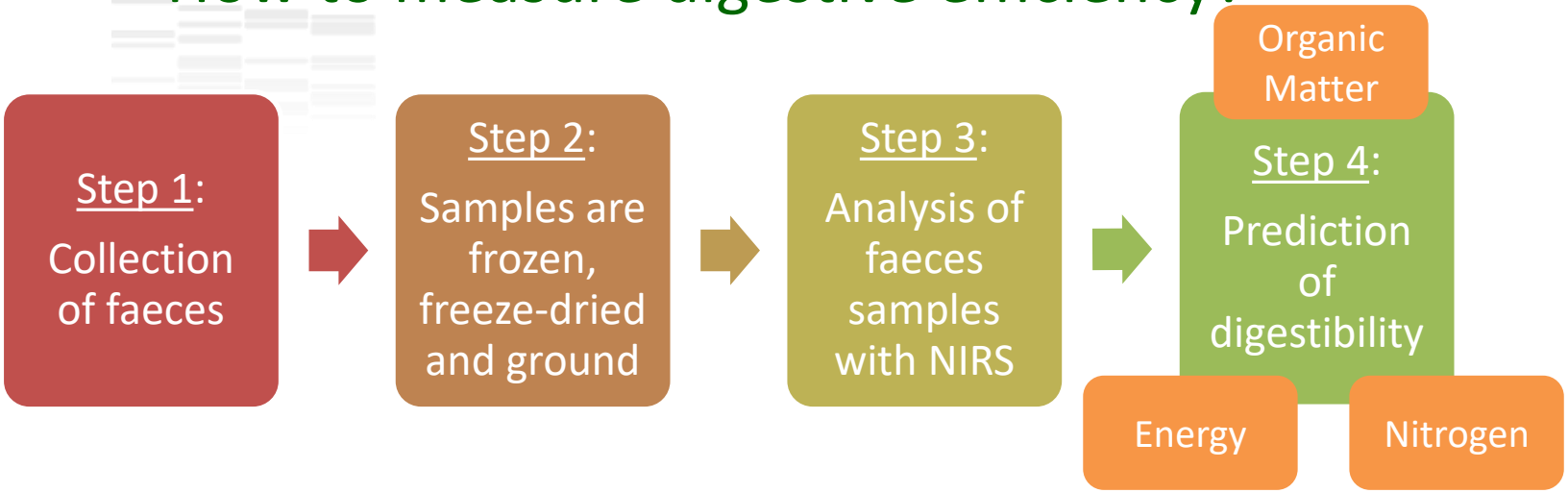
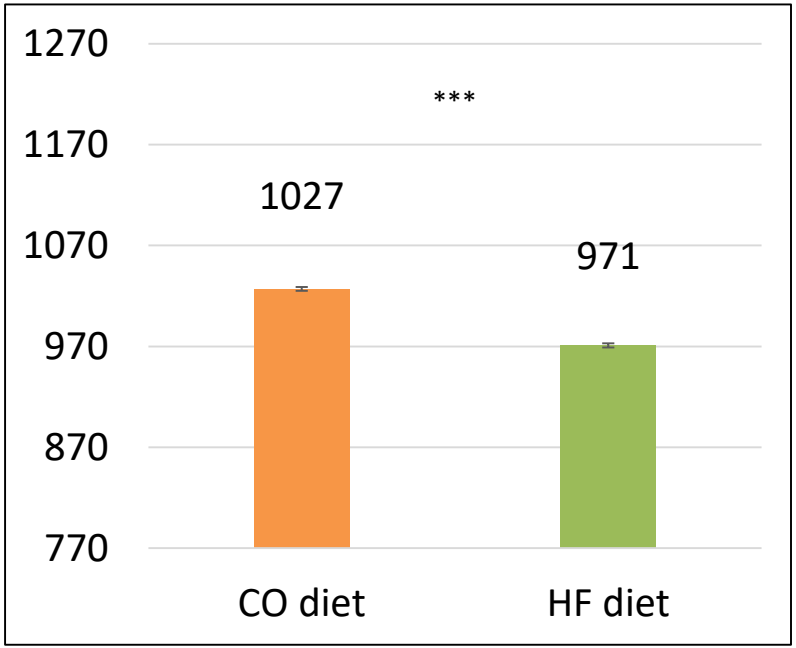


