Effect of a synbiotic (Biomim®IMBO) on growth performance traits of broiler chickens

Einfluss eines Synbiotikums (Biomim®IMBO) auf die Mastleistung von Broilern

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Introduction

The combination of prebiotics and probiotics in poultry nutrition providing synergy and net health benefits to the host is referred to as synbiotic. Probiotics are defined as live microbial feed supplements which are intended to colonize the gastrointestinal tract and confer physiological health and performance benefits to the host (FULLER, 1989; GIBSON and FULLER, 2000). They improve the balance of intestinal microbial flora, reduce the population of pathogenic microorganisms, stimulate the immune system, enhance nutrient availability to the host, and reduce losses and poor performance due to stress (TOMS and POWRIE, 2001; KHAN and NAZ, 2013). Prebiotics on the other hand are indigestible food ingredient that beneficially affect the host by selectively stimulating the growth and or activity of live microbials in the gastrointestinal tract of the host and thus improving their health and performance (GIBSON and ROBERFROID, 1995). In broiler industry, birds are reared in confinement, a stressful environment that predisposes birds to various pathogenic diseases. To enhance performance and reduce losses due to pathogenic or disease causing microorganisms within the poultry industry, feed additives such as antibiotics or growth promotants and anti-coccidial drugs are routinely used (CASTANON, 2007; HUME, 2011). Consequently, there has been increasing concerns about the impact of antimicrobial resistance to both food animals and humans. Therefore, probiotics and combinations of probiotics and prebiotics (synbiotics) have been introduced as an alternative to antibiotics and growth promoters in poultry production. They confer beneficial effects to the host when fed in the range of 10^8 to 10^9 cfu/g (MOUNTZOURIS et al., 2010) or 10^6 to 10^7 cfu/g (GUILLOT, 2001). Prebiotics and probiotics enhance poultry performance and they have low survival rates in poultry carcasses (YEO and KIM, 1997; ZOBAC and KUMPRECHOV, 2000; MOUNTZOURIS et al., 2007; AWAD et al., 2009). On the contrary, other studies did not reveal significant improvement in body weight gain of broilers fed diets containing probiotics (KAFILZADEH and SAFARIPARVAR, 2003; KARIMI and RAHIMI, 2003; KHAKSEFIDI and RAHIMI, 2004). While the beneficial effect of probiotics and prebiotics in poultry have been varied and often times inconclusive, the focus has shifted to the combined application of both probiotics and prebiotics "synbiotic" in poultry feeding. The synbiotic Biomim®IMBO is comprises the probiotic strain *Enterococcus faecium*, prebiotic fructo-oligosaccharides, cell wall fragments, and phycophytic substances derived from sea algae that strengthen the innate immune system. It is mixed directly into animal feed. AWAD et al. (2008, 2009) evaluated the combined effects of probiotics and synbiotics Biomim®IMBO each at 0.1% and 0.05% of broiler starter and grower diets, respectively. They reported that the inclusion of the synbiotic in the broilers diets significantly increased body weight and gain, carcass yield percentage and feed efficiency. On the other hand, GHASEMI et al. (2010) reported a significant increase in body weight gain and significant improvement in feed conversion ratio of broilers fed the synbiotic Biomim®IMBO at 0.1 and 0.15% of diet from day-old to 42 days of age.

They also reported a significant reduction in coccidian oocysts in broilers fed diets containing the 0.15% synbiotic when compared with the control. More recently, the effect of in ovo injection of prebiotics and synbiotics on growth performance and meat quality traits of broiler chickens was evaluated (MAIORANO et al., 2012) and supplying synbiotic had low effect on the performance traits. Determining the effective dose of probiotics, prebiotics and the synbiotic Biomin®IMBO in poultry feeding has been a challenge. Very few and inconsistent reports have shown that Biomin®IMBO may have potential for improving broilers performance. Therefore, due to inconsistencies of the available reports and paucity of conclusive data on the effect and effective and economical dose of synbiotics on broiler performance, the aim of this study was to: (1) ascertain the effect of the synbiotic Biomin®IMBO on performance of broilers; (2) determine the optimal level of synbiotics in diet; and (3) to determine if the recommended level of inclusion of Biomin®IMBO into feed is cost effective for broilers.

