



# PoulRye - results and outlook from German studies at the TIHO



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# TiHo - Modell

The screenshot shows a journal article from the *sustainability* journal. The article title is "Impact of Rye Inclusion in Diets for Broilers on Performance, Litter Quality, Foot Pad Health, Digesta Viscosity, Organ Traits and Intestinal Morphology". It is an Open Access article by Amr Abd El-Wahab, Jan Berend Lingens, Bussarakam Chuppava, Marwa F. E. Ahmed, Ahmed Osman, Marion Langeheine, Ralph Brehm, Venja Taube, Richard Grone, Andreas von Felde, Josef Kamphues, and Christian Visscher. The article is associated with the Department of Nutrition and Nutritional Deficiency Diseases at Mansoura University, the Institute for Animal Nutrition at Hannover University, the Department of Hygiene and Zoonoses at Mansoura University, the Institute for Anatomy at Hannover University, BEST 3 Geflügelmährung GmbH, KWS LOCHOW GmbH, and the University of Veterinary Medicine Hannover. The article was received on August 30, 2020, revised on September 17, 2020, accepted on September 17, 2020, and published on September 19, 2020. The DOI is <https://doi.org/10.3390/su12187753>. The article belongs to the collection "Sustainable Livestock Production". The left sidebar of the journal interface includes links for "Submit to this Journal", "Review for this Journal", and "Edit a Special Issue", along with an "Article Menu" and sections for "Article Overview", "Article Versions", "Export Article", "Related Info Links", and "More by Authors Links".

**sustainability**

Open Access Article

## Impact of Rye Inclusion in Diets for Broilers on Performance, Litter Quality, Foot Pad Health, Digesta Viscosity, Organ Traits and Intestinal Morphology

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# Experimental Design

Table 1. Experimental design concerning groups and feeding phases.

Week of Life	Group	Starter	Grower	Finisher	SFI <sup>1</sup>	SFII <sup>2</sup>	Crushed Corn	Squashed Rye
1	All groups	100%						
2			100%					
3	Control			100%				
	SFI-Corn				95%		5%	
	SFII-Rye					95%		5%
	Mixed				47.5%	47.5%	2.5%	2.5%
4	Control		100%					
	SFI-Corn				90%		10%	
	SFII-Rye					90%		10%
	Mixed				45%	45%	5%	5%
5	Control		100%					
	SFI-Corn				80%		20%	
	SFII-Rye					80%		20%
	Mixed				40%	40%	10%	10%
6	Control		100%					
	SFI-Corn				70%		30%	
	SFII-Rye					70%		30%
	Mixed				35%	35%	15%	15%

<sup>1,2</sup> Supplementary feeds commercially produced for corn and rye, respectively.

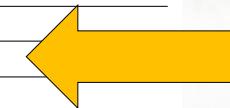
# AA's analysed week 3+4

**Table 5** Amino acids contents of ingredients of the compound feedingstuffs for broilers in the grower period in the different groups (from analysed values)

week 3	Item [g/kg DM]	Finisher	SFI (95%) +Corn (5%)	SFII (95%) +Rye (5%)	Mixed SFI+Corn (47.5+2.5%) SFII+Rye (47.5+2.5%)
	Arginine	13.91	14.23	14.36	14.29
	Cysteine	4.14	4.07	4.08	4.08
	Isoleucine	9.12	9.29	9.60	9.45
	Leucine	16.63	17.08	17.21	17.14
	Lysine	13.12	13.29	13.86	13.57
	Methionine	7.31	6.86	7.22	7.04
	Phenylalanine	10.61	10.89	11.20	11.04
	Threonine	9.52	9.61	8.70	9.16
	Valine	10.50	10.56	10.91	10.73

**Table 7** Amino acids contents of ingredients of the compound feedingstuffs for broilers in the grower period in the different groups (from analysed values)

