Using leftovers to reduce the environmental impact of animal production

Hannah van Zanten - Animal Production Systems Group

H. Mollenhorst, P. Bikker, T. Vellinga, I.J.M. de Boer

WAGENINGEN UNIVERSITY
WAGENINGEN UR

Introduction

- Livestock sector ⟶ major impact on the environment
- Impact mainly from production and utilization of feed

- Impact reduced by feeding co-products to livestock

Up-grading waste

Feeding agricultural co-products, transforms inedible products for humans into edible products

Aim of PhD study

Exploring the potential of co-products to reduce environmental impacts in the livestock sector, accounting the alternative use of co-products

The production of a co-product is limited!

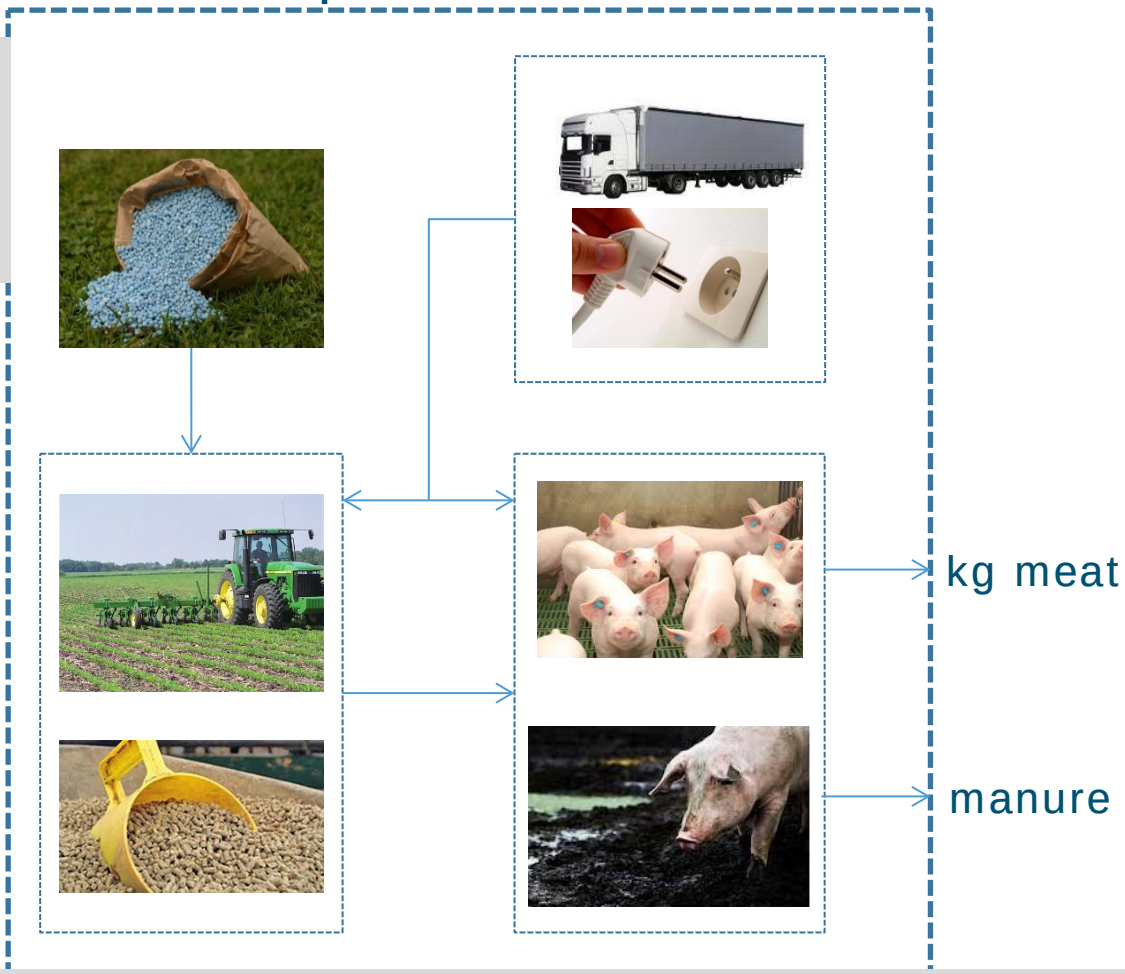
Replacing SBM by RSM in diets of pigs

- Co-product increasingly used ⟶ Rapeseed meal (RSM)
  - 5% of RSM in diets in 1994, 15% expected in 2013
  - increased production RS oil for biodiesel
- Replacing soybean meal (SBM) by RSM in diets of growing pigs
  - how does the diet composition change
  - environmental impact

Method: life cycle assessment

Evaluate the environmental impact of a product during the entire production chain

Attributional LCA
Consequential LCA



CO_2-eq / kg pork: $(1 \times CO_2 + 25 \times CH_4 + 298 \times N_2O)$ / kg pork

Diet composition

Replacing SBM by RSM

- Nutritional values differs:

	Crude protein g/kg	Net energy MJ/kg	Lysine g/kg
SMB	464	8.27	25.5
RSM	335	6.25	13.3

- SBM 15% and RSM 24% exchange, based on crude protein
- 4 scenarios ⟶ compensate loss in net energy and lysine in different ways

Scenarios

	Ingredient	NE MJ/kg	AID-LYS g/kg	Feed intake kg
Scenario 1	15% SBM	9.50	7.24	Ad libitum
Scenario 2	24% RSM	9.50	7.24	Ad libitum
Scenario 3	24% RSM	8.98	6.77	Ad libitum
Scenario 4	24% RSM	8.98	6.77	Ad libitum -6%

- To compose the diets
  - least cost optimisation (price 2012)
- Different growth performance
  - growth model (INRAporc)
- Scenarios applied from 50 kg onwards for growing pigs