Material and Method

Birds and dietary treatments

In a completely randomized design, two hundred Ross 308 broilers were assigned to five experimental diets which were fed from hatch to six weeks of age (WOA). All the five experimental treatments were fed as starter (hatch-2 WOA), grower (2–5 WOA) and finisher (5–6 WOA). The five experimental starter diets comprised Biomin®IMBO at 0% (control diet; T1), 0.1% (recommended by manufacturer; T2), 0.075% (25% less than the manufacturer recommendation; T3), 0.15% (50% higher than the level recommended by the manufacturer; T4) and 0.125% (25% higher than the level recommended by the manufacturer; T5), respectively. The five experimental diets comprised Biomin®IMBO at 0, 0.05, 0.0375, 0.075 and 0.0625% during the grower phase, respectively; and 0, 0.025, 0.01875, 0.0375 and 0.03125% during the finishing phase, respectively (Table 1). All the starter, grower and finisher experimental diets contained 3025, 3150 and 3200 kcal of metabolizable energy (ME)/kg of diet, and 24.9, 23 and 22% crude protein (CP), respectively. The ME of the diets was estimated using the Carpenter and Clegg equation (LEESON and SUMMERS, 2001). The composition of the experimental diets and the respective calculated nutrient levels are presented in Tables 2 and 3, respectively.

Table 1. Level of synbiotic Biomin®IMBO supplementation in the experimental diets

Zulagenhöhe des Synbiotikums Biomin®IMBO zu den Versuchsrationen

Treatment ¹	Starter (0–2 wk)	Grower (2–5 wk)	Finisher (5–6 wk)
	%		
T1	0	0	0
T2	0.1	0.05	0.025
T3	0.075	0.0375	0.01875
T4	0.15	0.075	0.0375
T5	0.125	0.0625	0.03125

¹ T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

Table 2. Ingredients composition of experimental diets
Zusammensetzung der Versuchsrationen

Ingredients	Starter (0–2 wk)	Grower (2–5 wk)	Finisher (5–6 wk)
Corn	46.09	50.91	48.88
Soybean meal	40.00	35.00	39.97
Fish meal	3.00	3.00	–
Meat meal	3.00	3.00	–
Oil	4.56	5.45	7.38
DL-Methionine	0.29	0.23	0.17
L-lysine	0.04	–	–
L-Threonine	0.03	–	–
CaHPO ₄	0.99	0.75	1.64
CaCO ₃	0.98	0.76	1.00
KHCO ₃	0.05	0.03	–
NaCl	0.37	0.37	0.45
Vitamin-Mineral Premix ¹	0.60	0.50	0.50

¹ Vitamin A: 5000 IU/g; Vitamin D3: 500 IU/g; Vitamin E: 3 mg/g; Vitamin K3: 1.5 mg/g; Vitamin B2: 1 mg/g; Calcium Pantothenate: 4 mg/g; Niacin: 15 mg/g; Vitamin B6: 13 mg/g; Cu: 3 mg/g; Zn: 15 mg/g; Mn: 20 mg/g; Fe: 10 mg/g; K: 0.3 mg/g

Table 3. Nutrient composition of experimental diets fed to broilers
Nährstoffgehalte der Versuchsrationen

Ingredients	Starter (0–2 wks)	Grower (2–5 wks)	Finisher (5–6 wks)
ME (MJ/kg)	12.7	13.2	13.4
Crude protein (%)	24.9	23.0	22.0
Lysine (%)	1.41	1.26	1.22
Methionine (%)	0.67	0.59	0.50
Met+Cys (%)	1.05	0.94	0.85
Threonine (%)	1.98	0.87	0.85
Tryptophan (%)	0.30	0.27	0.28
Arginine (%)	1.68	1.54	1.51
Iso-Leucine (%)	1.04	0.95	0.94
Valine (%)	1.60	1.07	1.03
Leucine (%)	1.99	1.87	1.82
Calcium (%)	1.05	0.90	0.85
Available P (%)	0.50	0.45	0.42
Sodium (%)	0.23	0.23	0.20
Potassium (%)	1.00	0.90	0.93
Chloride (%)	0.30	0.30	0.30
Choline (g/kg)	1.48	1.37	1.37
Linoleic acid (%)	1.21	1.27	1.24
Crude fiber (%)	3.78	3.52	3.73
Ether extract (%)	6.84	7.87	9.22