Digestibility coefficient (DC) = % of nutrients absorbed by the intestine

Comparison of LSMeans of performances between diets



Average Daily Gain (ADG) (g/day)

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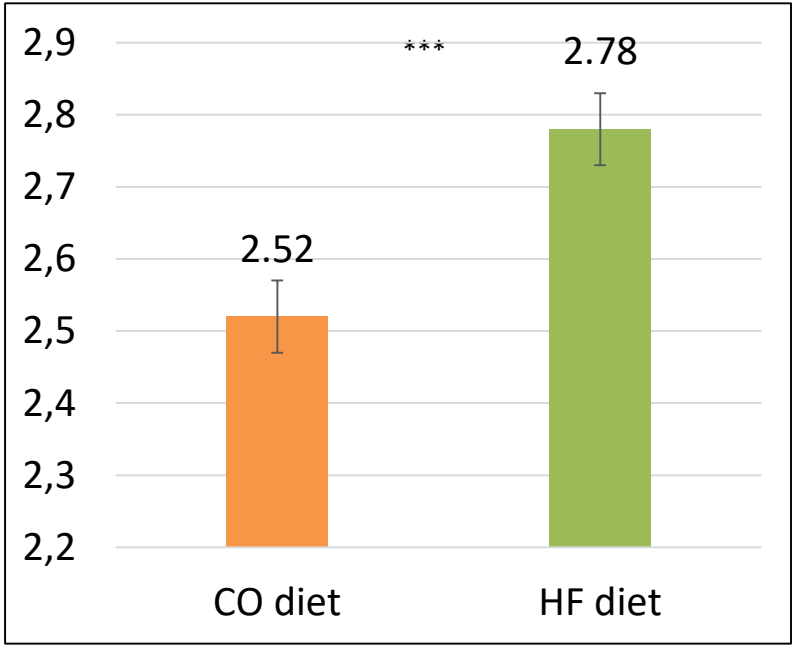

Feed Conversion Ratio (FCR)

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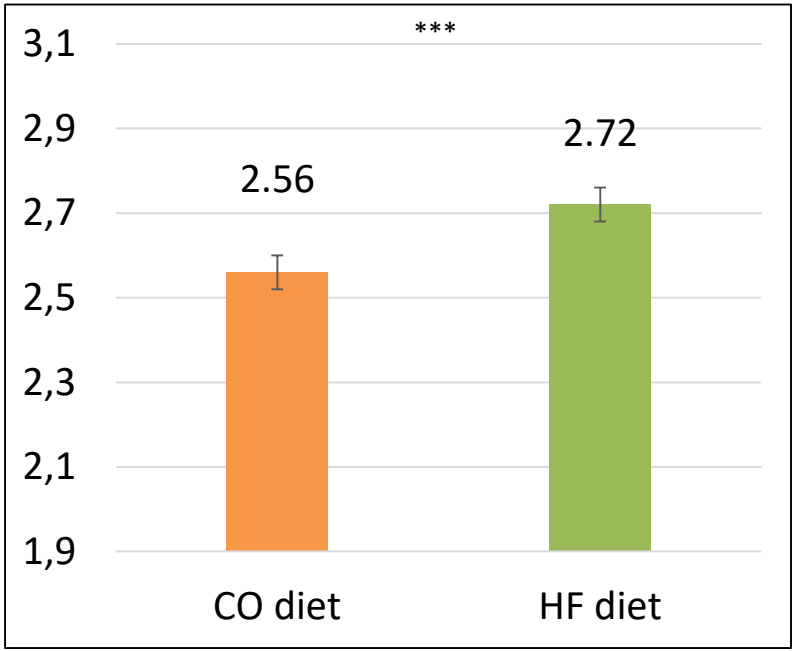

Daily Feed Intake (DFI) (kg/day)