	Scenario 1 9.5 NE, 7.24 AID LYS	Scenario 2 9.5 NE, 7.24 AID LYS
RSM		24.00
SBM	15.00	
Peas	9.36	10.00
Maize	30.00	30.00
Wheat	29.74	29.15
Wheat middlings	0.90	
Barley	**10.10**	
Sugarcane molasses	2.00	2.00
Phytase	0.65	0.65
Premix	0.40	0.40
Animal fat		2.24
Limestone	1.24	0.95
Salt	0.37	0.38
Monocalcium phosphate	0.11	0.21
L-Lysine	0.10	0.01
L-Tryptophane		0.01
L-Threonine		0.01
DL-Methionine	0.03	0.21

	Scenario 1 9.5 NE, 7.24 AID LYS	Scenario 2 9.5 NE, 7.24 AID LYS
RSM		24.00
SBM	15.00	
Peas	9.36	10.00
Maize	30.00	30.00
Wheat	29.74	29.15
Wheat middlings	0.90	
Barley	10.10	
Sugarcane molasses	2.00	2.00
Phytase	0.65	0.65
Premix	0.40	0.40
Animal fat		**2.24**
Limestone	1.24	0.95
Salt	0.37	0.38
Monocalcium phosphate	0.11	0.21
L-Lysine	0.10	0.01
L-Tryptophane		0.01
L-Threonine		0.01
DL-Methionine	0.03	0.21

	Scenario 1 9.5 NE, 7.24 AID LYS	Scenario 2 9.5 NE, 7.24 AID LYS
RSM		24.00
SBM	15.00	
Peas	9.36	10.00
Maize	30.00	30.00
Wheat	29.74	29.15
Wheat middlings	0.90	
Barley	10.10	
Sugarcane molasses	2.00	2.00
Phytase	0.65	0.65
Premix	0.40	0.40
Animal fat		2.24
Limestone	1.24	0.95
Salt	0.37	0.38
Monocalcium phosphate	0.11	0.21
L-Lysine	**0.10**	**0.01**
L-Tryptophane		**0.01**
L-Threonine		**0.01**
DL-Methionine	**0.03**	**0.21**

	Scenario 1 9.5 NE, 7.24 AID LYS	Scenario 2 9.5 NE, 7.24 AID LYS	Scenario 3+4 9.5 NE, 7.24 AID LYS
RSM		24.00	24.00
SBM	15.00		
Peas	**9.36**	**10.00**	**2.69**
Maize	30.00	30.00	30.00
Wheat	29.74	29.15	34.37
Wheat middlings	0.90		4.56
Barley	10.10		
Sugarcane molasses	2.00	2.00	2.00
Phytase	0.65	0.65	0.53
Premix	0.40	0.40	0.40
Animal fat		2.24	
Limestone	1.24	0.95	0.86
Salt	0.37	0.38	0.37
Monocalcium phosphate	0.11	0.21	0.22
L-Lysine	0.10	0.01	
L-Tryptophane		0.01	
L-Threonine		0.01	
DL-Methionine	0.03	0.21	0.22

	Scenario 1 9.5 NE, 7.24 AID LYS	Scenario 2 9.5 NE, 7.24 AID LYS	Scenario 3+4 9.5 NE, 7.24 AID LYS
RSM		24.00	24.00
SBM	15.00		
Peas	9.36	10.00	2.69
Maize	30.00	30.00	30.00
Wheat	29.74	29.15	34.37
Wheat middlings	**0.90**		**4.56**
Barley	10.10		
Sugarcane molasses	2.00	2.00	2.00
Phytase	0.65	0.65	0.53
Premix	0.40	0.40	0.40
Animal fat		2.24	
Limestone	1.24	0.95	0.86
Salt	0.37	0.38	0.37
Monocalcium phosphate	0.11	0.21	0.22
L-Lysine	0.10	0.01	
L-Tryptophane		0.01	
L-Threonine		0.01	
DL-Methionine	0.03	0.21	0.22

	Scenario 1 9.5 NE, 7.24 AID LYS	Scenario 2 9.5 NE, 7.24 AID LYS	Scenario 3+4 9.5 NE, 7.24 AID LYS
RSM		24.00	24.00
SBM	15.00		
Peas	9.36	10.00	2.69
Maize	30.00	30.00	30.00
Wheat	29.74	29.15	34.37
Wheat middlings	0.90		4.56
Barley	10.10		
Sugarcane molasses	2.00	2.00	2.00
Phytase	0.65	0.65	0.53
Premix	0.40	0.40	0.40
Animal fat		**2.24**	
Limestone	1.24	0.95	0.86
Salt	0.37	0.38	0.37
Monocalcium phosphate	0.11	0.21	0.22
L-Lysine	**0.10**	**0.01**	
L-Tryptophane		**0.01**	
L-Threonine		**0.01**	
DL-Methionine	**0.03**	**0.21**	**0.22**

