Increase of animal welfare by the use of rye in modern pig feeding

Dr. Richard Grone| Global Product Management Feed

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KWS

Pig production – current challenges

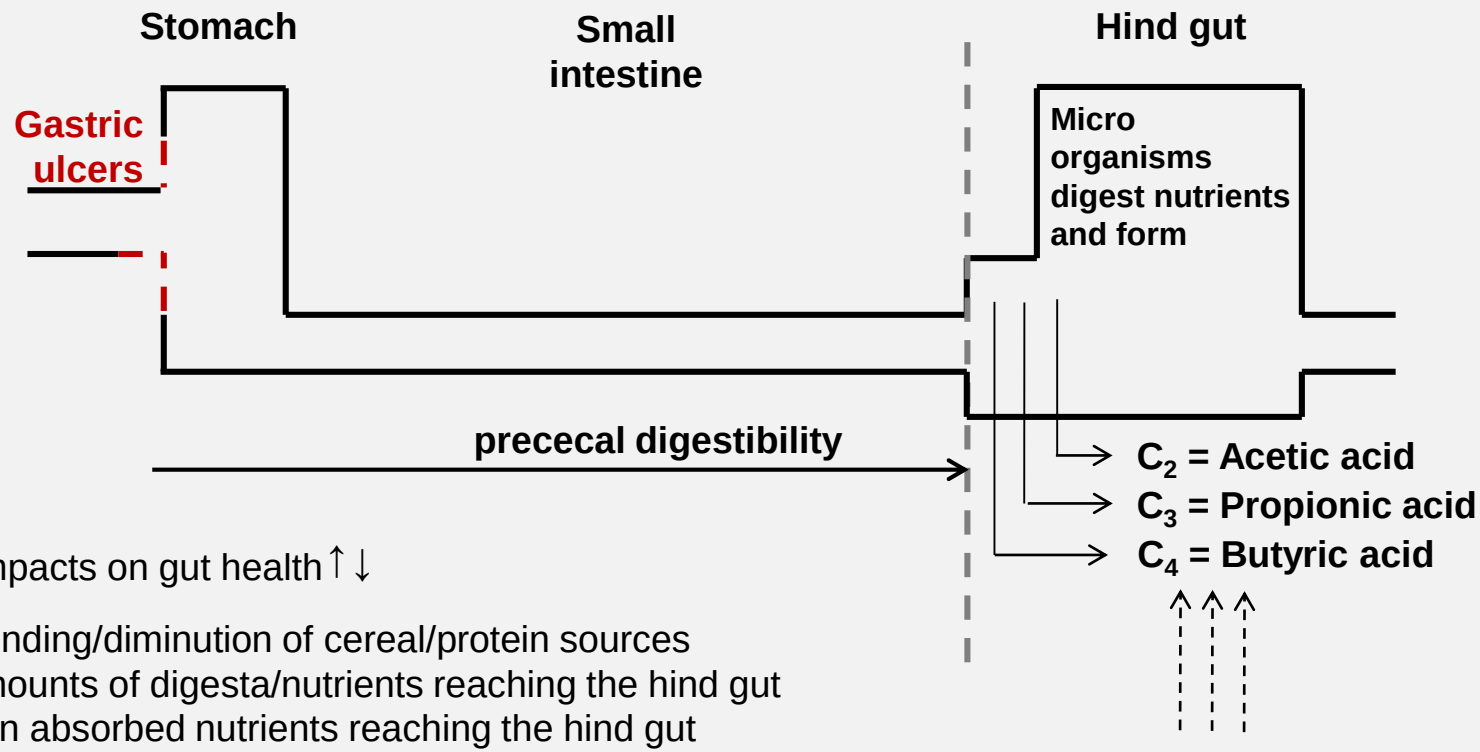
- Bureaucracy
- Castration without anesthesia
- New EU regulations regarding tail cutting
- Future housing conditions for sows
- Salmonella
- African swine fever

The long-term agricultural perspective

- Ban of chemical active ingredients
- New fertilizer regulations
- Animal welfare
- Restricted use of water
- New emissions regulation
- Bees/insects protection
- Biodiversity

Background of feeding for animal welfare – the view of veterinarian science

The alimentary tract of pigs – a model



Main impacts on gut health ↑↓

1. Grinding/diminution of cereal/protein sources
2. Amounts of digesta/nutrients reaching the hind gut
3. Non absorbed nutrients reaching the hind gut
   - Cellulose, pectin →
   - Starch →
   - Inulin, Polyfructans, Arabinoxylans →

Acetic acid (C_2) ↑
Propionic acid (C_3) + Butyric acid ↑
Butyric acid (C_4) ↑↑

Source: University of Veterinary Medicine Hanover, Foundation, 2019

Is there a special need for high butyric acid levels in pig‘s digesta?

Favoring gut health due to „trophic effects“ regarding the mucosa

lifetime, renewing, regeneration, maturation

improved health/reduced amounts of antibiotics

Lowering the „boar taint“ prevalence in fattening boars

polyfructanes (inulin) highest efficacy against „boar taint“

rate of condemnation of carcasses due to sensorial deviations

Reducing salmonella prevalence at individuals/herd level

at high butyric acid levels: down regulation of invasion genes in salmonella

improved food safety and favored consumers‘ protection

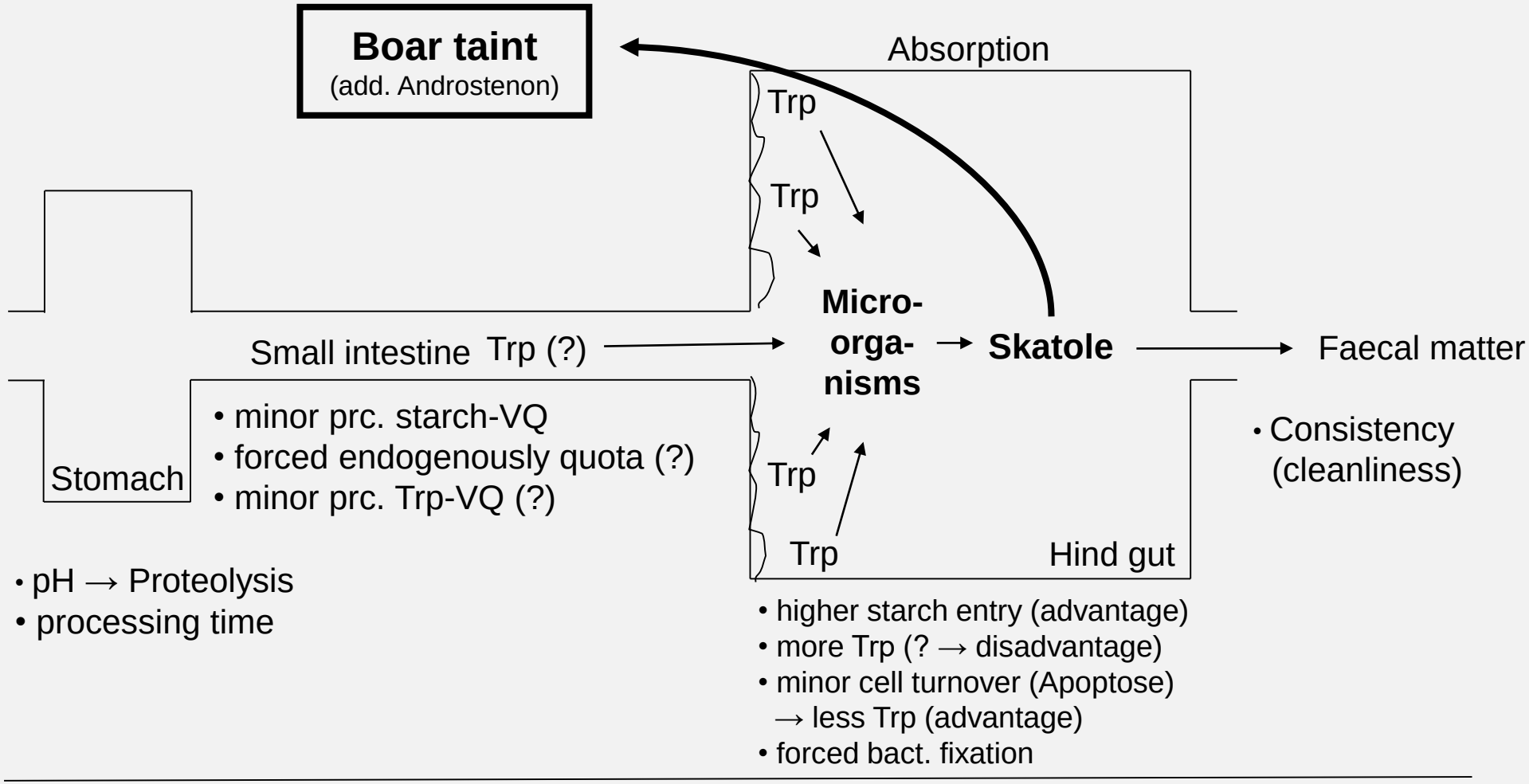
Fostering the feeling of satiety/avoiding behavioral disorders

