Effect of riboflavin source and dosage on performance traits and welfare indicators in broilers

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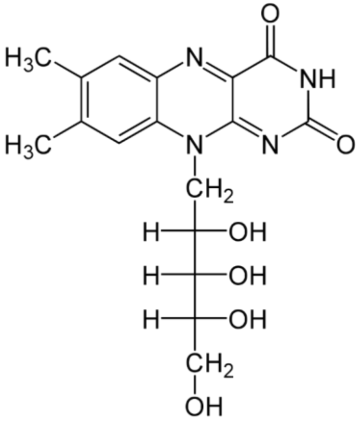
Background

- Monogastrics cannot metabolize riboflavin (vitamin B2)
- Co-factor for multiple flavin enzymes
- **Deficiency:**
  - **Decreased growth**
  - **Diminished appetite**
  - **Mucosa inflammations**
  - **Epithelial irritations**
  - **Nervous malformations**
  - **„Curled-toe paralysis“**



Ogunmodede, 1977; Chung and Baker, 1990; Wyatt et al., 1973; Johnson and Storts, 1988; Cai et al., 2006

Background

- Monogastrics cannot metabolize riboflavin (vitamin B2)
- Supplementation through premixes (3-4 times the recommended levels of NRC, 1994)
- Production by microorganisms *Candida famata, Bacillus subtilis, Ashbya gossypii*

  → Genetically modified in conventional production
- Options for organic production:
  1. Use of feed components with high native riboflavin contents, but availability (Witten and Aulrich, 2018, 2019)
  2. Supplementation of organic diets with riboflavin from sources without genetic modification

Objectives

…. to investigate the utility of a riboflavin-enriched feed produced with the yeast *A. gossypii* by fermentation without genetic modification at graded dosages as alternative to riboflavin produced from GMO in slow-growing broilers on performance and health traits.

… to investigate whether a negative control with zero supplemented riboflavin would cause deficiency symptoms if this vitamin is not supplemented

Materials & Methods

- 2 runs with 800 one-day old chicken
- Slow-growing genotype: Ranger Gold™ (Aviagen Epi GmbH)
- 40 groups of 20 chicken (4 animals/ m^2)
- Floor husbandry
- Starter diet from day 1 to 28, finisher until slaughter at 62/63 days
- 4 dietary treatments:
  - 1) without riboflavin supplementation (negative control, 'N-C'),
  - 2) with conventional riboflavin supplementation at 9.6 mg riboflavin/kg in starter and 8.0 mg/kg in finisher (positive control, 'P-C'),
  - 3) with riboflavin supplementation from the non-GMO source at 3.5 mg/kg ('A-low'),
  - 4) with riboflavin supplementation from the non-GMO source at 9.6 mg/kg in starter and 8.0 mg/kg in finisher ('A-high').

Riboflavin content of feed components

Component	DM (%)	Riboflavin (mg/kg OM)
Maize (whole grain)	86.8	0.99
Wheat (whole grain)	86.9	0.80
Wheat (powder)	85.9	0.76
Triticale (whole grain)	86.3	0.89

NRC recommendations (1994):
3.6 mg/kg

[1] Below the lower limit of detection; [2] The premix was prepared by the company Miavit GmbH (Essen, Germany) without riboflavin supplementation

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Component	DM (%)	Riboflavin (mg/kg OM)
Maize (whole grain)	86.8	0.99
Wheat (whole grain)	86.9	0.80
Wheat (powder)	85.9	0.76
Triticale (whole grain)	86.3	0.89
Peas (whole bean)	85.7	1.57
Soy (whole beans)	93.8	2.47
Soy cake (pellet)	92.3	2.95
Wheat gluten feed (pellet)	92.2	3.07
Wheat bran	86.1	2.00
Rapeseed cake (pellet)	93.1	2.86
Maize gluten feed (pellet)	92.4	2.67
Linseed cake (pellet)	91.4	1.91
Sesame cake (pellet)	91.6	4.21
Beer yeast (powder)	94.2	20.40
Grass meal (powder)	90.2	8.81
Sunflower oil	99.9	[1]
Premix [2]	96.2	[1]