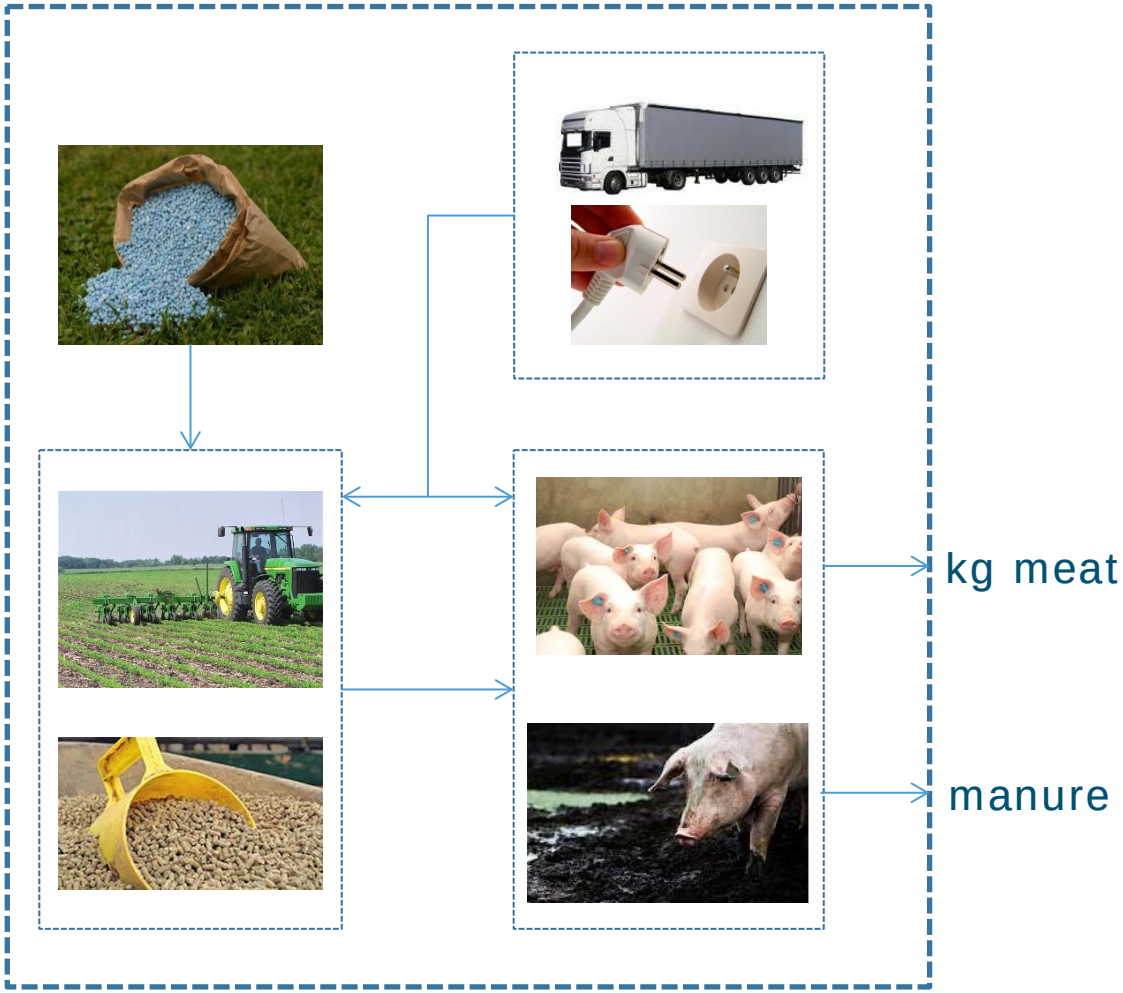
Growth performance

Based on Inraporc

	Scenario 1 SBM, 9.5 NE, 7.24 AID LYS	Scenario 2 RSM, 9.5 NE, 7.24 AID LYS	Scenario 3 RSM, 8.98 NE, 6.77 AID LYS	Scenario 4 RSM, 8.98 NE, 6.77 AID LYS
Final age (d)	180	180	180	180
Duration (d)	110	110	110	110
Total feed intake (kg)	223	220	236	223
Final protein mass (kg)	19.35	19.35	19.35	19.24
Final Lipid mass (kg)	19.12	19.20	19.12	17.00
Final body weight (kg)	117.28	117.34	117.28	115.23

Results: attributional LCA

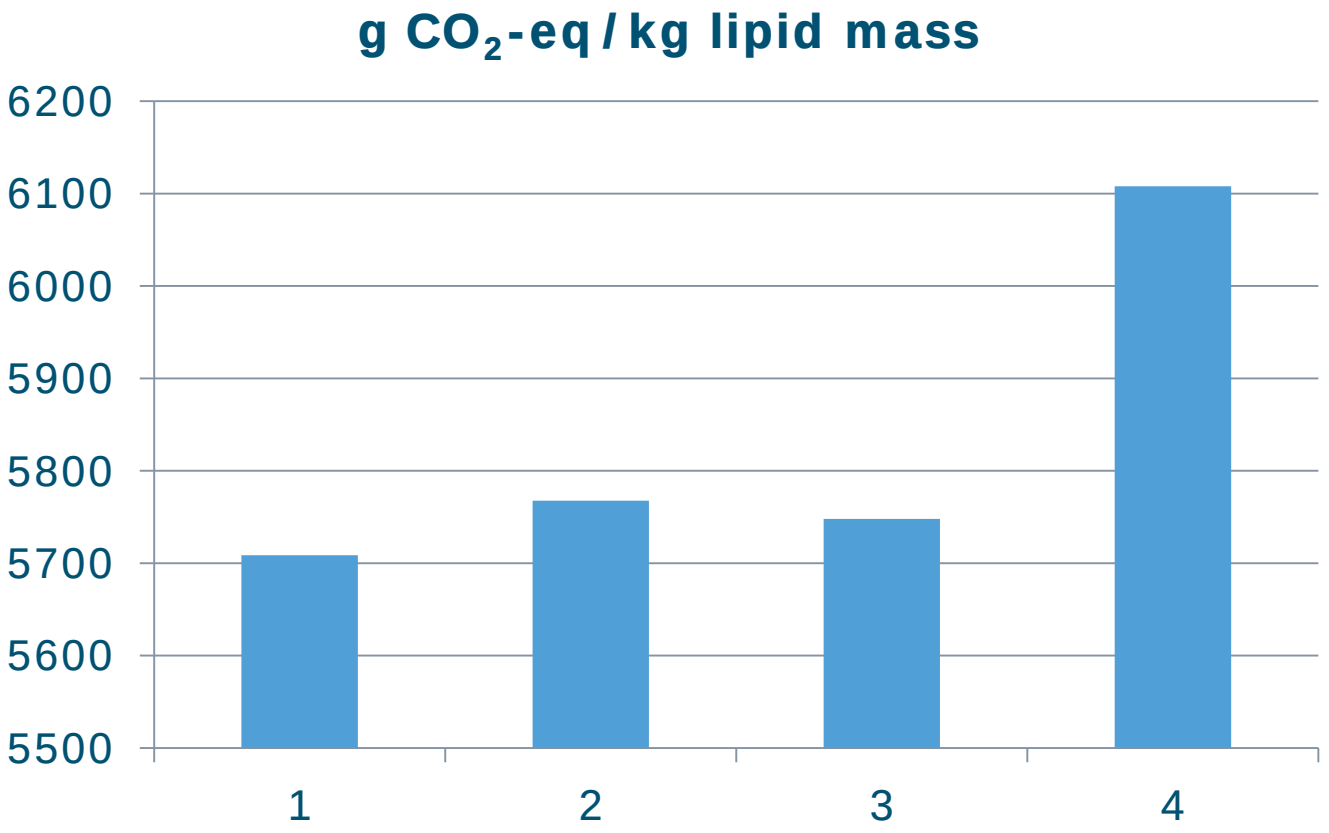
ALCA describes the proportion of the environmental impact related to kg of pork ⟶ status quo