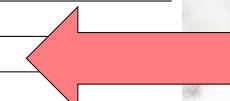
week 4	Item [g/kg DM]	Finisher	SFI (90%) +Corn (10%)	SFII (90%) +Rye (10%)	Mixed SFI+Corn (45+5%) SFII+Rye (45+5%)
	Arginine	13.91	13.73	13.89	13.81
	Cysteine	4.14	3.99	4.00	3.99
	Isoleucine	9.12	8.98	9.26	9.12
	Leucine	16.63	16.83	16.64	16.73
	Lysine	13.12	12.76	13.34	13.05
	Methionine	7.31	6.62	6.94	6.78
	Phenylalanine	10.61	10.57	10.84	10.71
	Threonine	9.52	9.32	8.42	8.87
	Valine	10.50	10.26	10.59	10.43



# AA's analysed week 5+6

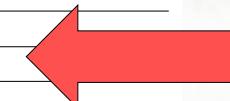
**Table 9** Amino acids contents of ingredients of the compound feedingstuffs for broilers in the grower period in the different groups (from analysed values)

week 5	Item [g/kg DM]	Finisher	SFI (80%) +Corn (20%)	SFII (80%) +Rye (20%)	Mixed SFI+Corn (40+10%) SFII+Rye (40+10%)
	Arginine	13.91	12.75	12.93	12.84
	Cysteine	4.14	3.81	3.83	3.82
	Isoleucine	9.12	8.35	8.58	8.46
	Leucine	16.63	16.33	15.49	15.91
	Lysine	13.12	11.70	12.30	12.00
	Methionine	7.31	6.12	6.36	6.24
	Phenylalanine	10.61	9.95	10.14	10.04
	Threonine	9.52	8.75	7.85	8.30
	Valine	10.50	9.67	9.95	9.81



**Table 11** Amino acids contents of ingredients of the compound feedingstuffs for broilers in the grower period in the different groups (from analysed values)

week 6	Item [g/kg DM]	Finisher	SFI (70%) +Corn (30%)	SFII (70%) +Rye (30%)	Mixed SFI+Corn (35+15%) SFII+Rye (35+15%)
	Arginine	13.91	11.76	11.98	11.87
	Cysteine	4.14	3.64	3.67	3.65
	Isoleucine	9.12	7.71	7.90	7.81
	Leucine	16.63	15.83	14.35	15.09
	Lysine	13.12	10.64	11.26	10.95
	Methionine	7.31	5.63	5.79	5.71
	Phenylalanine	10.61	9.32	9.43	9.37
	Threonine	9.52	8.18	7.28	7.73
	Valine	10.50	9.09	9.31	9.20



# Performance

Table 3. Average body weight (g) of broilers from d 7 to d 42 of life (mean  $\pm$  SEM).

Day of Life	Experimental Diets				<i>p</i> -Value
	Control	SFI-Corn <sup>1</sup>	SFII-Rye <sup>2</sup>	Mixed	
7	219 <sup>a</sup> $\pm$ 1.11	224 <sup>a</sup> $\pm$ 1.65	220 <sup>a</sup> $\pm$ 1.72	221 <sup>a</sup> $\pm$ 2.03	0.185
14	534 <sup>a</sup> $\pm$ 1.97	546 <sup>a</sup> $\pm$ 4.16	532 <sup>a</sup> $\pm$ 7.63	536 <sup>a</sup> $\pm$ 3.29	0.186
21	1004 <sup>b</sup> $\pm$ 2.96	1041 <sup>a</sup> $\pm$ 11.6	1039 <sup>a</sup> $\pm$ 7.68	1027 <sup>ab</sup> $\pm$ 9.53	0.018
28	1646 <sup>a</sup> $\pm$ 11.6	1708 <sup>a</sup> $\pm$ 25.7	1658 <sup>a</sup> $\pm$ 18.0	1668 <sup>a</sup> $\pm$ 19.1	0.148
35	2350 <sup>a</sup> $\pm$ 14.1	2367 <sup>a</sup> $\pm$ 40.1	2320 <sup>a</sup> $\pm$ 26.7	2338 <sup>a</sup> $\pm$ 37.3	0.761
42	3038 <sup>a</sup> $\pm$ 20.7	2970 <sup>a</sup> $\pm$ 51.3	2932 <sup>a</sup> $\pm$ 39.5	2899 <sup>a</sup> $\pm$ 42.3	0.106

<sup>a,b</sup> Means within the same row with different superscripts differ significantly (*p* < 0.05). <sup>1,2</sup> Supplementary feeds commercially produced for corn and rye.