NRC recommendations (1994):
3.6 mg/kg

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Composition of basal diet

Component	DM (%)	Riboflavin (mg/kg OM)	Starter diet (%)	Finisher diet (%)
Maize (whole grain)	86.8	0.99	15.0	15.0
Wheat (whole grain)	86.9	0.80	16.4	11.0
Wheat (powder)	85.9	0.76	-	7.7
Triticale (whole grain)	86.3	0.89	6.0	18.0
Peas (whole bean)	85.7	1.57	12.0	12.0
Soy (whole beans)	93.8	2.47	1.8	-
Soy cake (pellet)	92.3	2.95	13.9	13.4
Wheat gluten feed (pellet)	92.2	3.07	8.7	-
Wheat bran	86.1	2.00	8.0	6.0
Rapeseed cake (pellet)	93.1	2.86	-	4.0
Maize gluten feed (pellet)	92.4	2.67	4.6	4.6
Linseed cake (pellet)	91.4	1.91	4.0	-
Sesame cake (pellet)	91.6	4.21	3.0	-
Beer yeast (powder)	94.2	20.40	2.5	-
Grass meal (powder)	90.2	8.81	-	4.0
Sunflower oil	99.9	[1]	0.5	-
Premix [2]	96.2	[1]	0.6	0.5

[1] Below the lower limit of detection; [2] The premix was prepared by the company Miavit GmbH (Essen, Germany) without riboflavin supplementation

Dietary treatments – Starter diet

Item	Dietary treatments - starter diet				Riboflavin suspension
	N-C	P-C	A-low	A-high	
Dry matter (g/kg)	885	882	878	877	54
Riboflavin (mg/kg OM)	3.00	9.36	5.51	11.40	741.00
Crude protein (g/kg of OM)	215	222	216	227	17
Ether extract (g/kg of OM)	57	56	57	60	18
Crude fiber (g/kg of OM)	33	41	44	42	<3
Saccharose (g/kg of OM)	38	38	37	40	<10
Starch (g/kg of OM)	346	341	340	329	<10
Nitrogen-free extracts (g/kg of OM)	510	499	498	477	11
Crude ash (g/kg of OM)	70	64	63	71	8
ME (MJ/kg of OM)	11.6	11.5	11.5	11.6	0.9
Amino acids					
Lysine (g/kg of OM)	9.3	9.4	9.2	9.8	0.6
Methionine (g/kg of OM)	3.4	3.5	3.4	3.6	<0.5
Cysteine (g/kg of OM)	3.8	3.6	3.8	3.9	<0.5
Threonine (g/kg of OM)	7.7	7.6	7.6	8.1	<0.5

Dietary treatments – Finisher diet

Item	Dietary treatments - finisher diet				Riboflavin suspension
	N-C	P-C	A-low	A-high	
Dry matter (g/kg)	875	874	872	865	54
Riboflavin (mg/kg OM)	1.99	9.15	5.43	11.00	741.00
Crude protein (g/kg of OM)	187	181	182	178	17
Ether extract (g/kg of OM)	42	40	42	40	18
Crude fiber (g/kg of OM)	43	41	41	40	<3
Saccharose (g/kg of OM)	40	40	43	40	<10
Starch (g/kg of OM)	398	399	402	404	<10
Nitrogen-free extracts (g/kg of OM)	533	542	537	541	11
Crude ash (g/kg of OM)	70	70	70	66	8
ME (MJ/kg of OM)	11.5	11.4	11.5	11.4	0.9
Amino acids					
Lysine (g/kg of OM)	8.2	8.4	8.3	7.9	0.6
Methionine (g/kg of OM)	2.9	2.9	2.8	2.8	<0.5
Cysteine (g/kg of OM)	3.2	3.3	3.1	3.1	<0.5
Threonine (g/kg of OM)	6.7	6.7	6.6	6.4	<0.5