Based on Dolman et al. 2012

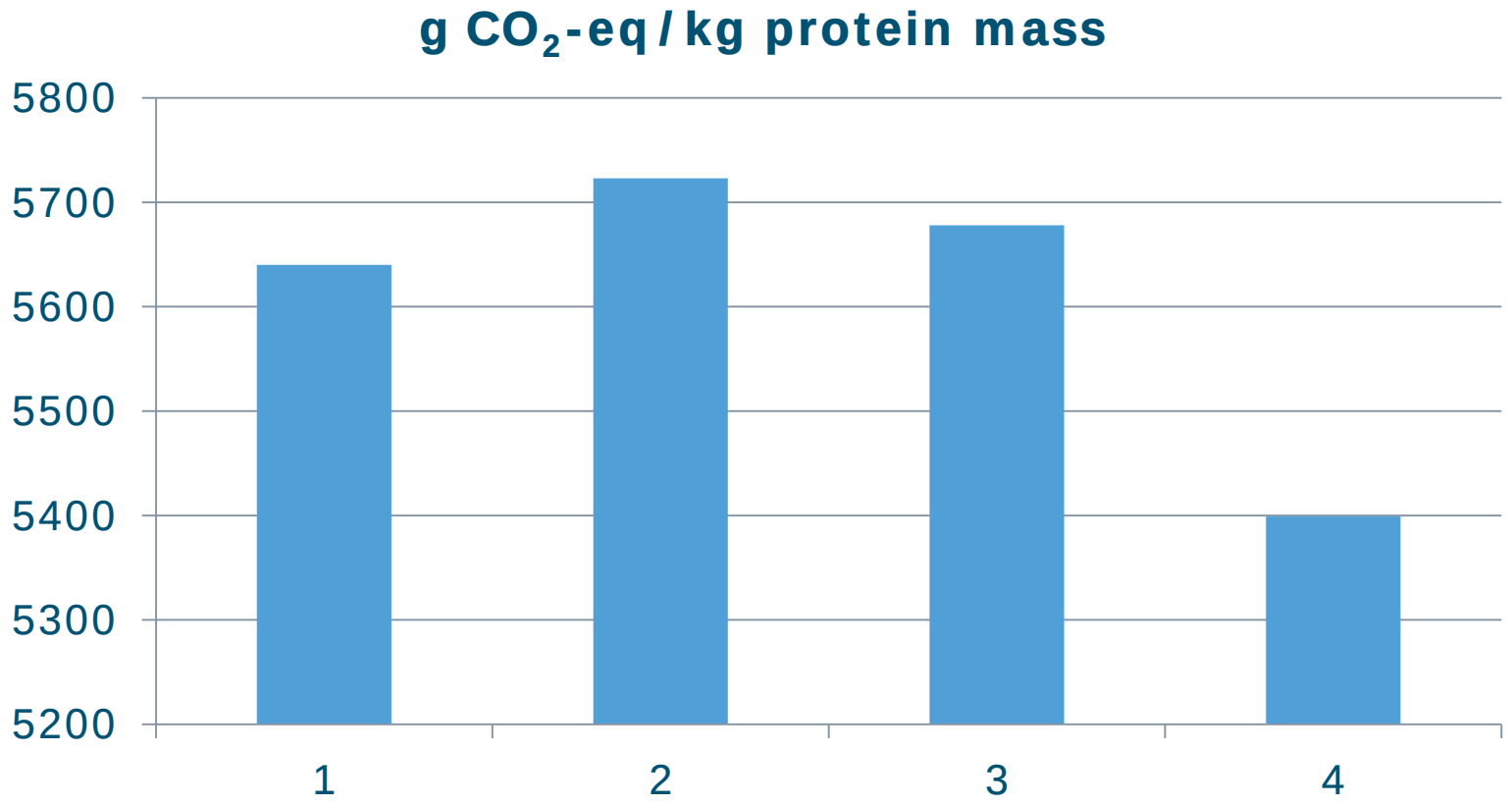
Results (ALCA)

Global warming impact per kg lipid mass



Results (ALCA)