## Significant differences at d 21: BW higher for corn and pure rye

Table 4. Feed intake, water intake, mean of body weight gain (BWG) and feed conversion ratio (FCR) of broilers during trial from 14 to 42 d (mean  $\pm$  SEM).

	Experimental Diets				<i>p</i> -Value
	Control	SFI-Corn <sup>1</sup>	SFII-Rye <sup>2</sup>	Mixed	
Feed intake (g)	4008 <sup>a</sup> $\pm$ 60.5	4039 <sup>a</sup> $\pm$ 86.7	4089 <sup>a</sup> $\pm$ 76.5	4083 <sup>a</sup> $\pm$ 58.9	0.834
Water intake (g)	7012 <sup>a</sup> $\pm$ 106	7113 <sup>a</sup> $\pm$ 122	7462 <sup>a</sup> $\pm$ 144	7107 <sup>a</sup> $\pm$ 252	0.258
W/F ratio <sup>3</sup>	1.75 <sup>a</sup> $\pm$ 0.04	1.77 <sup>a</sup> $\pm$ 0.04	1.83 <sup>a</sup> $\pm$ 0.02	1.74 <sup>a</sup> $\pm$ 0.05	0.466
BWG (g)	2504 <sup>a</sup> $\pm$ 20.6	2424 <sup>a</sup> $\pm$ 48.3	2400 <sup>a</sup> $\pm$ 40.7	2363 <sup>a</sup> $\pm$ 40.6	0.093
FCR	1.60 <sup>c</sup> $\pm$ 0.02	1.67 <sup>b</sup> $\pm$ 0.01	1.70 <sup>a,b</sup> $\pm$ 0.01	1.73 <sup>a</sup> $\pm$ 0.02	<0.001

<sup>a,b,c</sup> Means within the same row with different superscripts differ significantly (*p* < 0.05). <sup>1,2</sup> Supplementary feeds commercially produced for corn and rye. <sup>3</sup> Water to feed intake ratio.