mass of digesta, more continuous serum levels of glucose/insulin

improved animal welfare/wellbeing/image of pork production

Source: University of Veterinary Medicine Hanover, Foundation, 2019

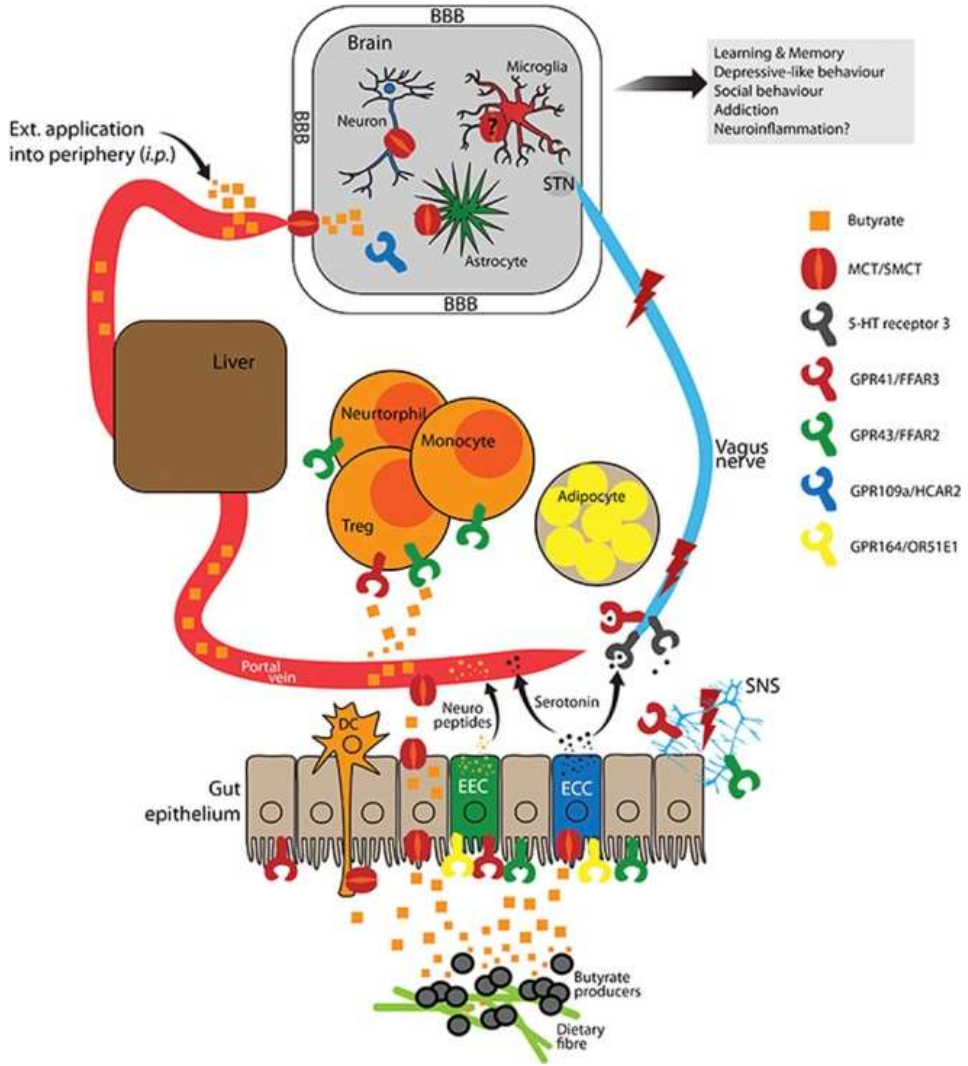
Boar taint



[1)] hypotheses deduced from analysis for the use of **row potato starch/inulin**
(Claus et al. 2003, Lösel a. Claus 2005, Zamaratskaia et al. 2005, Chen et al. 2007, Rideout et al. 2004, Hansen et al. 2006)

Source: Kamphues and Betscher 2011, University of Veterinary Medicine Hanover, Foundation

Schematic summary of butyrate effects on host physiology and brain function



- Learning & Memory
- Depressive-like behaviour
- Social behaviour
- Addiction
- Neuroinflammation?

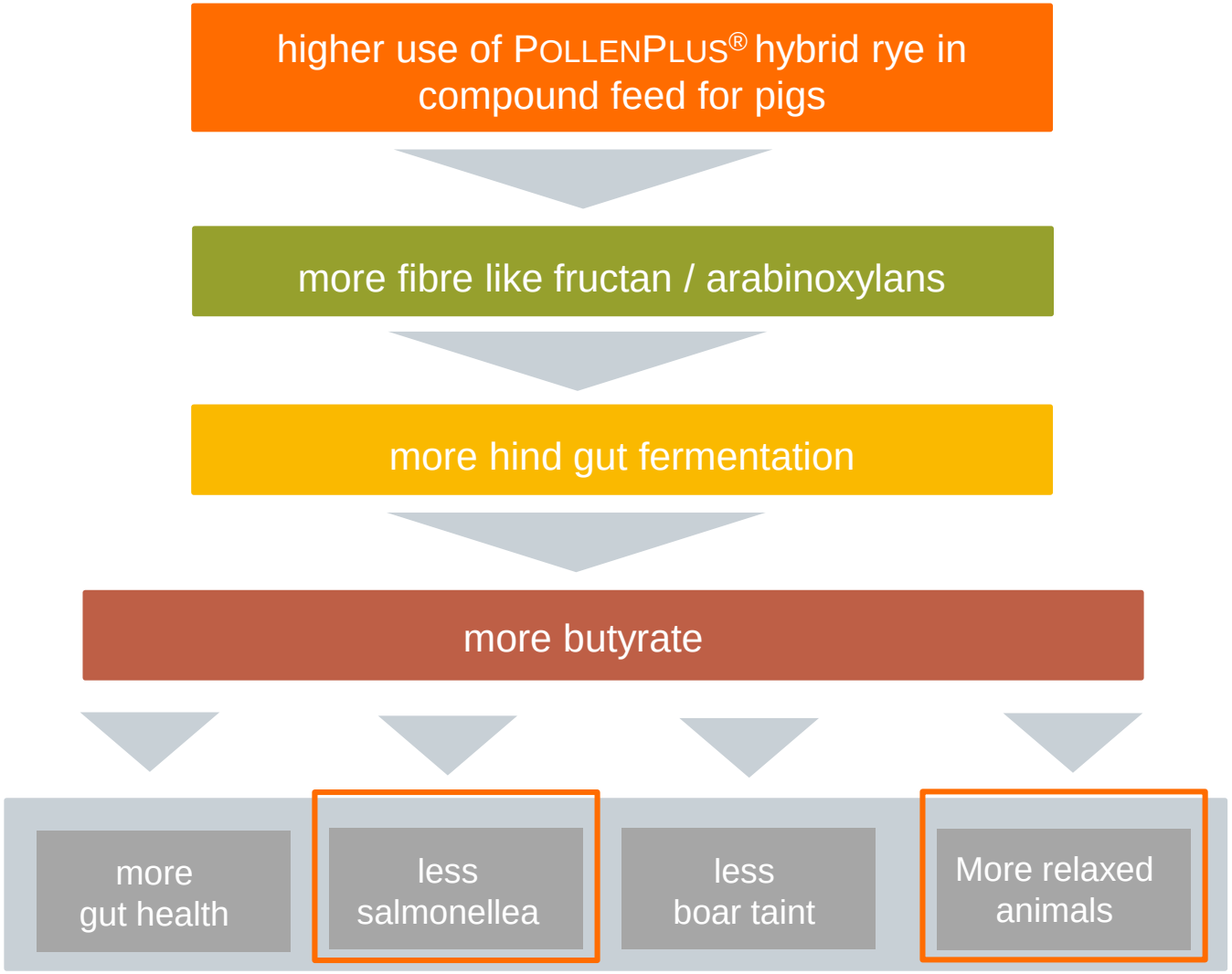
Key:
STN: Solitary tract nucleus
BBB: Blood brain barrier
SNS: Sympathetic nervous system
EEC: Enteroendocrine cell
ECC: Enterochromaffin cell
DC: Dendritic cell
Treg: T-regulatory cell

Source: University of Veterinary Medicine Hanover, Foundation, 2019

Objective

- Forced butyrate formation directly where it is needed
  → in the large intestine

Higher animal welfare due to rye feeding



In animal nutrition butyrate shows a wide range of positive characteristics.