Management of experimental birds

At day-old experimental birds were weighed individually and randomly assigned to floors pens where brooding was carried out for all experimental birds during the first three WOA. Room temperature was maintained at 30–33°C for the first week and reduced gradually by 2.8°C every week until 20°C and at this point on no artificial heating was provided to the birds. The birds received a 22 h light and two h of dark (22L: 2D) regiment throughout the study period. During the first week, feed and water were provided in feeder trays and conical drinkers, respectively. During the rearing period, chute feeders and drinkers were used. Feed and water were provided *ad libitum*. Body weight (BW) and feed consumption were measured weekly from hatch to six WOA and at the end of starter, grower and finisher periods. Feed conversion ratio (FCR) was calculated by dividing weekly feed consumption by weekly body weight gain for each replicate. The energy or protein conversion ratio represented the amount of kcal or grams of protein needed to produce 1 g of live weight. Mortality was recorded as it occurred. The economic calculations were based on the cost of total feed used to produce 1 kg live broiler weight and the income from selling a kg of live broiler. Production index was calculated as broiler final body weight divided by the average feed conversion ratio for the entire 42 weeks multiplied by 100.

Statistical analyses

Data were analyzed by the ANOVA option of the general linear model of SAS/STAT software (SAS INSTITUTE, 2003) as a completely randomized design with the synbiotic as main effects. The statistical model used was: $Y_{ijk} = \mu + T_i + R_{ij} + \varepsilon_{ijk}$, where: Y_{ijk} = response variables from each individual replication or pen, μ = the overall mean; T_i = the effect of dietary synbiotic; R_{ij} = the inter-experimental unit (replications) error term; and ε_{ijk} = the intra-experimental unit error term. Means were compared for significant differences using the LS-MEANS option of SAS INSTITUTE (2003). Significance implies $P < 0.05$ unless stated otherwise.

Results

Mean BW gains of broilers fed diets containing the synbiotic Biomin®IMBO from hatch to 6 WOA are presented in Table 4. Body weight gain of broilers fed the various concentrations of dietary synbiotic was not different ($P > 0.05$) at 1, 3, 4 and 6 WOA. However, during the second WOA birds fed diets containing synbiotic at the concentration recommended by the manufacturer (0.1%) and those fed diets containing 0.15 and 0.125% Biomin®IMBO exhibited higher ($P < 0.05$) BW gain than birds fed the control diet and those fed diets containing 0.075% Biomin®IMBO. During the 5th WOA, BW gains of birds fed diets containing 0.15% Biomin IMBO were significantly higher ($P < 0.05$) than those of birds fed other dietary concentrations of Biomin®IMBO. When the BW gains were evaluated for the starter, grower and finisher phases, birds fed diets containing any of the synbiotic concentration had significantly higher ($P < 0.05$) BW gain than the control during the starter phase. On the other hand, during the grower and finisher phases, birds fed diets containing the 0.075 and 0.15% Biomin Biomin®IMBO had higher BW gains than all other dietary treatments.

Table 4. Body weight gain and body weight of broilers**Lebendmassezuwachs und Lebendmasse der Broiler**

WOA	Treatments				
	T1	T2	T3	T4	T5
	BW gain (g/bird/wk)				
1	83.3 ± 2.64 ^a	82.1 ± 3.01 ^a	81.2 ± 1.71 ^a	86.4 ± 2.14 ^a	82.4 ± 3.05 ^a
2	197 ± 18.9 ^b	247 ± 12.1 ^a	227 ± 12.0 ^{ab}	248 ± 6.43 ^a	261 ± 9.10 ^a
3	320 ± 27.1 ^a	272 ± 44.3 ^a	338 ± 10.6 ^a	318 ± 9.85 ^a	291 ± 22.6 ^a
4	519 ± 28.0 ^a	399 ± 50.9 ^b	613 ± 27.1 ^a	522 ± 51.2 ^a	524 ± 39.4 ^a
5	671 ± 37.8 ^{ab}	563 ± 79.6 ^b	655 ± 15.0 ^{ab}	721 ± 8.92 ^a	616 ± 37.7 ^{ab}
6	677 ± 16.8 ^a	660 ± 42.5 ^a	707 ± 33.0 ^a	619 ± 95.6 ^a	620 ± 16.3 ^a
	(g/bird)				
0–2	280 ± 19.4 ^b	330 ± 13.3 ^a	309 ± 12.9 ^{ab}	334 ± 7.93 ^a	343 ± 7.52 ^a
2–5	1443 ± 40.1 ^{ab}	1235 ± 150 ^b	1573 ± 19.5 ^a	1560 ± 52.8 ^a	1430 ± 86.8 ^{ab}
0–6	2400 ± 46.2 ^{ab}	2225 ± 157 ^b	2588 ± 64.0 ^a	2514 ± 40.6 ^a	2393 ± 71.5 ^{ab}
FBW ¹	2477 ± 46.2 ^{ab}	2260 ± 120 ^b	2605 ± 64.0 ^a	2514 ± 40.6 ^{ab}	2394 ± 71.5 ^{ab}