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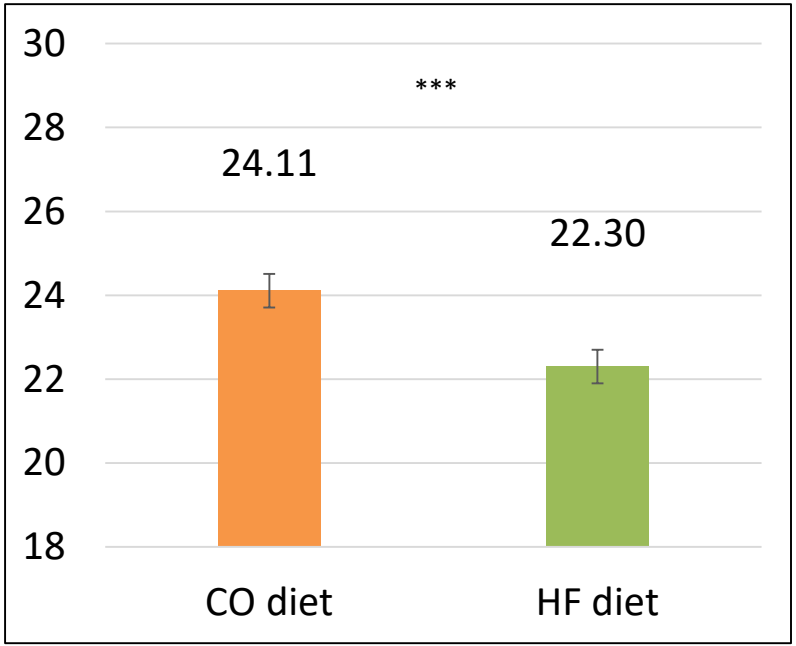

Daily Feed Intake (DFI) (MJ/day)

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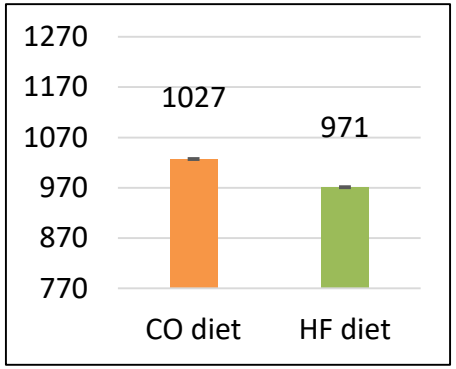

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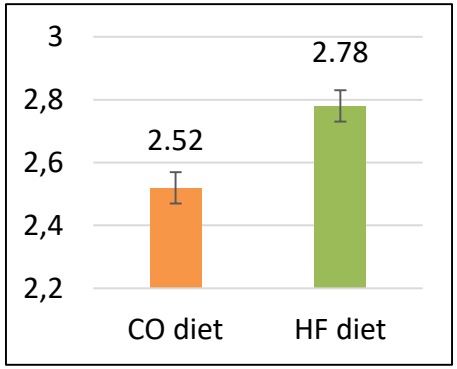

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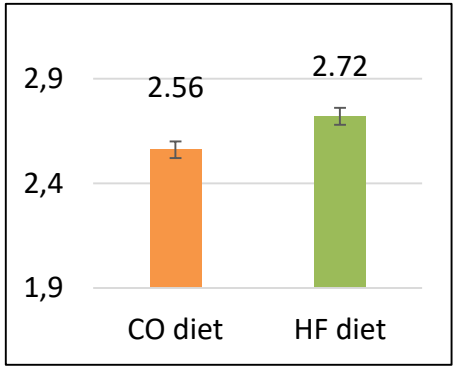