Butyrate formation potential
(RODEHUTSCORD et al. 2016)

Cereal	Rye	Barley	Wheat	Triticale
Sum of butyrate formating substances in g/kg TS	60.0	15.7	23.7	18.3

Highest fructan and soluble arabinoxylan levels: Rye
Factor: 2.5 - approx. 4.0

Butyrate formation of rye in vitro: factor 2.4 times more than in wheat (HARTUNG 2019)

Trial description and results of the field study in Germany

Key parameters

- 14 pig farmers of Viehvermarktung Walsrode e.G.
- 12,761 fattening places (67.119 pigs), 8 farms with boars (46,061 boars)
- Different feeding systems
- Boars, Sows und castrated male pigs
- PIC-, Victoria-, DAN- * PI
- Data: Performance data, feed data, carcass data

Feeding concept

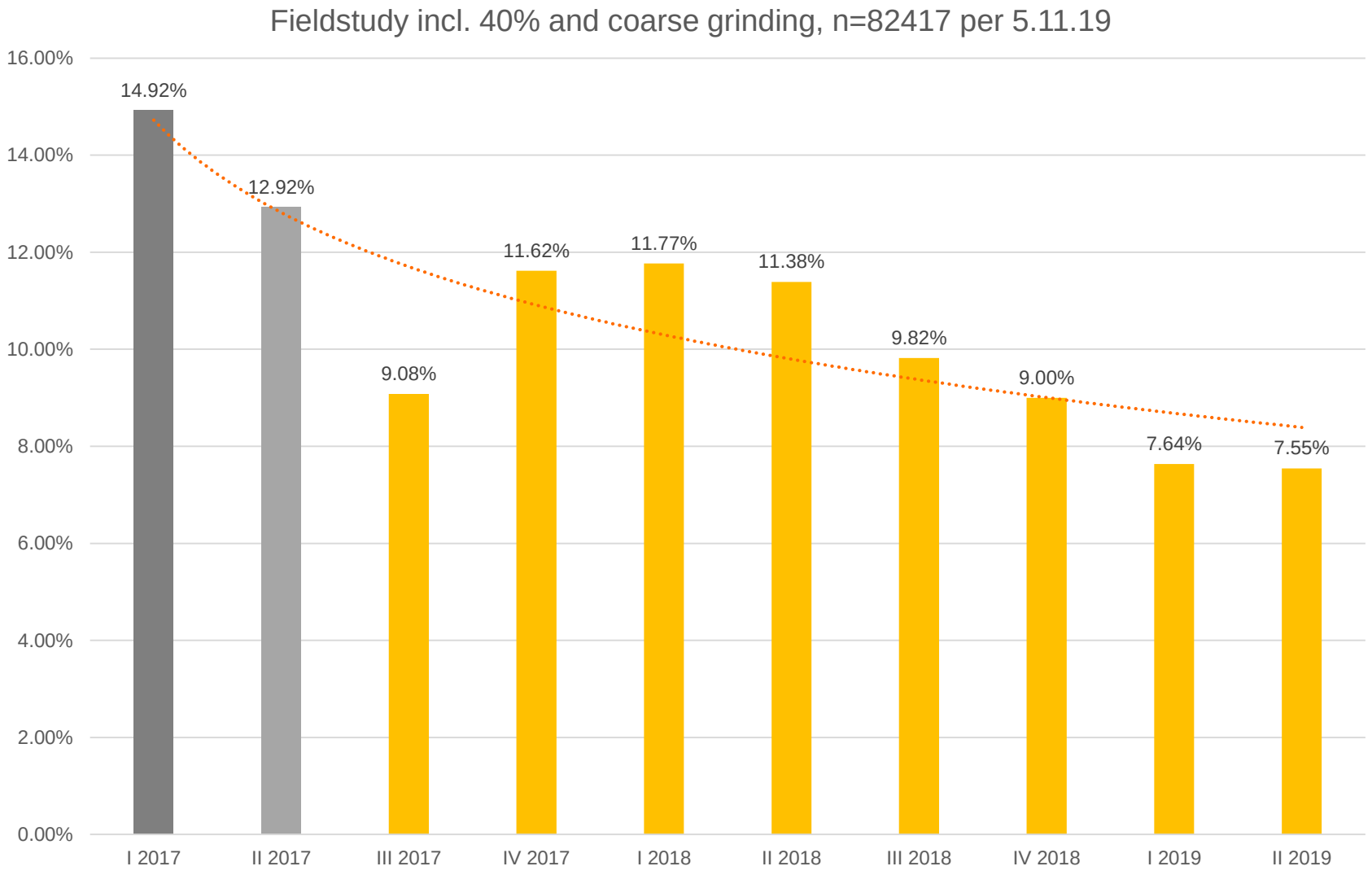
- Coarse grinding (max. 20% < 0,25 mm)
- 40% Rye + 25% Barley in the finisher diet III > 80 kg life weight (5% I; 20% II)
- Relation of lysin/energy min. 0,75 in the finisher phase

Overview about boar taint deviators, n=46,061 boars

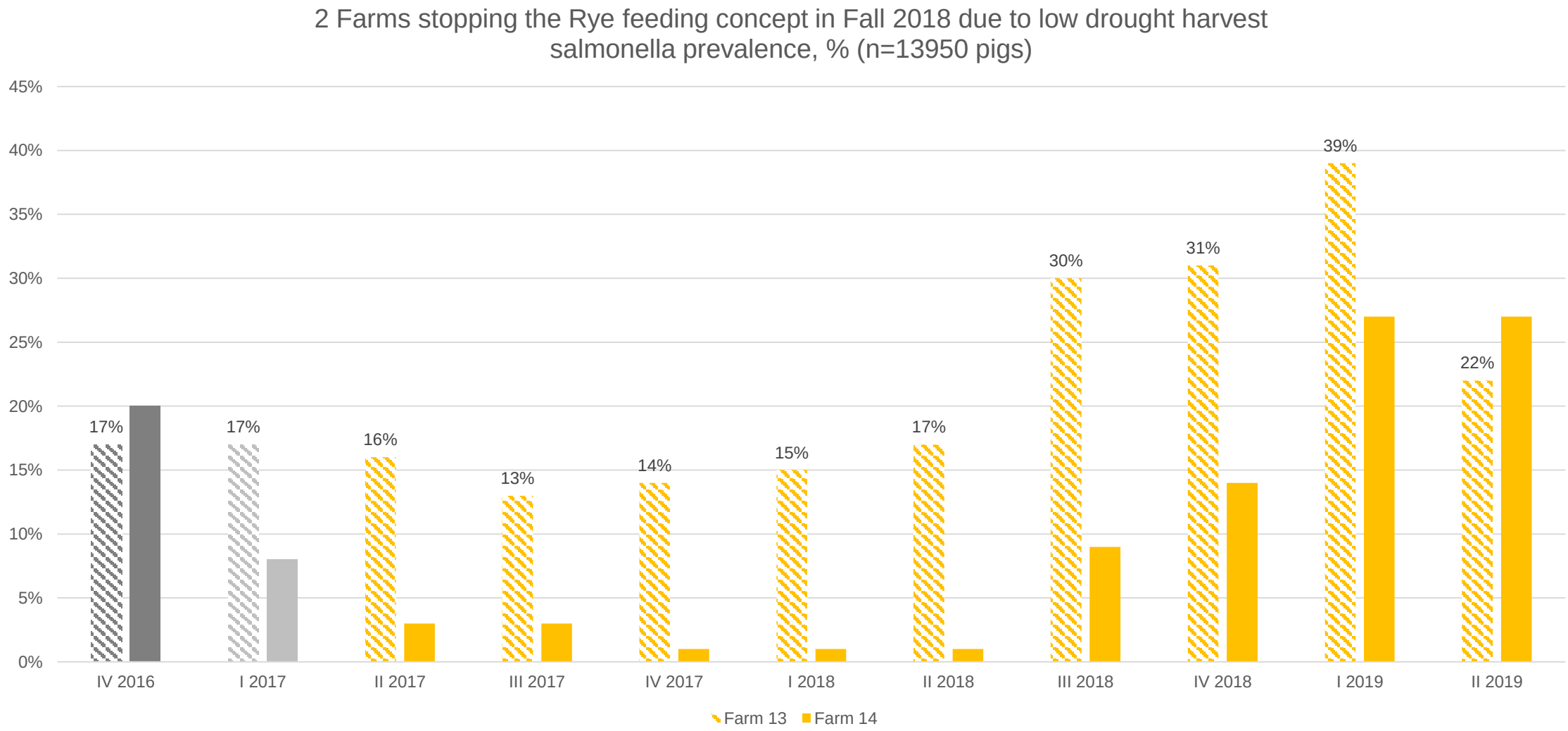
8 out of 9 farms are without stinkers since 1 year