^{a,b} Means (± standard error) within each row of dietary treatments with no common superscript differ significantly at P < 0.05.

¹ Final BW at 42 day of age. T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

The feed consumption of broilers fed diets containing the synbiotic is presented in Table 5. Feed consumption was significantly higher (P < 0.05) in birds fed diets containing any of the dietary concentrations of Biomin®IMBO when compared with the control at 1 WOA. Although not statistically significant (P > 0.05) birds fed the 0.15% Biomin®IMBO exhibited higher feed consumption than the control. At 6 WOA, birds fed diets containing 0.075% Biomin®IMBO consumed more feed (P < 0.05) than those fed the control diet. During the grower and finisher phases, birds fed the 0.15% synbiotic consumed more feed (P < 0.05) than those in other dietary treatments.

Table 5. Feed consumption of broilers
Futtermverbrauch der Broiler

WOA	Treatments				
	T1	T2	T3	T4	T5
	(g/bird/wk)				
1	197 ± 5.54 ^a	152 ± 14.9 ^b	159 ± 20.9 ^b	150 ± 6.25 ^b	151 ± 6.45 ^b
2	374 ± 10.1 ^a	381 ± 19.5 ^a	399 ± 7.85 ^a	360 ± 18.1 ^a	385 ± 19.1 ^a
3	601 ± 41.1 ^a	689 ± 56.3 ^a	599 ± 56.2 ^a	644 ± 37.6 ^a	649 ± 22.1 ^a
4	997 ± 30.3 ^{ab}	964 ± 95.8 ^b	1161 ± 46.2 ^a	1129 ± 55.0 ^a	999 ± 31.9 ^{ab}
5	1076 ± 62.1 ^{ab}	992 ± 68.6 ^b	1115 ± 33.19 ^{ab}	1147 ± 54.2 ^a	987 ± 37.2 ^b
6	1742 ± 100 ^b	1870 ± 60.9 ^{ab}	2011 ± 109 ^a	1873 ± 122 ^{ab}	1853 ± 39.7 ^{ab}
	(g/bird)				
0–2	572 ± 10.6 ^a	534 ± 25.4 ^{ab}	558 ± 16.2 ^{ab}	510 ± 22.6 ^b	536 ± 20.3 ^{ab}
2–5	2675 ± 61.7 ^b	2645 ± 87.1 ^b	2874 ± 66.9 ^{ab}	2920 ± 29.2 ^a	2635 ± 83.4 ^b
TFC ¹	4989 ± 150 ^b	5049 ± 152 ^{ab}	5442 ± 110 ^a	5304 ± 87.7 ^{ab}	5023 ± 122 ^b

^{a,b} Means (± standard error) within each row of dietary treatments with no common superscript differ significantly at P < 0.05.

¹ Total feed consumption at 42 day of age. T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

The mean consumption of ME in broilers fed diets containing the synbiotic from hatch to 6 WOA is reported in Table 6. On average, birds fed diets containing any of the Biomin®IMBO levels demonstrated a significant increase in consumption of ME when compared with the control at 1 WOA. However, at 2–3 WOA, differences in the consumption of ME among dietary concentrations of Biomin®IMBO and the control were not significant (P > 0.05). In contrast, at 4–6 WOA, consumption of ME by birds fed diets containing 0.0375 and 0.075% Biomin®IMBO was higher (P < 0.05) than that of birds fed the control diet as well as those fed diets containing other concentrations of synbiotic. A summation of ME consumption by production phases indicated that birds fed the 0.0375 and 0.075% Biomin®IMBO during the grower phase consumed higher ME when compared with other dietary treatments.