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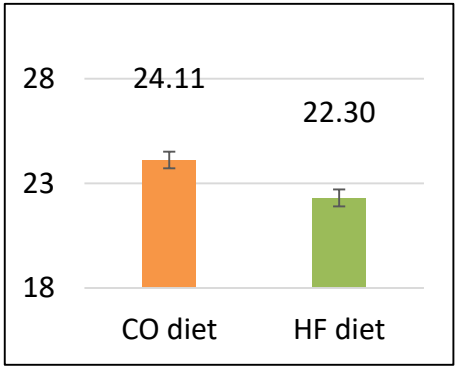
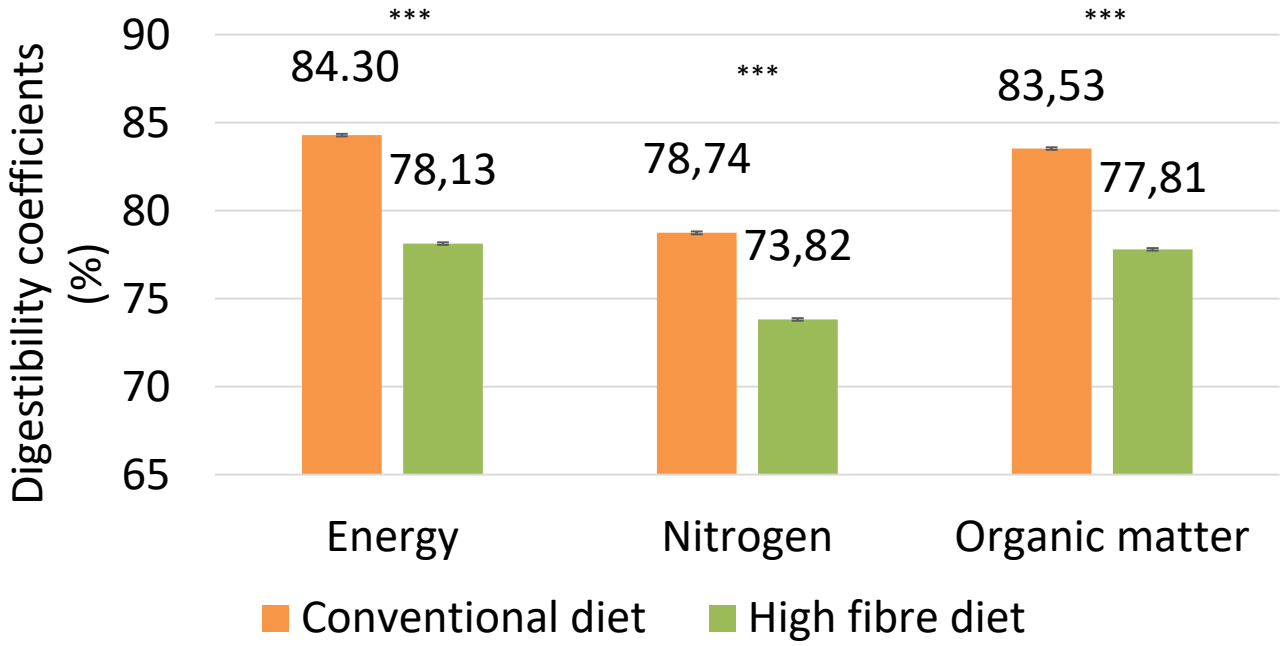


Daily Feed Intake (DFI) (MJ/day)

Comparison of LSMeans of digestibility coefficients between diets



Genetic model

Fixed effect

- Batch

Random effects

- Diet Pen Batch
- Genetic additive effects

$$h^2 = \frac{\text{Genetic variance}}{\text{Phenotypic variance}}$$

Heritability of digestibility coefficients

	Heritability – CO diet (standard error)	Heritability – HF diet (standard error)	Genetic correlations CO - FD (standard error)
DC Energy	0.38 (0.12)	0.54 (0.15)	0.76 (0.15)
DC Nitrogen	0.41 (0.12)	0.56 (0.15)	0.86 (0.16)
DC Organic Matter	0.40 (0.12)	0.54 (0.15)	0.79 (0.15)

- ▶ Heritability exists for digestibility coefficients, even for CO diet
- ▶ The proportion of genetic variance of digestive efficiency is higher with the fibre diet
- ▶ Digestibility coefficients measured in CO and HF diets are similar traits

Genetic correlations with traits of interest

Digestibility coefficients	Average Daily Gain	Daily Feed Intake	Feed Conversion Ratio
Energy	-0.53 (0.13)	-0.75 (0.10)	-0.39 (0.14)
Nitrogen	-0.52 (0.13)	-0.74 (0.10)	-0.50 (0.25)
Organic Matter	-0.42 (0.13)	-0.66 (0.10)	-0.43 (0.13)