FCR-values increase with increasing protein reduction; corn=rye

# Exkreta – DM / Viskosity

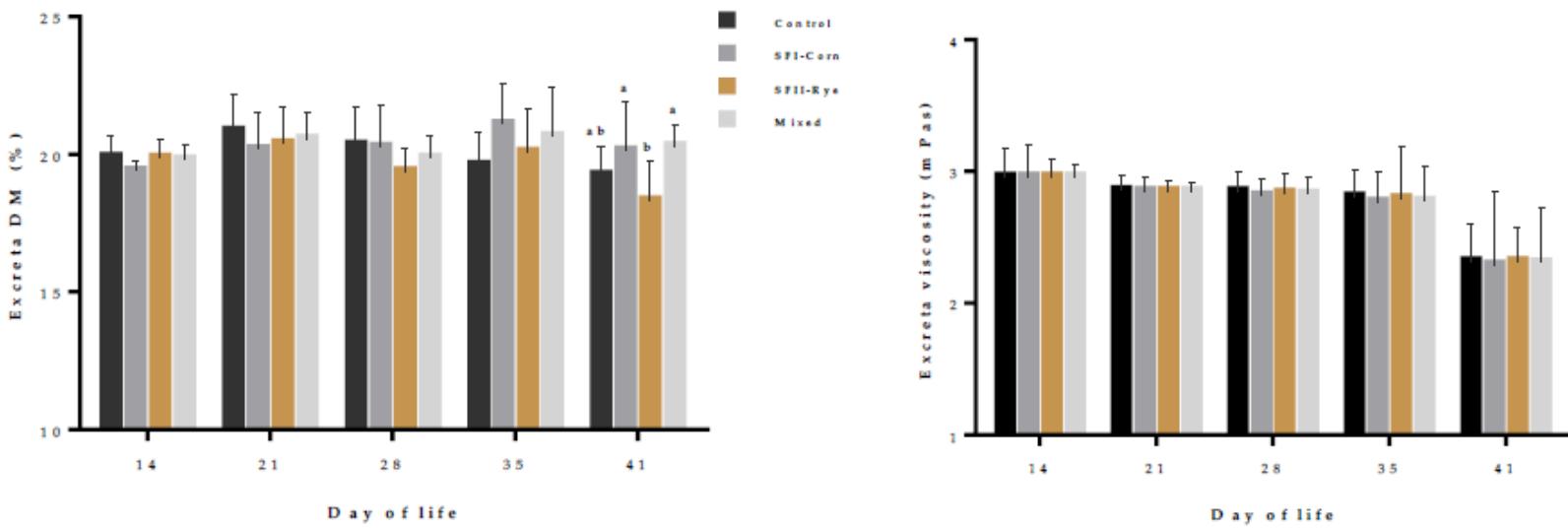


Figure 2. Dry matter (DM)-content and viscosity of excreta throughout the trial (d 14–d 41). <sup>a,b</sup> Means at d 41 for excreta DM with different superscripts differ significantly ( $p < 0.05$ ).

Significantly higher moisture content in excreta of rye fed birds (corn vs. Rye); no differences in comparison to common compound feed

# Litter quality /FPD

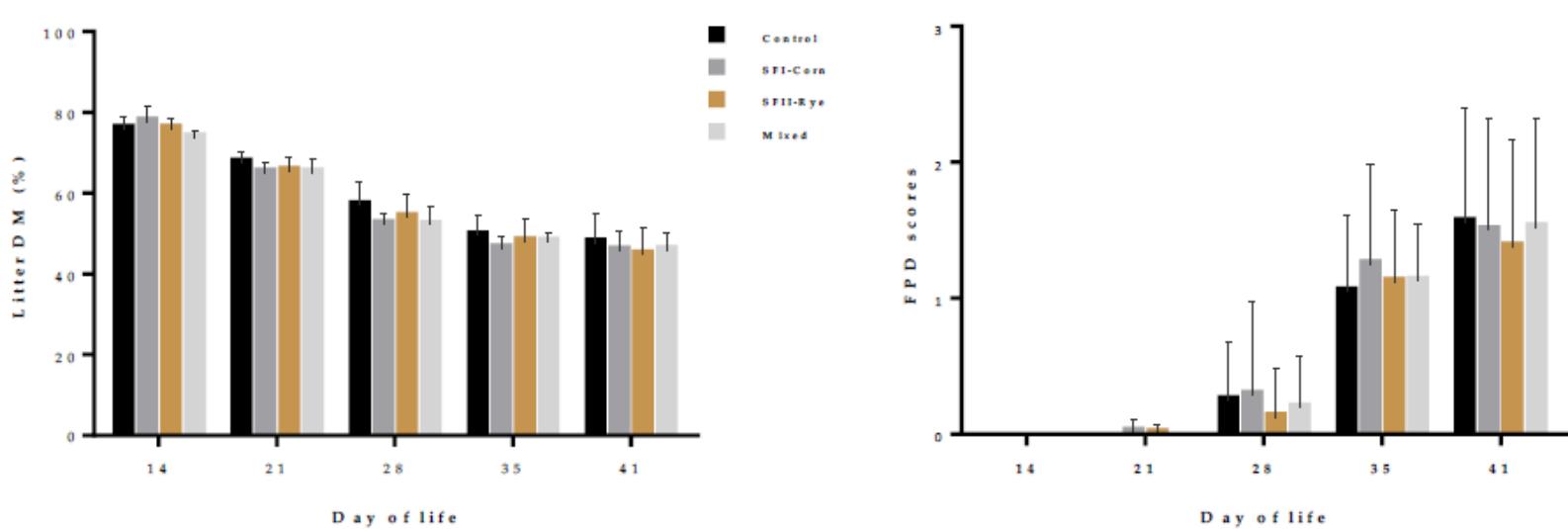


Figure 3. DM-content of litter material and foot pad scores during the trial (14–41 d).