Farm	1	2	3	4	5	6	7	8	9	Total
II 2017	887	1.464	700	804	960	699	225	1.638	1.968	9.345
Boar taint deviators 2nd quarter	228	25	54	0	155	0	0	123	0	585
III 2017	893	1.466	700	800	960	700	220	1.650	1.900	9.289
Boar taint deviators 3rd quarter	0	0	0	0	0	0	5	0	0	5
IV 2017	893	1.466	700	800	960	700	220	1.650	1.900	9.289
Boar taint deviators 4th quarter	0	0	0	0	0	0	93	0	0	93
I 2018	893	1.466	700	800	960	700		1.650	1.900	9.069
Boar taint deviators 1st quarter	0	0	0	0	0	0		0	0	0
II 2018	893	1.466	700	800	960	700		1.650	1.900	9.069
Boar taint deviators 2nd quarter	0	0	0	0	0	0		0	0	0

~50% Salmonella reduction over the whole testing period!



What happens, when you stop Rye feeding? Done by quart III 2018



Evaluation until quarter II 2018: 14 farms with 12,761 fattening places offer in total 67,119 pigs

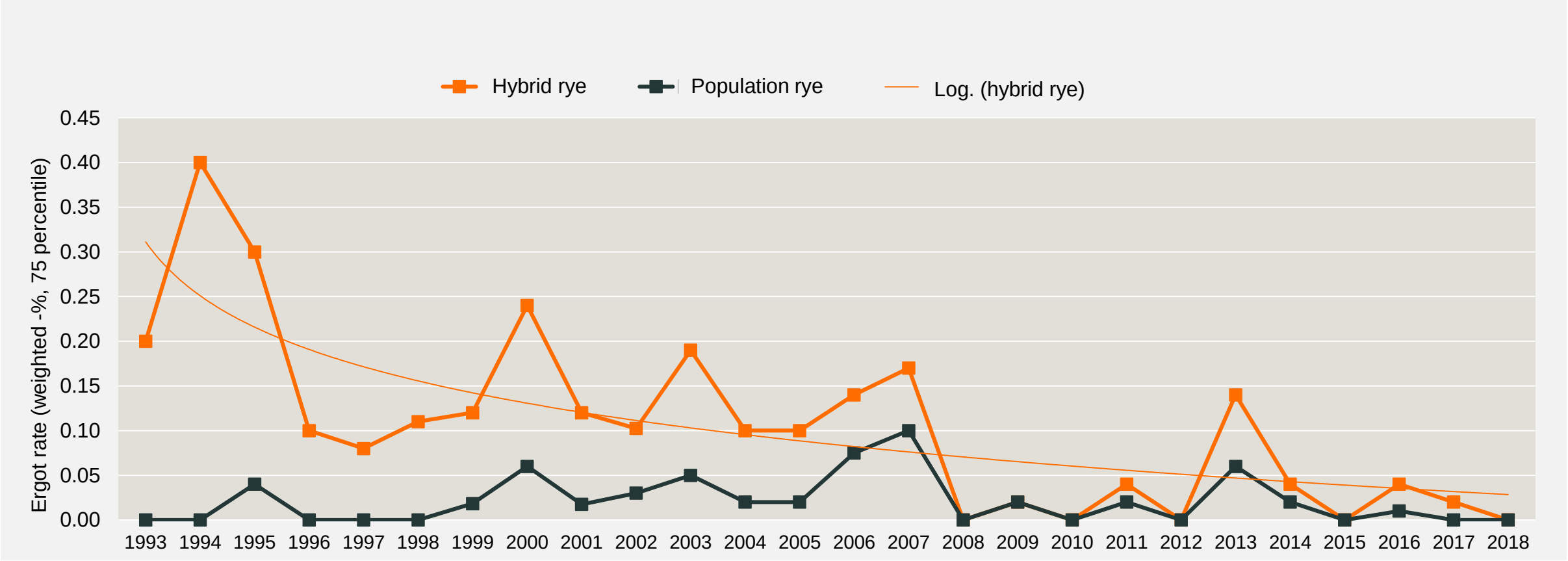
Results by individual housing conditions and given feeding concept:

- Salmonella reduction
- Reduction or avoidance of boar taint deviators
- At the same time good performance (notable > 800g daily increase in weight),
  on some farms 1,000g daily increase in weight

Reduced mortality rates

The field study has been finished in summer 2019.

Development of the ergot problems since 1993



Source: MRI Besondere Ernteermittlung 1993-2018, Populationsroggen und Hybridroggen

Good reasons for the renaissance of rye

Highest efficiency regarding the utilization of water, nitrogen, phosphorus

Less crude fiber but highest dietary fiber contents

Highest stimulating of butyrate production in the digestive tract

- nutrient for the gut mucous membrane
- reducing Salmonella prevalence
- lowering risk of boar taint
- enabling well being
- natural prebiotic function

Highest native phytase activity

Source: University of Veterinary Medicine Hanover, Foundation, 2019

Background:
Current recommendations for upper levels of rye in swine diets (DLG 2006)

Sows

25 %

Piglets

10 %
< 15 kg BW

20 %
> 15 kg BW

Fattening pigs

30 %
28-40 kg BW
(pre fattening)

40 %
40-60 kg BW
(starter)

50 %
60-90 kg BW
(grower)

50 %
> 90 kg BW (finisher)

Source: University of Veterinary Medicine Hanover, Foundation, 2019

Experimental feeding trials

- 20 boxes – individual housing trial experimental design

- ad libitum feeding / pellets

1.1
- **Wheat vs. Rye**
- Age: **52 ± 2,22** days; BW: **19,5 ± 3,07** kg
- 20 piglets

1.2
- **Wheat vs. Rye**
- Age: **42 ± 0,410 d**ays; BW: **12,7 ± 1,21** kg
- 20 piglets

2.1
- **60 % Rye – Soya vs. Rape seeds**
- Age: **47 ± 0,489** days; KM: **15,1 ± 1,57** kg
- 20 piglets

2.2
- **60 % Rye – Soya vs. Rape Seeds**
- 20 piglets

Source: University of Veterinary Medicine Hanover, Foundation, 2019

Material and methods

Trial 1.1 and 1.2 wheat vs. rye

	Group 1 Diet I	Group 2 Diet II	Group 3 Diet III	Group 4 Diet IV
Wheat	69,0 %	46,0 %	23,0 %	
Rye		23,0 %	46,0 %	69,0 %
Soybean meal	11,5 %	11,5 %	11,5 %	11,5 %
Barley	10,0 %	10,0 %	10,0 %	10,0 %
Potato protein	5,1 %	4,95 %	4,9 %	4,9 %
Calcium carbonate	1,00 %	1,00 %	0,95 %	0,95 %
Monocalcium-phosphate	0,90 %	0,90 %	0,95 %	1,00%
Soya oil	0,50 %	0,50 %	0,50 %	0,50 %
Sodium chloride	0,35 %	0,40 %	0,40 %	0,40 %