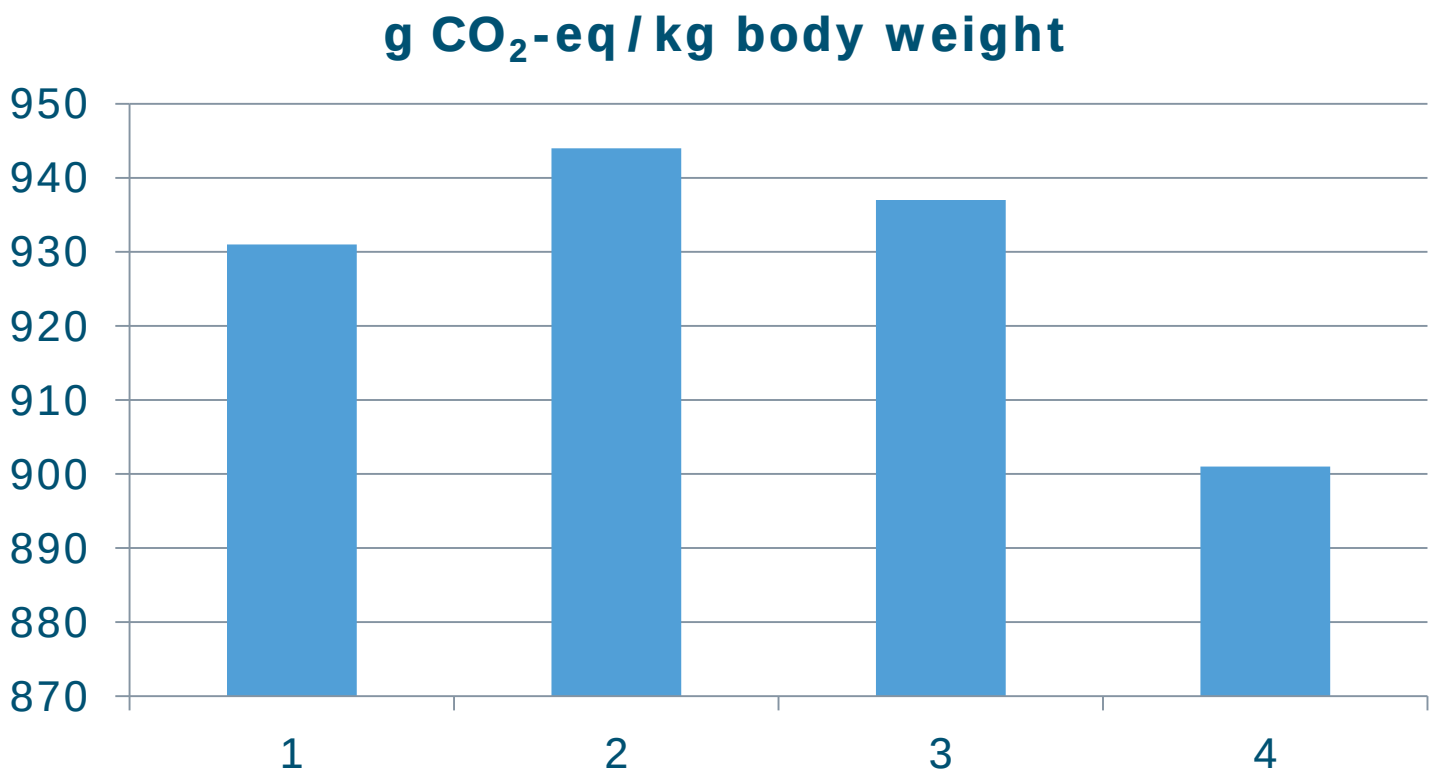
Global warming impact per kg protein



WAGENINGEN UNIVERSITY
WAGENINGEN UR

Results (ALCA)