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Unfavorable with Average Daily Gain

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Favorable with Daily Feed Intake and Feed Conversion Ratio

Genetic correlations with traits of interest

Digestibility coefficients	Lean Meat Percentage	Carcass Yield	Ultimate pH
Energy	0.19 (0.15)	-0.19 (0.17)	-0.40 (0.23)
Nitrogen	0.14 (0.14)	-0.20 (0.17)	-0.42 (0.22)
Organic Matter	0.18 (0.14)	-0.19 (0.17)	-0.38 (0.22)

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Slightly favorable with Lean Meat Percentage

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Unfavorable with ultimate pH

Conclusion and perspectives

Summary

- Brings a new piece of information: measure of digestibility of animals becomes possible
- A cheaper method: <20€ per sample (140€ with a chemical method)
- A heritable trait: interesting for breeding schemes
- Favorable genetic correlations with DFI, FCR and LMP
- Unfavorable genetic correlations with some traits: to take into account for defining breeding strategies

What's next?

- What is the correlated selection response of this trait following current selection?
- What is the contribution of intestinal microbiota to the variability of digestive efficiency?

Acknowledgments

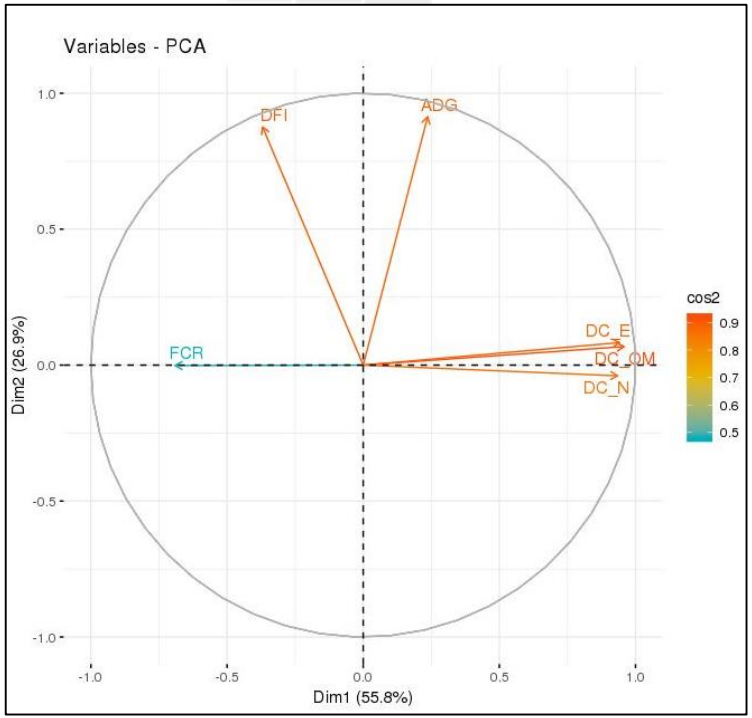
Thank you for your attention!

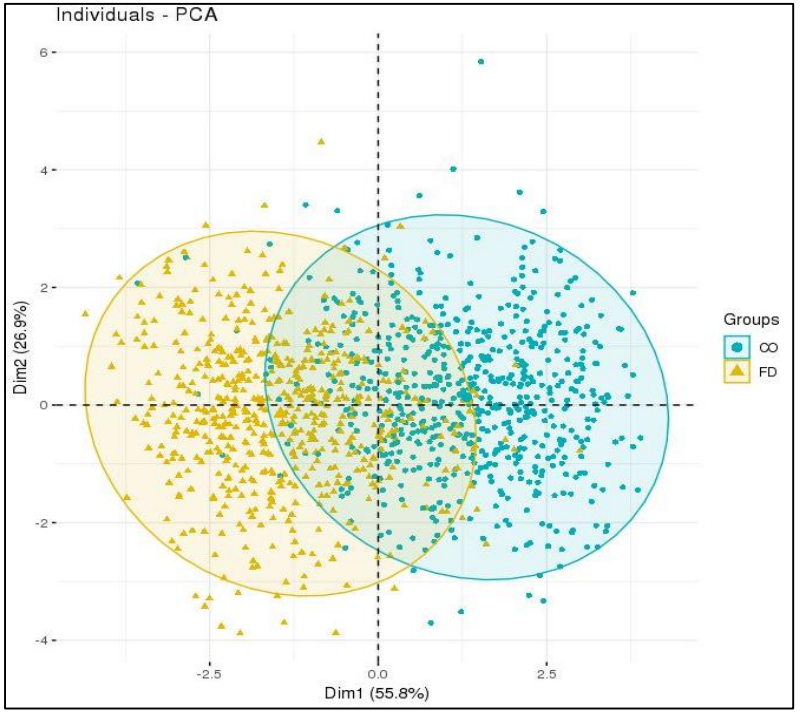
To the funding bodies: FGporc and H2020 Feed A Gene project.