Trial 2.1 and 2.2 soya vs. rape seeds

	Group 1 Diet I	Group 2 Diet II	Group 3 Diet III	Group 4 Diet IV
Rye	60,0 %	60,0 %	60,0 %	60,0 %
Soybean meal	18,1 %	13,6 %	8,10 %	
Rape seeds meal		6,70 %	16,1 %	28,0 %
Barley	15,1 %	13,5 %	10,0 %	6,50 %
Ligno cellulose	2,00 %	1,50 %	1,00 %	0,70 %
Calcium carbonate	0,80 %	0,75 %	0,75 %	0,70 %
Monocalcium-phosphate	0,90 %	0,80 %	0,60 %	0,45%
Soya oil	0,65 %	0,70 %	1,00 %	1,70 %
Sodium chloride	0,45 %	0,45 %	0,45 %	0,45 %

Source: University of Veterinary Medicine Hanover, Foundation, 2019

First results of a trial with young fattening pigs (n=4x5 piglets) by the use of rye instead of wheat (dry pelleted diets)

Group	1	2	3	4
Wheat Rye	1,0 0	0,66 0,33	0,33 0,66	0 1,0
Feed intake, g/day	1239 (± 298)	1165 (± 288)	1227 (± 351)	1318 (± 342)
Digestibility OS, %	89,5 ± (0,854)	88,6 (± 1,92)	86,8 (± 1,38)	88,5 (± 0,953)
Daily gain, g	884 (± 101)	854 (± 163)	874 (± 147)	889 (± 108)
FW (kg/kg)	1,59 (± 0,266)	1,54 (± 0,249)	1,57 (± 0,242)	1,66 (± 0,350)
DM content in the faeces, %	26,8 (± 1,19)	28,5 (± 3,78)	25,9 (± 2,61)	28,1 (± 2,02)

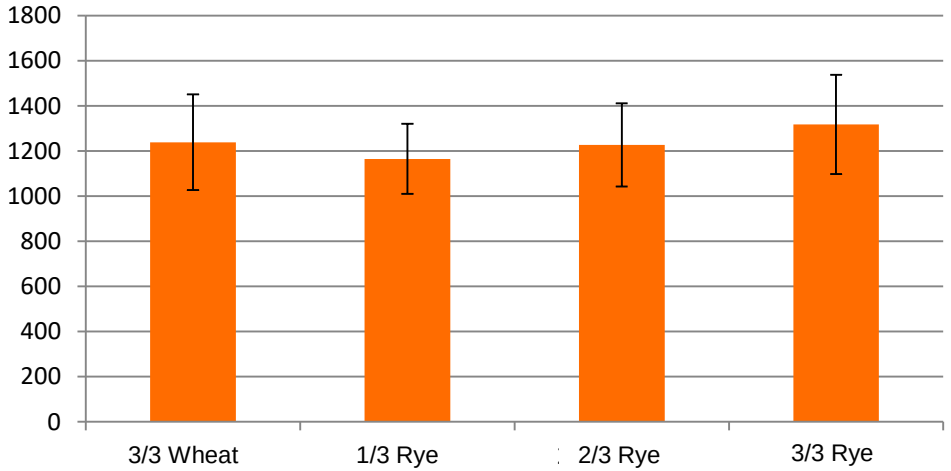
[1)] Feed compound: 79 % cereals (69 % wheat versus rye, 10 % barley), 11,5 % soybean meal
Energy (MJ ME/kg): 13,7 – 13,9
Crude protein (g/kg): 170 – 190

Source: University of Veterinary Medicine Hanover, Foundation, 2019

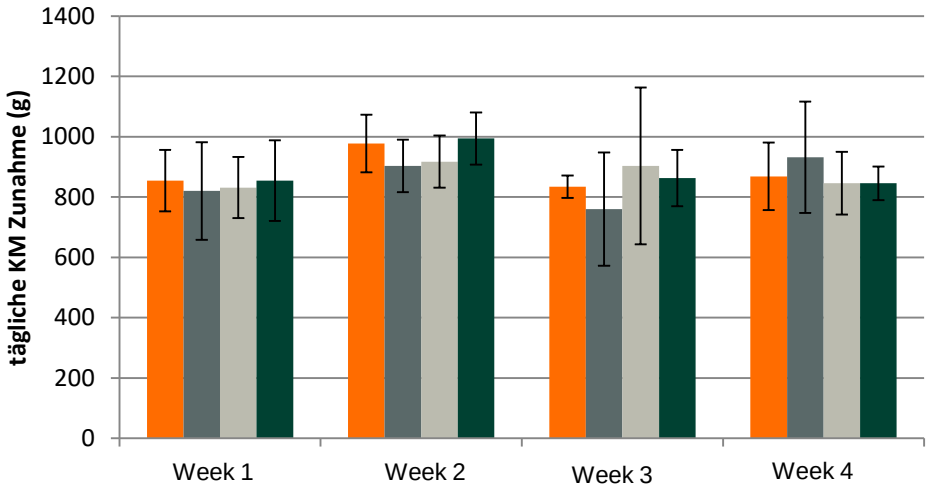
Results (wheat vs. rye), dm intake / gains

Trial 1.1

DM intake / day (g)

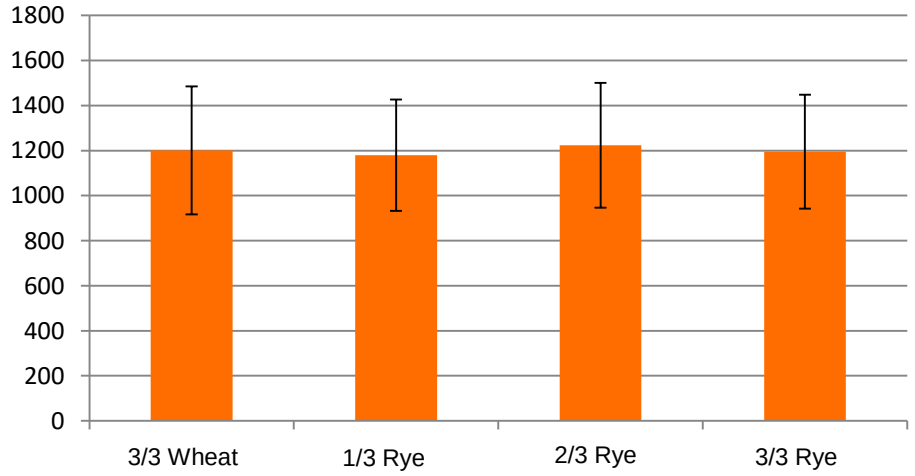


Body weight gains (g)



Trial 1.2

DM intake / day (g)