Data collection

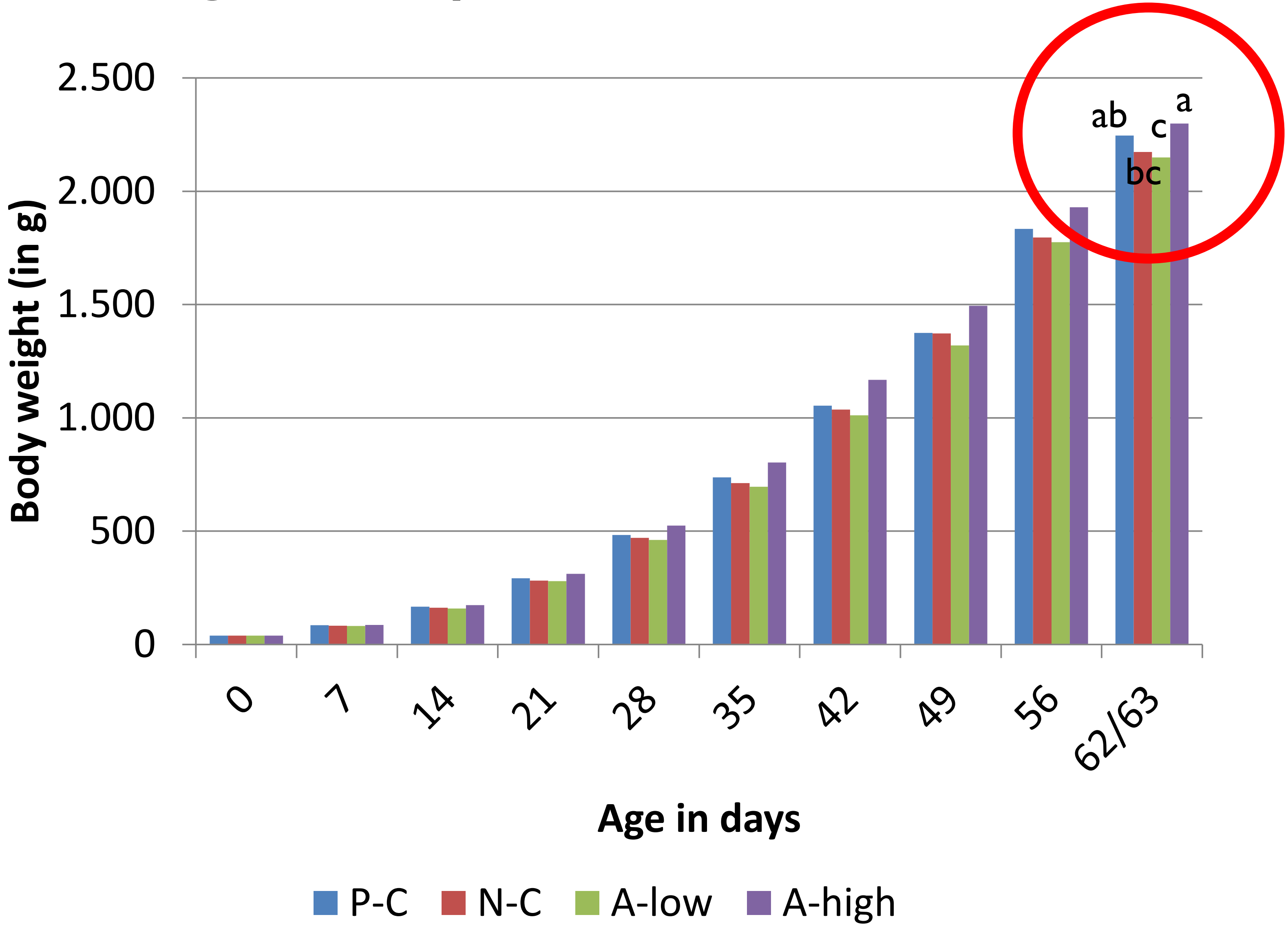
- Body weight recorded weekly
- Feed consumption measured weekly at pen level
- Mortality
- Slaughter traits
- European broiler index
  - DWG (g) x survival rate (%)/feed conversion (kg feed/kg body weight gain) x 10
- Income over feed costs
  - Body weight (kg) x 2.65 € - feed consumption (kg) x 0.56 €