Table 6. Mean feed conversion ratio of broilers**Durchschnittliche Futterverwertung der Broiler**

WOA	Treatments				
	T1	T2	T3	T4	T5
	(g feed/g BW gain)				
1	2.37 ± 0.04 ^a	1.85 ± 0.13 ^b	1.94 ± 0.23 ^b	1.73 ± 0.04 ^b	1.83 ± 0.03 ^b
2	1.93 ± 0.14 ^a	1.54 ± 0.04 ^b	1.77 ± 0.11 ^{ab}	1.46 ± 0.08 ^b	1.49 ± 0.11 ^b
3	1.85 ± 0.19 ^b	2.67 ± 0.29 ^a	1.76 ± 0.11 ^b	2.03 ± 0.11 ^b	2.25 ± 0.09 ^{ab}
4	1.93 ± 0.10 ^b	2.46 ± 0.16 ^a	1.90 ± 0.09 ^b	2.21 ± 0.19 ^{ab}	1.93 ± 0.11 ^b
5	1.61 ± 0.06 ^a	1.87 ± 0.30 ^a	1.70 ± 0.07 ^a	1.59 ± 0.08 ^a	1.61 ± 0.08 ^a
6	2.57 ± 0.09 ^b	2.88 ± 0.22 ^{ab}	2.86 ± 0.15 ^{ab}	3.17 ± 0.33 ^a	2.99 ± 0.09 ^{ab}
	(g feed/g BW gain)				
0–2	2.06 ± 0.11 ^a	1.62 ± 0.05 ^b	1.82 ± 0.11 ^{ab}	1.53 ± 0.06 ^b	1.57 ± 0.09 ^b
2–5	1.76 ± 0.02 ^b	2.22 ± 0.20 ^a	1.79 ± 0.03 ^b	1.88 ± 0.05 ^b	1.85 ± 0.06 ^b
TFC ¹	2.01 ± 0.02 ^b	2.29 ± 0.11 ^a	2.08 ± 0.02 ^b	2.11 ± 0.01 ^b	2.10 ± 0.02 ^b

^{a-c} Means (± standard error) within each row of dietary treatments with no common superscript differ significantly, P < 0.05.

¹ Total feed consumption at 42 days of age. T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

The consumptions of dietary protein by broilers fed diets containing the synbiotic Biomin®IMBO are presented in Table 7. During the 1st WOA, mean consumption of protein was significantly higher (P < 0.05) in broilers fed diets containing Biomin®IMBO when compared with the control. At 4 and 5 WOA protein consumption was significantly higher (P < 0.05) in broilers fed 0.0375 and 0.075% Biomin®IMBO when compared with the other dietary treatments. In overall, protein consumption was higher in birds fed diets containing the 0.0375 and 0.075% Biomin®IMBO during grower phase and when all growth phases were combined (total protein consumption).

Table 7. Consumption of metabolizable energy of broilers**Aufnahme an umsetzbarer Energie**

WOA	Treatments				
	T1	T2	T3	T4	T5
	(MJ/bird/wk)				
1	2.50 ± 0.07 ^a	1.93 ± 0.19 ^b	2.01 ± 0.26 ^b	1.90 ± 0.08 ^b	1.91 ± 0.08 ^b
2	4.74 ± 0.13 ^a	4.83 ± 0.25 ^a	5.06 ± 0.10 ^a	4.56 ± 0.23 ^a	4.87 ± 0.24 ^a
3	7.62 ± 0.52 ^a	8.73 ± 0.71 ^a	7.58 ± 0.71 ^a	8.15 ± 0.48 ^a	8.22 ± 0.28 ^a
4	13.2 ± 0.40 ^b	12.7 ± 1.26 ^b	15.3 ± 0.61 ^a	14.9 ± 0.72 ^a	13.2 ± 0.42 ^b
5	14.2 ± 0.82 ^{ab}	13.1 ± 0.90 ^b	14.7 ± 0.44 ^{ab}	15.1 ± 0.72 ^a	13.0 ± 0.49 ^b
6	23.3 ± 1.34 ^b	25.1 ± 0.82 ^{ab}	26.9 ± 1.47 ^a	25.1 ± 1.63 ^{ab}	24.8 ± 0.53 ^{ab}
	(MJ/bird)				
0–2	7.24 ± 0.13 ^a	6.76 ± 0.33 ^a	7.06 ± 0.21 ^a	6.46 ± 0.29 ^a	6.79 ± 0.26 ^a
2–5	35.0 ± 0.82 ^b	34.5 ± 1.14 ^b	37.6 ± 0.86 ^a	38.2 ± 0.37 ^a	34.4 ± 1.09 ^b
TMEC ¹	65.5 ± 2.01 ^b	66.3 ± 2.01 ^b	71.6 ± 1.47 ^a	69.7 ± 1.21 ^{ab}	66.0 ± 1.59 ^b

^{a-c} Means (± standard error) within each row of dietary treatments with no common superscript differ significantly, P < 0.05.