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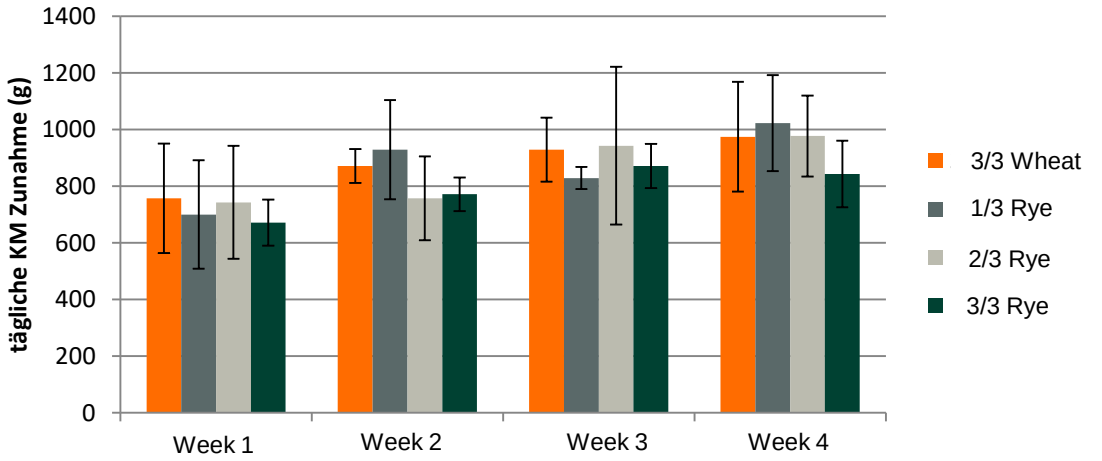
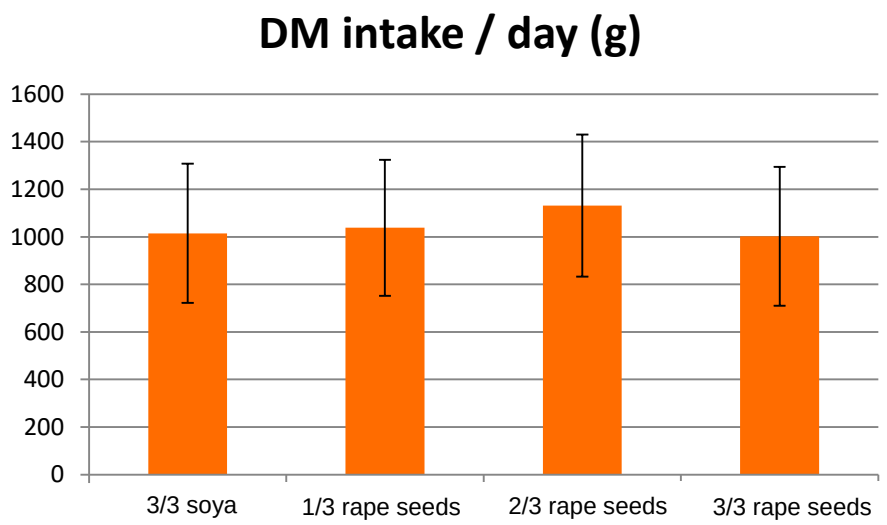
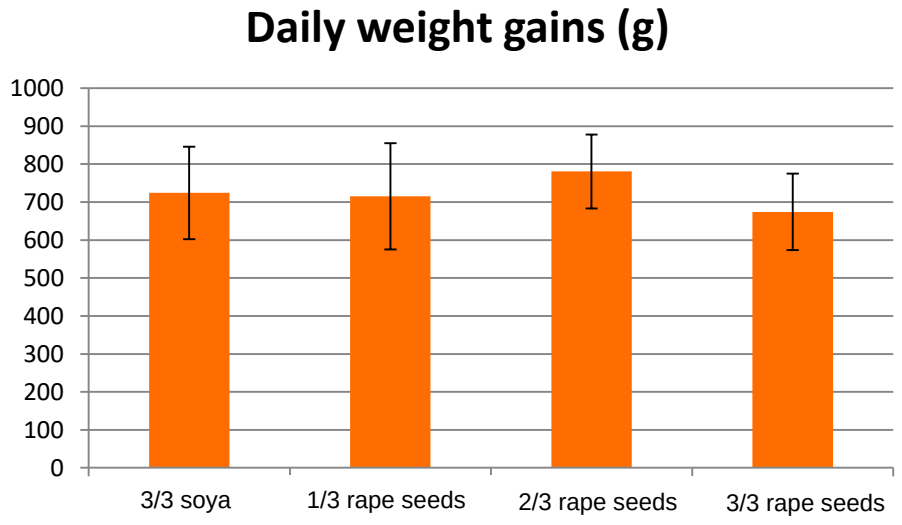
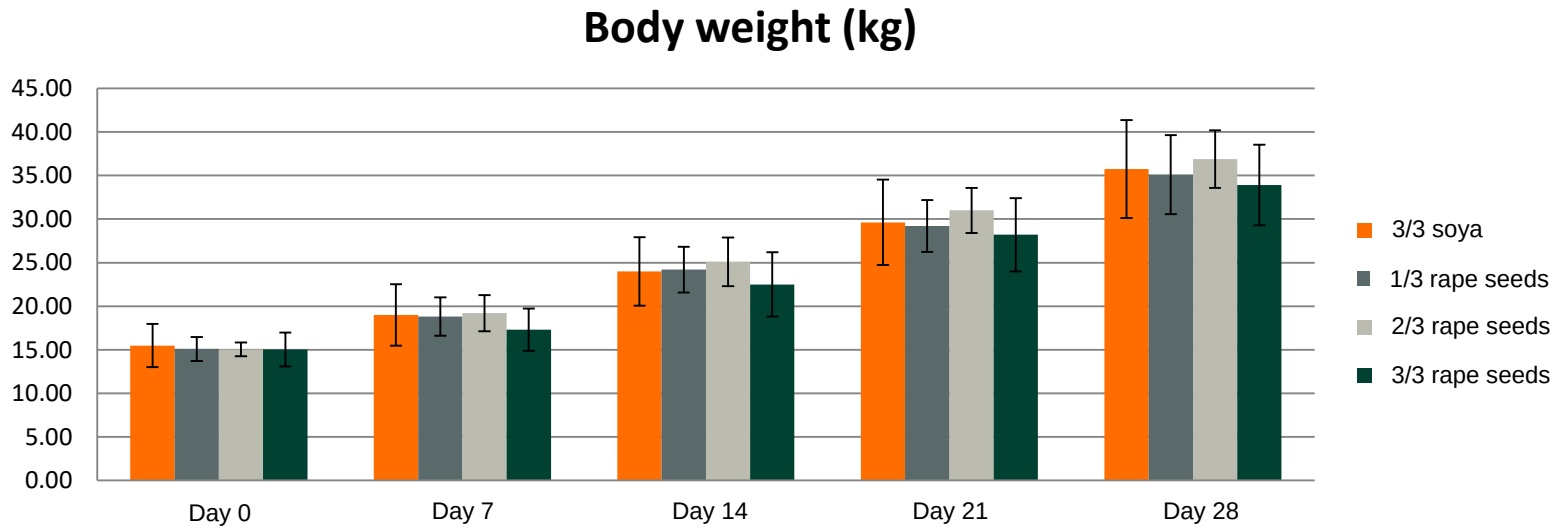


Source: University of Veterinary Medicine Hanover, Foundation, 2019

Results (soya bean vs. rape seeds), DM intake / daily weight gain







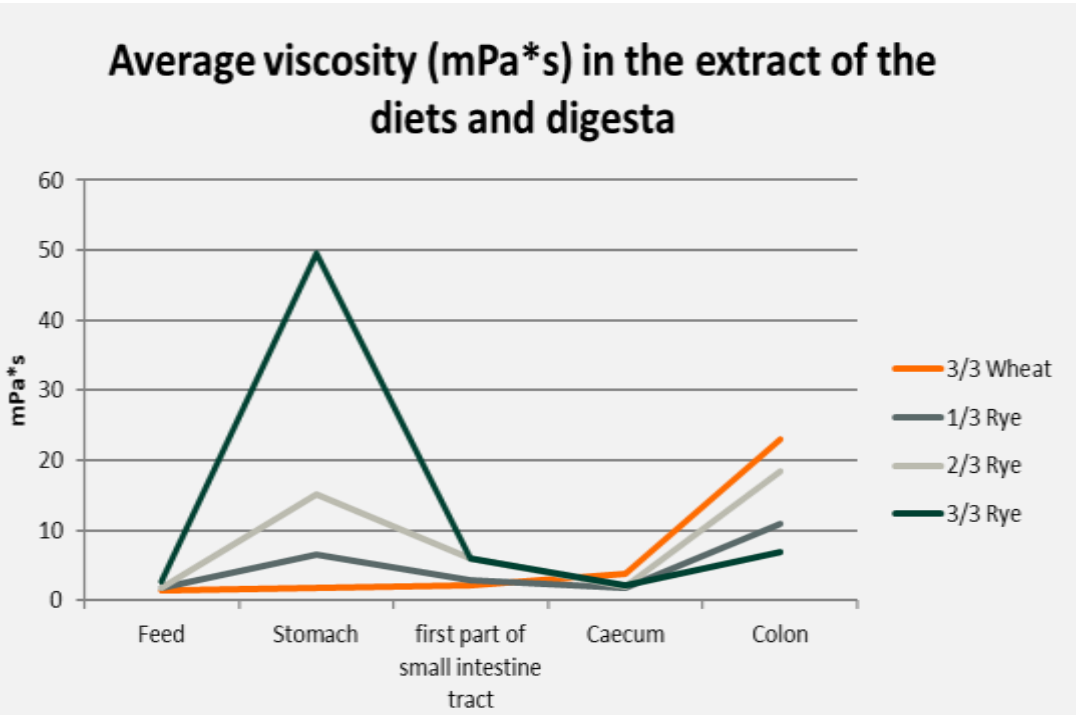
Source: University of Veterinary Medicine Hanover, Foundation, 2019

Results (wheat vs. rye), viscosity

Marked differences regarding digesta viscosity in pigs fed rye based diets [Grone 2018; Wilke 2019 (thesis in prep.)]