Statistical analysis

- SAS, version 9.4
- Model: $y = \mu + T_{\mathrm{i}} + R_{\mathrm{j}} + \mathrm{Ti} * \mathrm{R_j} + \mathrm{eijk}$,
  - T = treatment (1,2,3,4)
  - R = is the run (1,2)
  - T * R = interaction

Results

Body weight development



Performance traits

Item	Dietary treatment				SE
	N-C	P-C	A-low	A-high	
Feed consumption (g/animal)	5101[c]	5256[ab]	5018[c]	5430[a]	82.0
Feed conversion rate (kg feed/kg gain)	2.40	2.38	2.38	2.41	0.02
Mortality (%)	2.09	4.20	5.24	4.38	1.41
Mortality day 0 to 7 (%)	1.31	1.84	3.45	1.87	1.25
European broiler index (points)	143[ab]	145[ab]	137[b]	147[a]	3
Income over feed costs (IOFC) (€/animal)	2.58	2.67	2.56	2.71	0.05
IOFC corrected for additional riboflavin costs (€/animal)	2.58	2.67	2.51	2.58	0.05

Slaughter traits

Item	Dietary treatment				SE
	N-C	P-C	A-low	A-high	
Final body weight at day 56 (g)	2315^{a}	2305^{a}	2175^{b}	2316^{a}	29.4
Slaughter weight (SW, g[2])	1694^{a}	1691^{a}	1595^{b}	1725^{a}	24.0
Dressing (%[2])	73.3^{b}	73.3^{b}	73.3^{b}	74.4^{a}	0.3
Breast (% of SW)	23.7^{a}	23.6^{a}	22.9^{b}	23.4^{ab}	0.2
Thigh (% of SW)	30.9	31.1	31.1	30.7	0.17
Wings (% of SW)	11.4	11.5	11.6	11.4	0.08
Carcass (% of SW[2])	28.3	28.0	28.3	28.3	0.17
Abdominal fat (% of SW)	1.85^{ab}	1.77^{b}	1.75^{b}	2.01^{a}	0.07
Liver (% of SW)	2.66^{b}	2.79^{a}	2.83^{a}	2.67^{b}	0.04
Heart (% of SW)	0.48	0.49	0.49	0.49	0.01
Gizzard (% of SW)	1.54^{a}	1.63^{a}	1.62^{a}	1.43^{b}	0.04

Conclusions

- Levels of commercial recommendations did neither affect performance nor health and welfare traits when compared with its commercially available counterpart
- At lower dosage, growth was reduced as a result of decreased feed intake
- Findings limited to the study conditions → slow-growing broilers, diets rich in native riboflavin
- Further studies needed to verify whether riboflavin levels can be further reduced especially in finishing diets without inducing riboflavin deficiency in slow-growing broilers

The tested riboflavin derived from fermentation of *A. gossypii* can be used as alternative to riboflavin produced from GMO in broiler feeding

Liver color and foot pad scoring at slaughter

Item	Dietary treatment			
	N-C	P-C	A-low	A-high
Liver color[2]	n = 99	n = 99	n = 96	n = 97
0	28	19	39	46
1	57	64	48	45
2	14	16	9	6
$\chi^2 = 22.58; P < 0.01$				
Food pad dermatitis[3]	n = 198	n = 198	n = 192	n = 194
0	191	192	186	178
1	7	6	6	16
2	0	0	0	0
$\chi^2 = 8.65; P < 0.05$				