¹ Total metabolizable energy consumption at 42 days of age. T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

The FCR of broilers fed diets containing the synbiotic was lower (P < 0.05) than those of birds fed the control diet during 1–2 WOA (Table 8). During the 3rd WOA, only birds fed diets containing 0.0375% Biomin®IMBO had statistically lower (P < 0.05) FCR when compared with those fed the control diet. However, at 4–6 WOA the FCR of broilers fed diets containing the synbiotic were not statistically different from those fed the control diets.

Table 8. Protein consumption of broilers**Proteinaufnahme**

WOA	Treatments				
	T1	T2	T3	T4	T5
	(g/bird/wk)				
1	49.1 ± 1.38 ^a	37.9 ± 3.71 ^b	39.5 ± 5.20 ^b	37.3 ± 1.56 ^b	37.6 ± 1.61 ^b
2	93.2 ± 2.52 ^a	95.0 ± 4.86 ^a	99.4 ± 1.96 ^a	89.7 ± 4.51 ^a	95.8 ± 4.76 ^a
3	150 ± 10.2 ^a	172 ± 14.0 ^a	149 ± 14.0 ^a	160 ± 9.35 ^a	162 ± 5.51 ^a
4	229 ± 6.97 ^{ab}	222 ± 22.0 ^b	267 ± 10.6 ^a	260 ± 12.6 ^a	230 ± 7.35 ^{ab}
5	248 ± 14.3 ^{ab}	228 ± 15.8 ^b	256 ± 7.63 ^{ab}	264 ± 12.5 ^a	227 ± 8.56 ^b
6	383 ± 22.0 ^a	411 ± 13.4 ^a	442 ± 24.1 ^a	412 ± 26.7 ^a	408 ± 8.73 ^a
	(g/bird)				
0–2	142 ± 2.63 ^a	133 ± 6.48 ^a	139 ± 4.08 ^a	127 ± 5.64 ^a	133 ± 5.06 ^a
2–5	627 ± 13.9 ^b	622 ± 20.3 ^b	672 ± 16.3 ^a	684 ± 7.30 ^a	618 ± 19.5 ^b
TPC ¹	1152 ± 33.0 ^b	1166 ± 34.8 ^b	1254 ± 24.7 ^a	1223 ± 18.1 ^a	1159 ± 28.4 ^b

^{a,b} Means (± standard error) within each row of dietary treatments with no common superscript differ significantly at P < 0.05.

¹ Total protein consumption at 42 days of age. T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

The mean ME and CP conversion ratios of broilers fed diets containing the synbiotic are presented in Table 9 and 10, respectively. During the 1st and 2nd WOA, broilers fed diets containing Biomin®IMBO exhibited significantly lower ($P < 0.05$) ME and protein conversion ratios when compared with those fed the control diets. With the exception of birds fed the 0.0375% Biomin®IMBO at 4 WOA, whose ME conversion ratios were significantly lower than those of birds fed other dietary treatments, differences in ME and protein conversion ratios were not statistically significant ($P > 0.05$) among all dietary treatments at 3–6 WOA.