Global warming impact per kg body weight

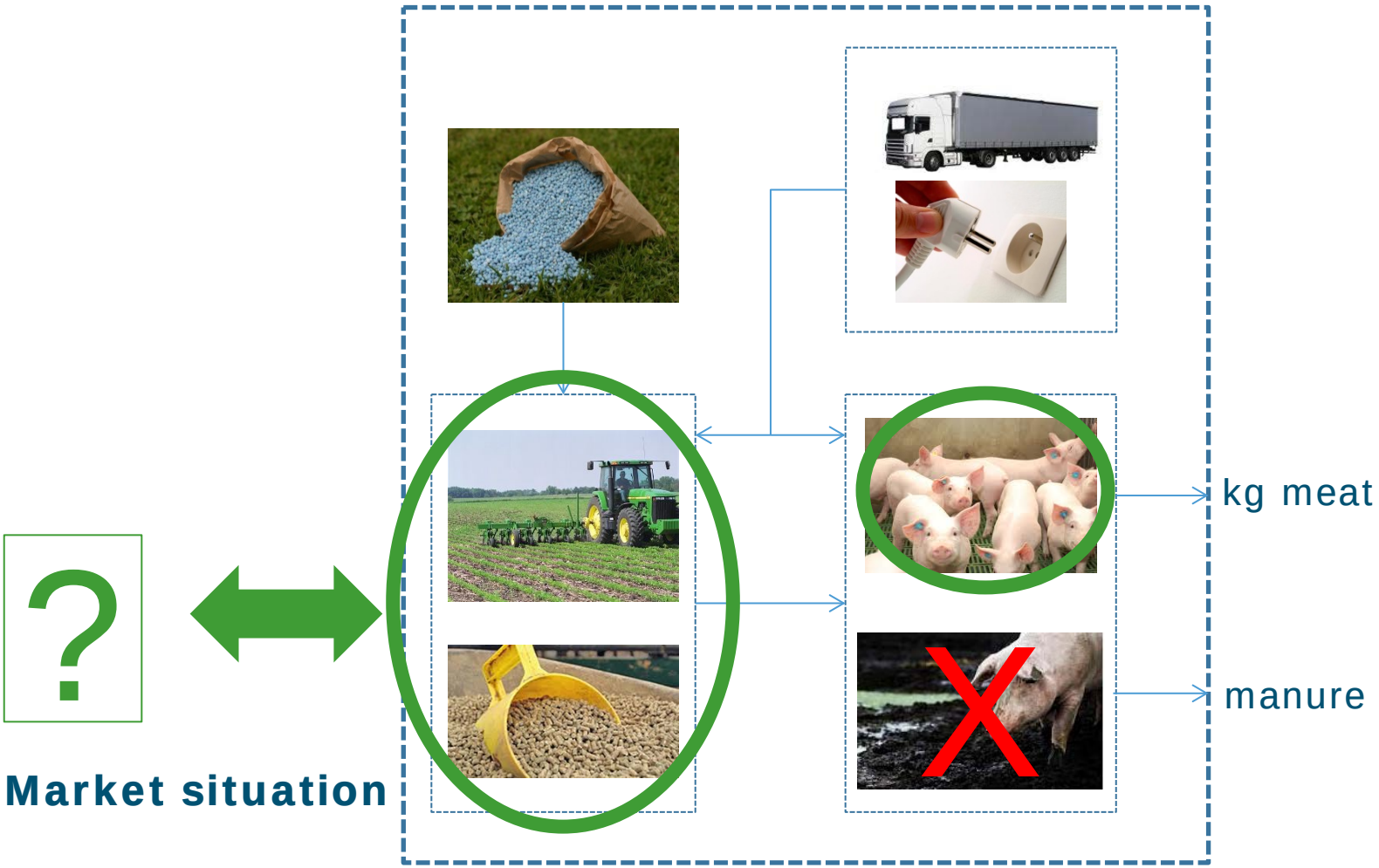


Reducing growth, potential for environment!

Results: consequential LCA

Consequential LCA describes the change in environmental impact as a consequence of a certain activity

Consequences of shifting from scenario 1 to 2



Based on Dolman et al. 2012

Consequential LCA

change in diet composition

	Scenario 1	Scenario 2	Difference
RSM		24.00	24.00
SBM	15.00		-15.00
Peas	9.36	10.00	0.64
Maize	30.00	30.00	0.00
Wheat	29.74	29.15	-0.59
Wheat middlings	0.90		-0.90
Barley	10.10		-10.1
Sugarcane molasse	2.00	2.00	0.00

Soybean meal CLCA

693 kg/CO_2-eq per ton SBM

Soybean meal CLCA

693 kg/CO_2-eq per ton SBM

217 kg oil per ton SBM

Soybean meal CLCA

693 kg/CO_2-eq per ton SBM

-825 kg/CO_2-eq per 15%

217 kg oil per ton SBM

4050 kg/CO_2-eq per 15%

Soybean meal CLCA

693 kg/CO_2-eq per ton SBM

-825 kg/CO_2-eq per 15%

217 kg oil per ton SBM

4050 kg/CO_2-eq per 15%

Consequential LCA

change in diet composition

	Scenario 1	Scenario 2	Difference	CO_2-eq
RSM		24.00	24.00	
SBM	15.00		-15.00	-825
Peas	9.36	10.00	0.64	
Maize	30.00	30.00	0.00	
Wheat	29.74	29.15	-0.59	
Wheat middlings	0.90		-0.90	
Barley	10.10		-10.10	
Sugarcane molasse	2.00	2.00	0.00	

Consequential LCA

change in diet composition

	Scenario 1	Scenario 2	Difference	CO_2-eq
RSM		24.00	24.00	
SBM	15.00		-15.00	4050
Peas	9.36	10.00	0.64	
Maize	30.00	30.00	0.00	
Wheat	29.74	29.15	-0.59	
Wheat middlings	0.90		-0.90	
Barley	10.10		-10.10	
Sugarcane molasse	2.00	2.00	0.00	

Assumption impact on results
CLCA difficult to apply for complete diets

Future

- Potential of innovative waste streams?
  - Insects fed on waste

- Which leftover for which animal, special idea's?

Thank your for your attention!