Effects:

- Negative impact of the resorption processes / enzymatic efficiency?
  - Speed of flooding of the absorptable nutrients ↓ (Weickert and Pfeiffer 2008)
  - Glucose absorption ↓, kinetics of the Insulin release and postprandial Glucose respond ↓ (Ellis et al. 1995, Weickert and Pfeiffer 2008)



Less postprandial insulin peak prevents a later hypoglycemia:

Longer lasting satiety feeling!

Source: Rosén et al. 2009, University of Veterinary Medicine Hanover, Foundation, 2019

First results prececal digestibility

Prececal digestibility of diet 1 (69 % wheat) and diet 2 (69 % rye) respectively

Feed	OM[1]	NfE[2]	CP[3]	EE[4]	Lys	Cys	Met
Diet 1 (wheat)	78.4±1.11[a]	81.5±0.98[a]	77.5±2.23[a]	75.7±1.87[a]	87.3±2.20[a]	78.3±3.40[a]	91.9±0.88[a]
Diet 2 (rye)	74.7±1.84[b]	76.8±1.88[b]	75.8±3.12[a]	72.7±5.59[a]	87.9±1.32[a]	73.3±3.63[a]	92.4±0.69[a]

[1]Organic matter, [2]N-free extractive, [3]crude protein, [4]ether extract

Significant differences only found for organic matter and NfE.

Higher amounts of these nutrients (compared to diet 1) reached the large intestine (1.25 times higher for NfE, 1.17 times higher for OM).

Source: University of Veterinary Medicine Hanover, Foundation, 2019

First results total tract digestibility

Total tract digestibility of diet 1 (69% wheat) and diet 2 (69% rye)

Feed	OM	NfE	CP	EE
Diet 1 (wheat)	91,2 ± 0,62	93,9 ± 0,42	91,0 ± 1,55	74,9 ± 2,91[a]
Diet 2 (rye)	90,1 ± 0,64	93,2 ± 0,25	89,2 ± 2,51	64,2 ± 2,18[b]

No significance for NfE and organic matter => increased influx of fermentable substances into the hind gut => favored fermentation.

Consequences: adequate supplementation of amino acids.

Source: University of Veterinary Medicine Hanover, Foundation, 2019

Results; prejudices disproved?

- „Rye is not palatable“

DM intake (g/day)	Trial 1.1		Trial 1.2	
	absolute	relative	absolute	relative
3/3 Wheat	1239	100	1201	100
1/3 Rye	1165	94	1181	98
2/3 Rye	1227	99	1224	102
3/3 Rye	1318	106	1196	100

- „Rye makes liquid feces“

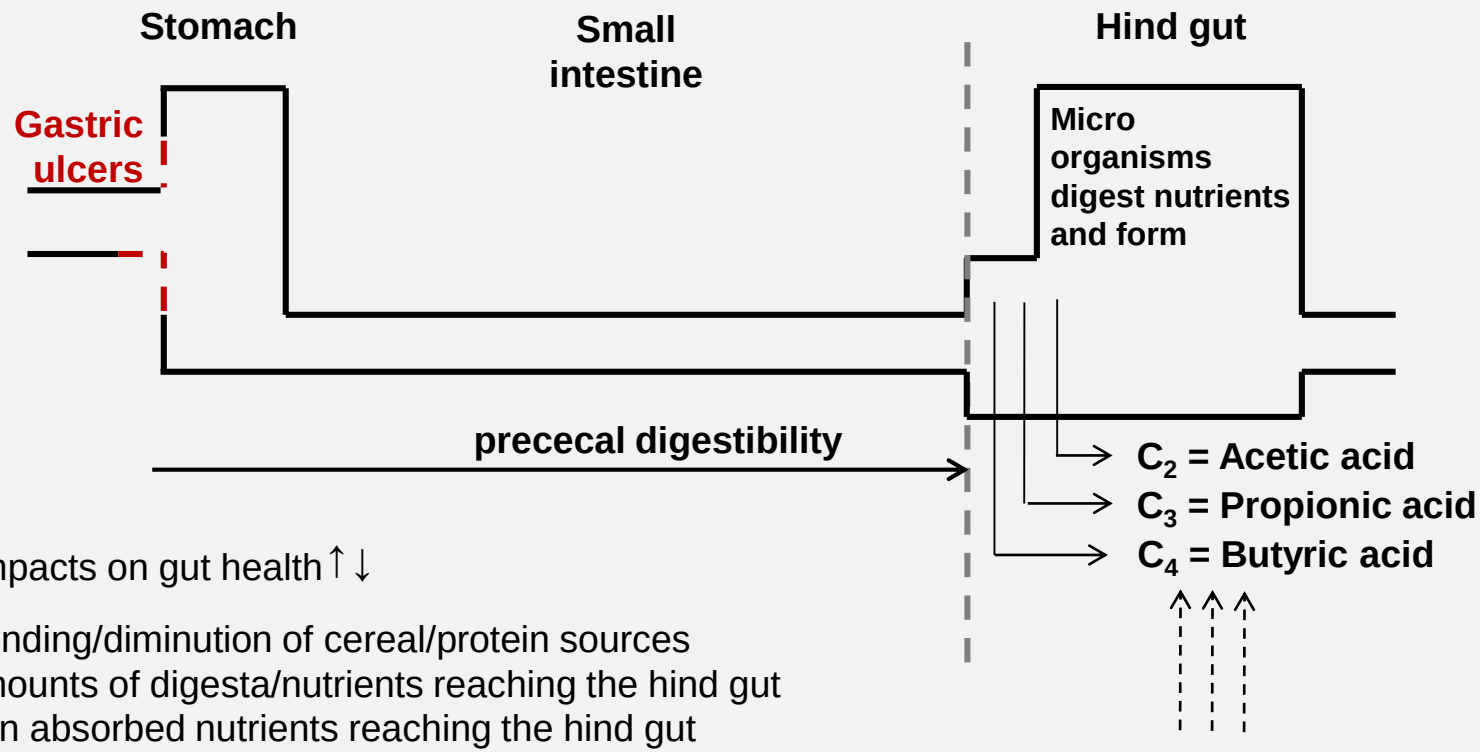
DM-content (g/kg)	DG 1.1		DG 1.2	
	absolute	relative	absolute	relative
3/3 Wheat	268	100	235	100
1/3 Rye	285	106	245	104
2/3 Rye	259	97	251	107
3/3 Rye	281	105	250	106

- „Compared to wheat – the performance with rye will be less“

relative body weight	Day 0		Day 7		Day 14		Day 21		Day 28	
	Trial 1.1	Trial 1.2	Trial 1.1	Trial 1.2	Trial 1.1	Trial1.2	Trial1.1	Trial 1.2	Trial 1.1	Trial 1.2
3/3 Wheat	100	100	132	143	169	192	200	245	233	300
1/3 Rye	100	100	131	138	166	189	197	235	233	291
2/3 Rye	100	100	133	141	168	183	204	235	237	288
3/3 Rye	100	100	127	138	159	181	186	229	214	277