To the phenotyping station staff in Le Rheu for animal raising and data recording.

To the UMR PEGASE (INRA, Rennes) staff for the determination of digestibility coefficients.

Appendix 1 – PCA of the three DC and traits of interest





Appendix 2 – Composition of diets

	Growing phase		Finishing phase	
Item	**CO diet**	**HF diet**	**CO diet**	**HF diet**
Wheat	42.10	38.00	45.10	39.30
Corn	25.00	0.00	25.00	0.00
Barley	10.00	16.90	10.00	17.60
Wheat bran	0.00	15.00	0.00	15.00
Rapeseed meal	6.00	6.00	10.00	9.90
Soybean hulls	0.00	8.00	0.00	8.00
Beet pulp	0.00	5.00	0.00	5.00
Sunflower meal	3.00	3.00	4.80	3.00
Soybean meal, 48% CP	10.4	5.40	2.50	0.00
Calcium carbonate	1.40	1.12	0.12	1.01
$_{L-}$Lys	0.44	0.35	0.11	0.31
$_{DL-}$Met	0.09	0.03	0.01	0.00
$_{L-}$Thr	0.13	0.11	0.02	0.10
pure valine	0.02	0.00	0.00	0.00
Dicalcium phosphate	0.49	0.29	0.05	0.00
NaCl	0.40	0.40	0.40	0.40
COV 0.5%	0.40	0.40	0.40	0.40
Total	100	100	100	100

Appendix 3 –LSmeans from the linear mixed models for pigs fed the CO or HF diets for growth and feed efficiency traits

	LSMeans ± standard error		
	CO diet	**HF diet**	**P-value**
ADG, g/day	1027±4	971±4	<0.0001
DFI, kg/day	2.56±0.08	2.72±0.09	<0.0001
DFI_J, MJ/day	24.11±0.75	22.30±0.81	<0.0001
FCR	2.52±0.01	2.78±0.01	<0.0001
FCR_J, MJ/kg	23.65±0.06	22.81±0.07	<0.0001

Appendix 4 –LSmeans from the linear mixed models for pigs fed the CO or HF diets carcass composition traits

	LSMeans ± standard error		
	CO diet	**HF diet**	**P-value**
Carcass Yield, %	78.75±0.05	77.60±0.06	<0.0001
Belly %, %	12.66±0.03	12.71±0.04	0.26
Loin %, %	28.33±0.04	28.82±0.04	<0.0001
Backfat %, %	7.48±0.03	6.54±0.04	<0.0001
Ham %, %	24.17±0.03	24.41±0.04	<0.0001
Shoulder %, %	23.82±0.03	23.84±0.03	0.62
Lean Meat %, %	58.36±0.10	59.72±0.11	<0.0001

Appendix 5 –LSmeans from the linear mixed models for pigs fed the CO or HF diets meat quality traits

	LSMeans ± standard error		
	CO diet	**HF diet**	**P-value**
upH	5.77±0.01	5.78±0.01	0.38
L color	48.01±0.18	47.71±0.19	0.11
a* color	8.31±0.13	8.08±0.13	0.02
b* color	9.00±0.05	8.75±0.08	0.008
MQI	0.22±0.01	0.42±0.01	0.11