Table 9. Metabolizable energy conversion ratio of broilers

Verwertung der Umsetzbaren Energie

WOA	Treatments				
	T1	T2	T3	T4	T5
	(kJ/g BW gain)				
1	30.0 ± 0.54 ^a	23.4 ± 1.63 ^b	24.6 ± 3.01 ^b	21.9 ± 0.50 ^b	23.2 ± 0.38 ^b
2	24.6 ± 1.84 ^a	19.6 ± 0.46 ^b	22.5 ± 1.42 ^a	18.5 ± 0.96 ^b	18.8 ± 1.51 ^b
3	23.5 ± 2.51 ^b	33.9 ± 3.77 ^a	22.3 ± 1.51 ^b	25.7 ± 1.42 ^b	28.5 ± 1.55 ^{ab}
4	25.5 ± 1.34 ^c	32.5 ± 2.14 ^a	25.1 ± 1.26 ^c	29.2 ± 2.55 ^{ab}	25.5 ± 1.47 ^{bc}
5	21.2 ± 0.75 ^a	24.6 ± 4.02 ^a	22.5 ± 0.88 ^a	21.0 ± 1.05 ^a	21.3 ± 1.05 ^a
6	34.4 ± 1.21 ^b	38.5 ± 3.06 ^{ab}	38.3 ± 1.97 ^{ab}	42.3 ± 4.48 ^a	40.1 ± 1.21 ^{ab}
	(kJ/g BW gain)				
0–2	26.1 ± 1.42 ^a	20.5 ± 0.59 ^b	23.1 ± 1.51 ^{ab}	19.3 ± 0.71 ^b	19.8 ± 1.17 ^b
2–5	23.0 ± 0.29 ^b	29.0 ± 0.50 ^a	23.4 ± 0.42 ^b	24.5 ± 0.63 ^b	24.2 ± 0.80 ^b
AMECR ¹	26.4 ± 0.33 ^b	30.1 ± 1.51 ^a	27.3 ± 0.33 ^b	27.8 ± 0.21 ^b	27.6 ± 0.25 ^b

^{a–c} Means (± standard error) within each row of dietary treatments with no common superscript differ significantly, $P < 0.05$.

¹ Average metabolizable energy conversion ratio at 42 days of age. T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

Table 10. Protein conversion ratio of broilers**Proteinverwertung**

WOA	Treatments				
	T1	T2	T3	T4	T5
(g protein/g BW gain)					
1	0.59 ± 0.01 ^a	0.46 ± 0.03 ^{bc}	0.48 ± 0.06 ^b	0.43 ± 0.01 ^c	0.46 ± 0.01 ^{bc}
2	0.48 ± 0.04 ^a	0.38 ± 0.01 ^b	0.44 ± 0.03 ^a	0.36 ± 0.02 ^b	0.37 ± 0.02 ^b
3	0.46 ± 0.05 ^c	0.61 ± 0.02 ^a	0.44 ± 0.02 ^c	0.51 ± 0.03 ^{bc}	0.56 ± 0.02 ^{ab}
4	0.44 ± 0.02 ^a	0.56 ± 0.03 ^a	0.44 ± 0.02 ^a	0.51 ± 0.04 ^a	0.44 ± 0.02 ^a
5	0.37 ± 0.01 ^a	0.42 ± 0.07 ^a	0.39 ± 0.01 ^a	0.37 ± 0.02 ^a	0.37 ± 0.02 ^a
6	0.56 ± 0.03 ^b	0.63 ± 0.04 ^{ab}	0.63 ± 0.03 ^{ab}	0.70 ± 0.07 ^a	0.66 ± 0.02 ^{ab}
(g protein/g BW gain)					
0–2	0.51 ± 0.03 ^a	0.40 ± 0.01 ^b	0.45 ± 0.03 ^{ab}	0.39 ± 0.01 ^b	0.39 ± 0.02 ^b
2–5	0.41 ± 0.01 ^a	0.52 ± 0.05 ^a	0.42 ± 0.01 ^a	0.44 ± 0.01 ^a	0.43 ± 0.01 ^a
APCR ¹	0.46 ± 0.01 ^a	0.52 ± 0.02 ^a	0.48 ± 0.01 ^a	0.49 ± 0.00 ^a	0.48 ± 0.00 ^a

^{a-c} Means within each row of dietary treatments with no common superscript differ significantly ($P < 0.05$).

¹ Average protein conversion ratio at 42 days of age. T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

Correlation coefficients among performance traits of broilers fed diets containing synbiotic are presented in Table 11. Positive and significant correlations ($P < 0.01$) were observed between Biomin®IMBO and BW gain during the starter phase. On the other hand, negative and significant correlations were observed between Biomin®IMBO and FCR ($P < 0.01$), ME conversion ratio ($P < 0.05$) and protein conversion ratios ($P < 0.05$). The correlations between BW gain and the feed, ME and protein conversion ratios were negative and significant during both the starter and grower phases ($P < 0.01$). Protein conversion ratios were also positively correlated with ME conversion ratios ($P < 0.01$).