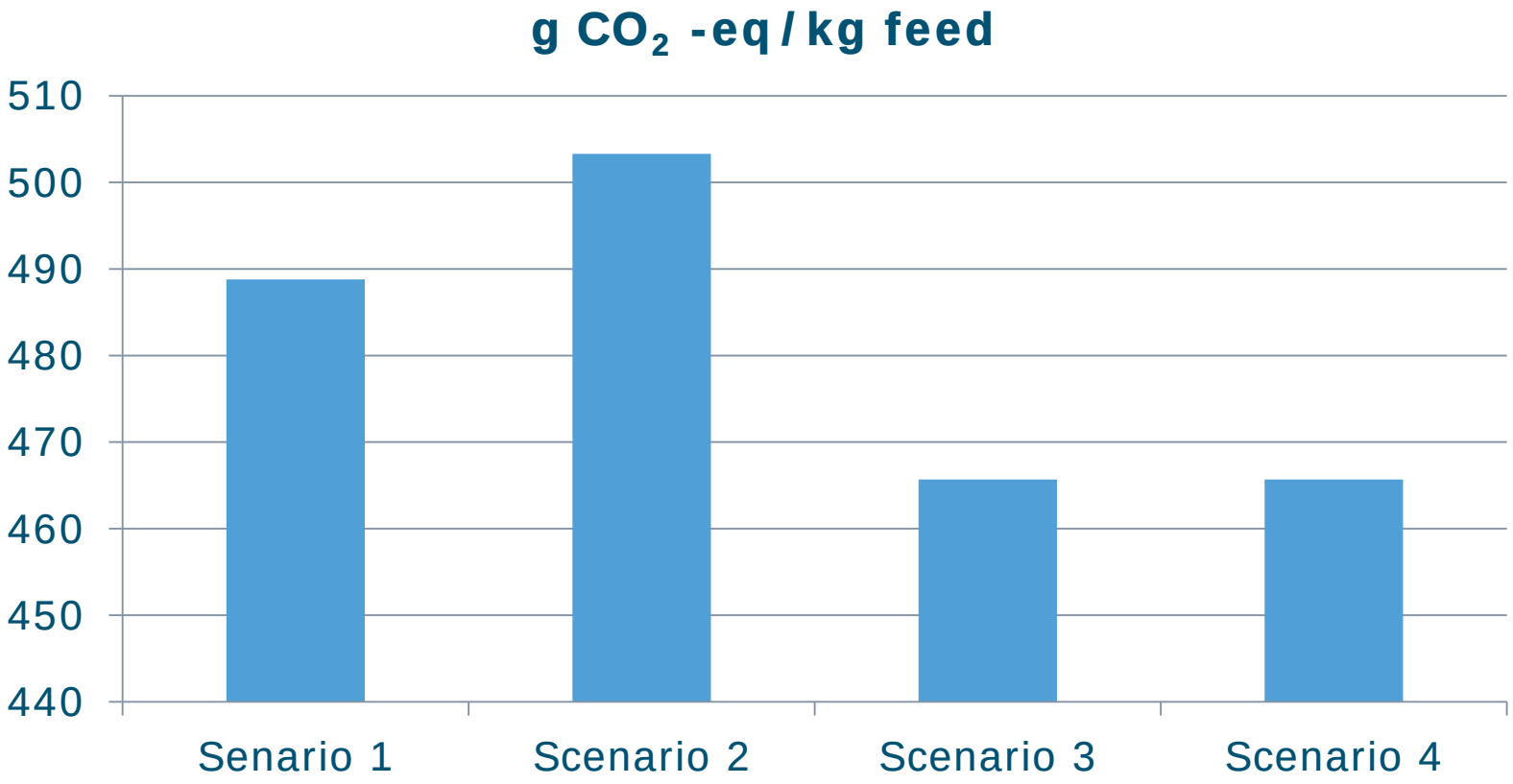
Future

- Potential of innovative waste streams?
  - Insects fed on waste

- Which leftover for which animal, special idea's?

Results (ALCA)

Global warming impact of diet composition



Van der Werf et al. 2005, between 472 and 792 g CO_2-eq per kg feed finishing pigs

Exchange SBM and RSM crude protein

- Based on Dutch Central Bureau (CVB) for Livestock feeding
- Scenario SBM CF<45 CP<480 : (-0.15*464) + (0.09*104) = 79
- Scenario rapeseed extruded CP <380: 0.24*335=80

	Crude protein g / kg
SMB	464
RSM	335
Barley	104

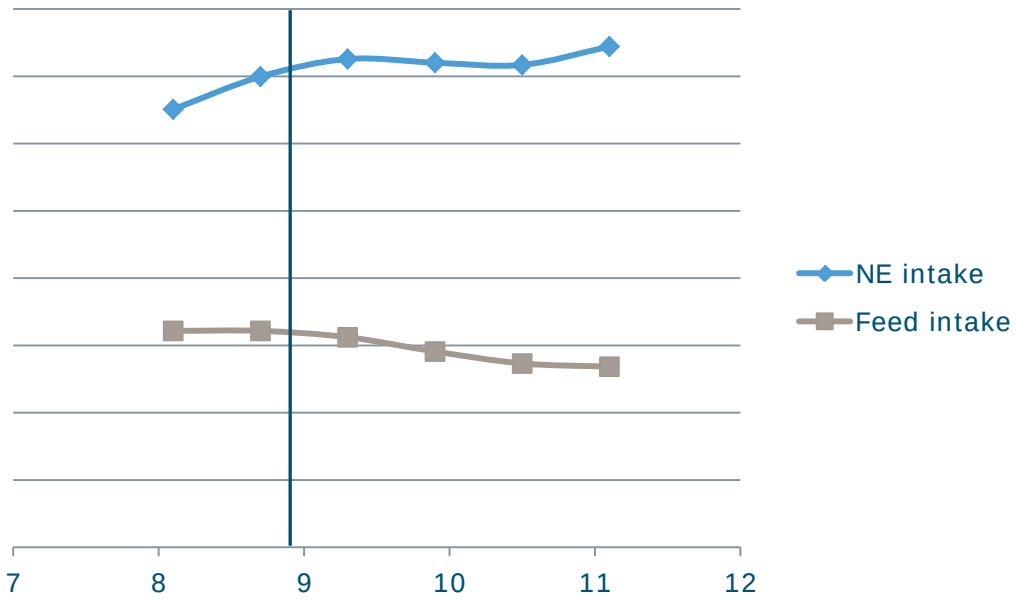
Why reduction to 8.98 NE and 6.7 AID LYS

- Based on Dutch Central Bureau for Livestock feeding
- Based on EW: 1 EW = 8.8 net energy
- Scenario SBM CF<45 CP<480 : (-0.15*0.94) + (0.09*1.05) = 0.2355 EW
- Scenario rapeseed extruded CP <380: 0.24*0.71=0.1704
- Difference= 0.07 EW ⟶ 1.08-0.07= 1.01 EW
- AID-LYS= 6.7 per 1 EW
  - 1.08 EW * 6.7= 7.24
  - 1.01 EW * 6.7= 6.77

	Net energy MJ/kg	Lysine g/kg
SMB	8.27	25.5
RSM	6.25	13.3
Barley	9.24	2.5

Pigs capable of increasing feed intake?