No differences concerning moisture content in litter material; no differences concerning foot pad health depending on diet

# N-Reduction

**Table 5.** Estimations of balance and efficiency of nitrogen in litter for the entire trial period (d 14–d 42, mean  $\pm$  SEM).

Parameter	Experimental Diets				<i>p</i> -Value
	Control	SFI-Corn <sup>1</sup>	SFII-Rye <sup>2</sup>	Mixed	
Amount of litter/pen (kg)	13.7 <sup>a</sup> $\pm$ 0.47	13.8 <sup>a</sup> $\pm$ 0.30	14.8 <sup>a</sup> $\pm$ 0.21	13.7 <sup>a</sup> $\pm$ 0.30	0.074
N-intake from feed/pen (g)	1136 <sup>a</sup> $\pm$ 16.6	945 <sup>b</sup> $\pm$ 20.2	963 <sup>b</sup> $\pm$ 18.2	959 <sup>b</sup> $\pm$ 13.6	<0.001
N-content in final litter/pen (g)	297 <sup>a</sup> $\pm$ 22.1	280 <sup>a</sup> $\pm$ 13.1	304 <sup>a</sup> $\pm$ 18.0	313 <sup>a</sup> $\pm$ 17.3	0.629
Weight gain/pen (g)	20,032 <sup>a</sup> $\pm$ 165	19,393 <sup>a</sup> $\pm$ 387	19,200 <sup>a</sup> $\pm$ 326	18,901 <sup>a</sup> $\pm$ 325	0.093
N-retained/pen (g)	708 <sup>a</sup> $\pm$ 2.06	654 <sup>a</sup> $\pm$ 12.0	655 <sup>a</sup> $\pm$ 9.23	637 <sup>a</sup> $\pm$ 9.87	0.126
N-retention efficiency (g N retained/g N consumed $\times$ 100)	62.3 <sup>c</sup> $\pm$ 0.87	69.2 <sup>a</sup> $\pm$ 0.49	68.0 <sup>b</sup> $\pm$ 0.62	66.4 <sup>b</sup> $\pm$ 0.56	<0.001
N-efficiency ratio (g weight gain/g N consumed)	17.6 <sup>c</sup> $\pm$ 0.22	20.5 <sup>a</sup> $\pm$ 0.13	19.9 <sup>b</sup> $\pm$ 0.13	19.7 <sup>b</sup> $\pm$ 0.19	<0.001
N-excretion (apparent)/pen (g)	429 <sup>a</sup> $\pm$ 16.4	291 <sup>b</sup> $\pm$ 9.47	308 <sup>b</sup> $\pm$ 10.8	322 <sup>b</sup> $\pm$ 7.23	<0.001
N-excretion (apparent)/bird (g)	55.3 <sup>a</sup> $\pm$ 2.04	33.1 <sup>b</sup> $\pm$ 1.18	36.4 <sup>b</sup> $\pm$ 1.35	36.9 <sup>b</sup> $\pm$ 0.90	<0.001

<sup>a,b,c</sup> Means within the same row with different superscripts differ significantly ( $p < 0.05$ ). <sup>1,2</sup> Supplementary feeds commercially produced for corn and rye.



**Significantly higher N-retention efficiency depending on cp-reduction**





# TiHo – Field Trials Broiler Production

**Table 1** Overview concerning the experimental design

Control in %		Experimental in %					
Day of life	Dietary phase	Starter	Grower	Finisher	SF-10%	SF-20%	Pure rye
0-7	starter	100	0	0	0	0	0
8-11	grower	0	80	0	18	0	2
12-14	grower	0	60	0	36	0	4
15-18	grower	0	30	0	63	0	7
19-21	grower	0	0	0	90	0	10
22-28	finisher	0	0	35	0	52	13
29-33	finisher	0	0	0	0	80	20





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