Source: University of Veterinary Medicine Hanover, Foundation, 2019

The alimentary tract of pigs – a model



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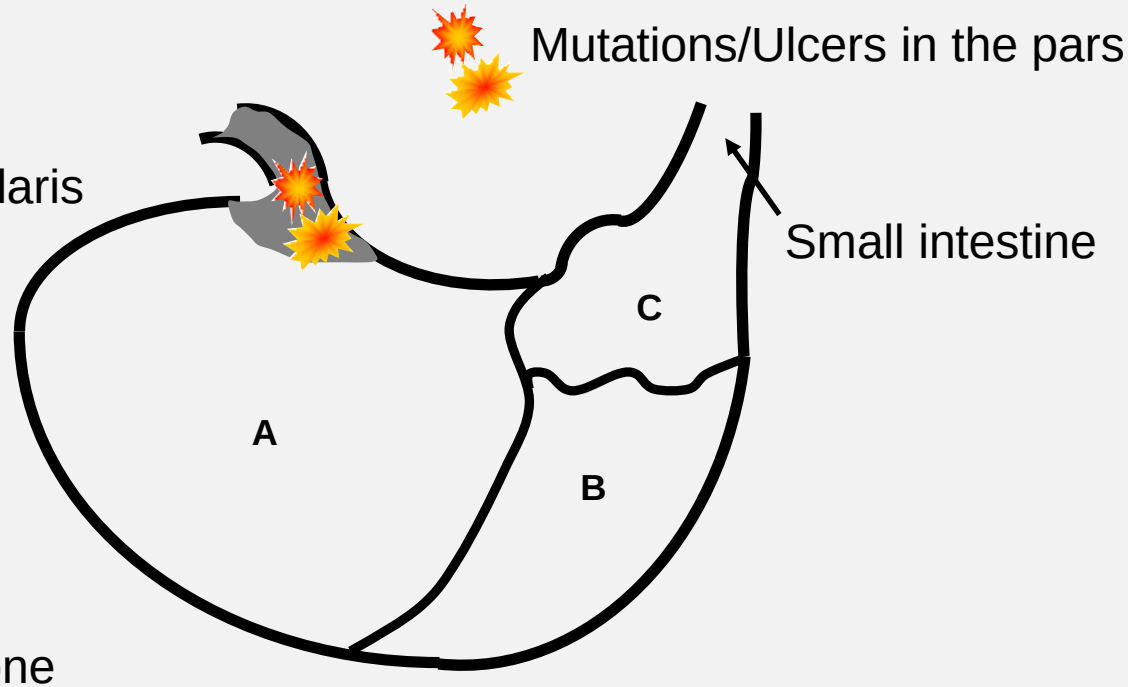
   - Inulin, Polyfructans, Arabinoxylans →

Acetic acid (C_2) ↑
Propionic acid (C_3) + Butyric acid ↑
Butyric acid (C_4) ↑↑

Source: University of Veterinary Medicine Hanover, Foundation, 2019

Stomach health



A Cardiac gland zone

B Fundus gland zone

C Pyloric gland zone

Source: University of Veterinary Medicine Hanover, Foundation, 2019

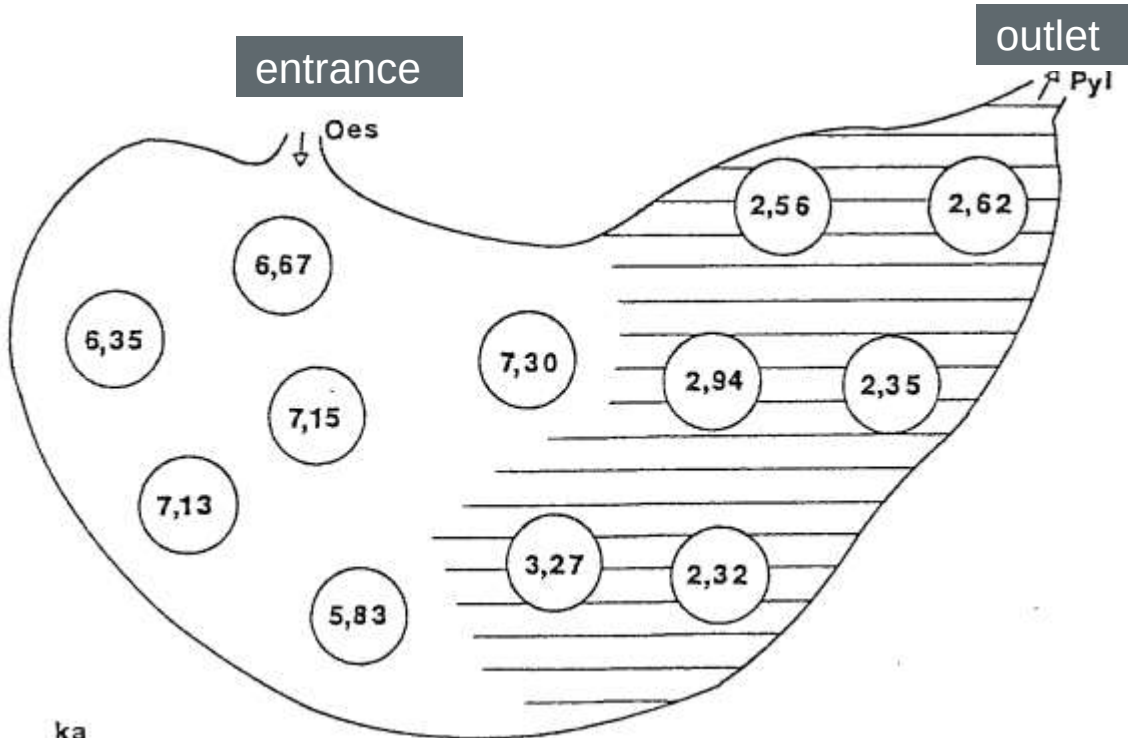
Stomach ulcers – undesired effect of too fine grinding intensity

Coarse grinding:
no alterations

Fine grinding:
severe ulceration

Source: University of Veterinary Medicine Hanover, Foundation, 2019

PH levels in the stomach of pigs



At good stomach stratification (rough feeding stuff):

- **Higher** PH levels at the stomach entrance
- **Lower** PH levels in the fundus and at the stomach outlet

At poor stomach stratification (fine feeding stuff):

- Mixing of the stomach content
- Stomach entrance gets in contact with low PH levels, HCl or Pepsin

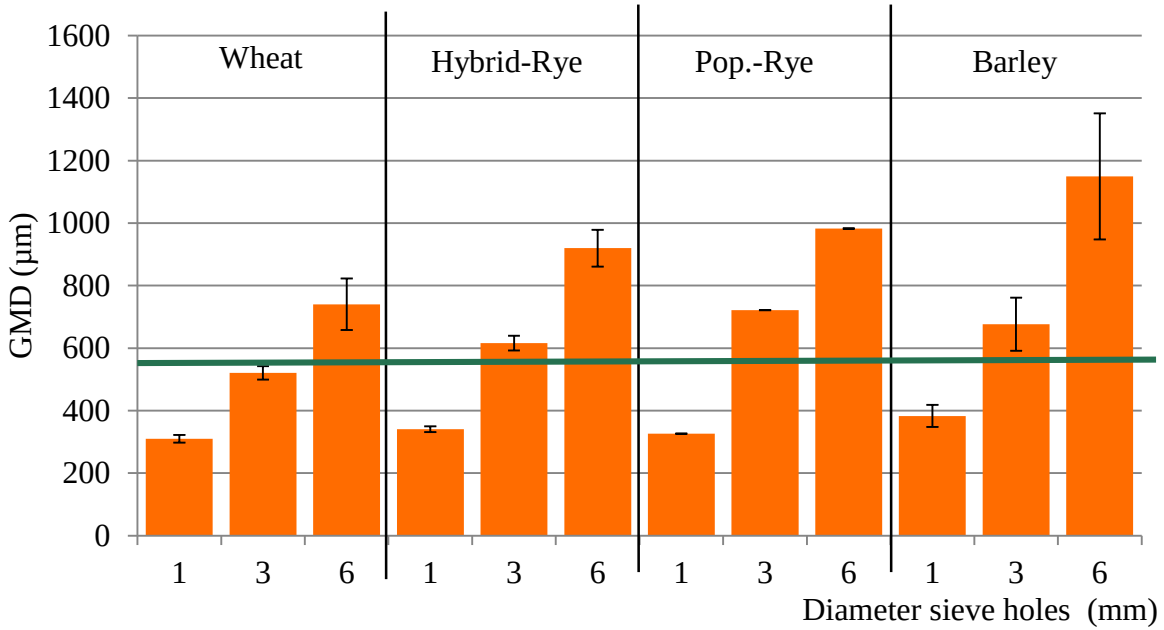
Source: University of Veterinary Medicine Hanover, Foundation, 2019

Particle size distribution (KAMPHUES et al. 2014)

Particle size (mm)	Dry sieve analysis (%)	Wet sieve analysis (%)
>1	>15-20	>15-20
<0,2	<20	<35

- Alternative: GMD > 550 µm

Dry sieve analysis (GRONE 2018)



- Barley > Rye > Wheat (regarding the same grinding intensity)
- Stomach health:
  - Wheat, Rye, Barley 6 mm: +
  - Rye, Barley 3 mm: +
  - Wheat 3 mm: -
  - Wheat, Rye, Barley 1 mm: -

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