- Based on N. Quiniou and J. Noblet 2012
- Netto energy concentration, MJ/kg



From apparent lysine to standard lysine

- Apparent lysine: Dutch Central Bureau for Livestock feeding and Bestmix
- Standard lysine: Inraporc
- Conversion based on Jansman et al. 2002
- Lys=0.4, met=0.11, cys=0.21, thr=0.61, trp=0.14
- DM content feed 880g/kg

Scenario 1 SBM		
	AID LYS	SID LYS
dlys	7.24	7.59
dmC	4.43	4.93
dthr	4.32	4.88
dtrp	1.30	1.55
Scenario 2 RSM		
dlys	7.24	7.59
dmC	4.43	5.27
dthr	4.32	4.88
dtrp	1.30	1.49
Scenario 3 RSM		
dlys	6.77	7.12
dmC	4.14	5.29
dthr	4.04	4.9
dtrp	1.21	1.42

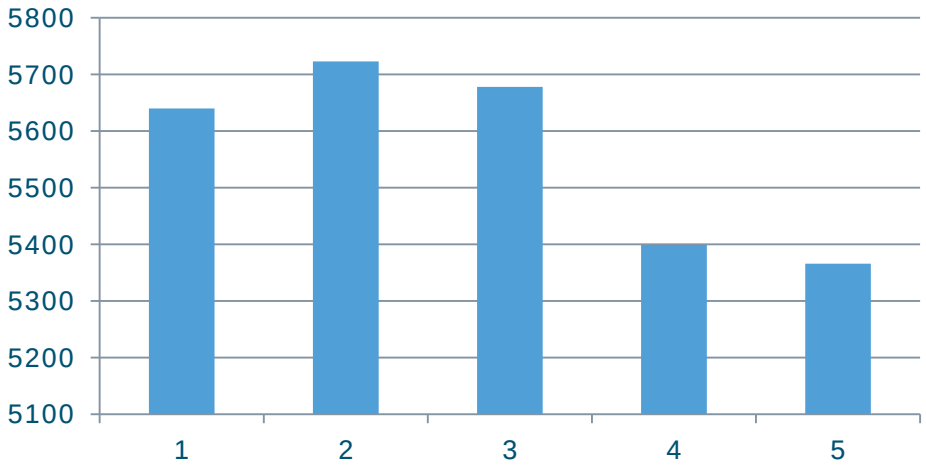
Restrictions

	Restriction
Peas	<10.00
Maize	<30.00
Wheat	<40.00
Sugarcane molasses SUG>475	2.00
Phytase 2 m2346 max 0,45%	<0.45
Premix:Mervit starter 2220	>0.40
Phytase 1 m 2346 max 0,2%	<0.20

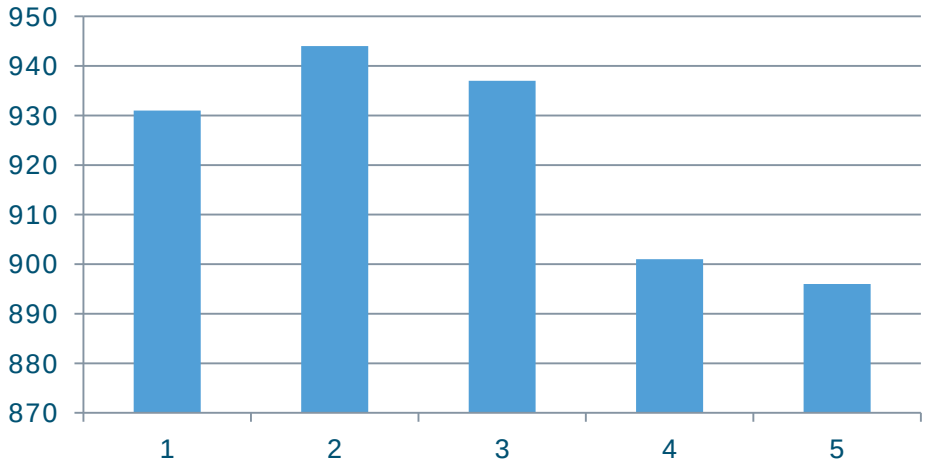
Results reduced feed intake scenario 1

form 223 to 211 kg

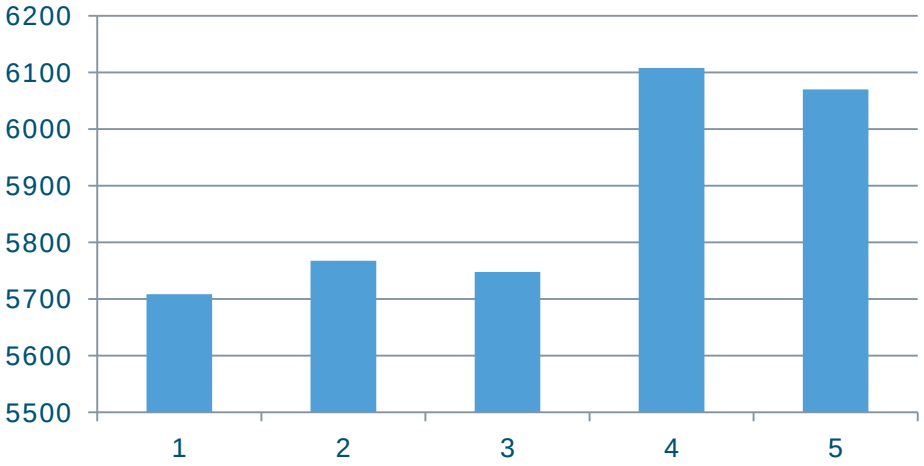
g CO_2-eq / kg protein mass



g CO_2-eq / kg body weight



g CO_2-eq / kg lipid mass



- Phytase 1 en 2: enzyme for improvement of digestibility of namely phosphate, calcium, and amino acids, magnesium and zinc.
- Mervit startvoer: premix, contains all types of vitamins.

Exchange SBM oil by RS oil or palm oil

- 1 ton SBM
  - = 1.146 ton soybeans
  - = 217 kg oil
- 1 ton RS
  - = 400 kg oil / 0.54 ton RS*1181co_2=638

    638-693=55 co_2-eq*-15%=**-825**co_2-eq
- 1 ton palm
  - 200 kg oil / 1.09 palm*884co_2=963

    963-693=-270 co_2-eq*-15%=**4050**co_2-eq