Table 11. Correlation coefficients among performance traits of broilers**Korrelationen zwischen den Leistungsmerkmalen der Broiler**

	BWG ¹	BWG ²	FCR ¹	FCR ²	MECR ¹	MECR ²	PCR ¹	PCR ²
Biomin®IMBO	0.58**	0.22	-0.58**	-0.25	-0.52*	-0.21	-0.52*	-0.22
BWG ¹		-0.14	-0.89**	0.16	-0.75**	0.09	-0.75**	-0.09
BWG ²			0.23	-0.89**	0.21	-0.80**	0.21	-0.79**
FCR ¹				-0.22	0.84**	-0.15	0.84**	-0.15
FCR ²					-0.17	0.91**	-0.17	0.90**
MECR ¹						-0.31	0.98**	-0.31
MECR ²							-0.31	0.97**
PCR ¹								-0.31

BWG: Body weight gain. FCR: feed conversion ratio. MECR: metabolizable energy conversion ratio. PCR: protein conversion ratio.

¹ Starter period (0–2 WOA). ² Grower period (3–5 WOA); * $P < 0.05$; ** $P < 0.01$.

The economic output parameters of broilers fed diets containing the synbiotic Biomin are presented in Table 12. Feeding broilers with diets containing the 0.075 and 0.0375% Biomin®IMBO during the starter and grower periods significantly improved production index and revenue margin/broiler ($P < 0.05$). Mean broiler live weight was

significantly higher ($P < 0.05$) in broilers fed starter diets containing 0.075, 0.15 and 0.125% Biomin®IMBO when compared with those fed control diet and starter diets containing 0.1% synbiotic.

Table 12. Economic output parameters of broilers

Wirtschaftlichkeitsparameter

Item	Treatments				
	T1	T2	T3	T4	T5
Production index	123 ± 1.82 ^{ab}	98.5 ± 11.1 ^b	126 ± 2.21 ^a	119 ± 2.24 ^{ab}	114 ± 4.21 ^b
Feed cost/kg live broiler (US) ¹	0.89 ± 0.01 ^b	1.009 ± 0.05 ^a	0.91 ± 0.01 ^b	0.93 ± 0.07 ^b	0.92 ± 0.01 ^b
Revenue margin/broiler (US) ²	5.98 ± 0.10 ^b	5.11 ± 0.16 ^c	6.25 ± 0.09 ^a	5.96 ± 0.10 ^b	5.69 ± 0.18 ^b
Broiler live weight (g)	2334 ± 46.2 ^c	2179 ± 101 ^{abc}	2511 ± 64.0 ^b	2540 ± 40.6 ^b	2565 ± 11.9 ^a

^{a-c} Means (± standard error) within each row of dietary treatments with no common superscript differ significantly ($P < 0.05$).

T1: control 0%; T2: recommended level by manufacturer; T3: 25% lower than recommended level by manufacturer; T4: 50% higher than recommended level by manufacturer; T5: 25% higher than recommended level by manufacturer.

¹ Feed cost at 0.44 per kg. ²Cost of whole dressed broiler at 3.3 per kg.

Discussion

Feeding synbiotic in broiler diets at the recommended concentration by the manufacturer (0.1%) and at higher levels (0.15 and 0.125%) significantly improved BW gain during the 2nd WOA. While the effect of the Biomin®IMBO was more pronounced at early age of broilers, significant improvement in BW gain was also noted during the grower phase. Correlation coefficients between the Biomin®IMBO and BW gain during the starter phase were positive and significant implying that synbiotic had influence enhancing the growth of broilers. Previous reports also demonstrated that inclusion of probiotics in broiler diets have the potential for improving body weight gain and overall performance in broilers. MOUNTZOURIS et al. (2007) reported that inclusion of a probiotics containing lactobacillus, bifidobacterium, enterococcus, and pediococcus strains in broiler diet improved body weight gain and significantly lowered feed conversion ratio. Further, AWAD et al. (2008) demonstrated that feeding the synbiotics Biomin®IMBO containing *Enterococcus faecium* and oligosaccharide to broilers significantly improved average body weight gain and feed conversion ratio. Earlier trials by JIN et al. (1998), in agreement with our findings, showed significant weight gain in broiler fed diets containing probiotics. In other earlier studies, YEO and KIM (1997) reported that the daily weight gain of chicken fed diet containing probiotics significantly increased when compared with control group. The positive effect of probiotics on BW gain of broilers has also been cited in many other reports (MIDILLI and TUNCER, 2001; KABIR et al., 2004). Feeding broilers a probiotics constituted using *Lactobacillus acidophilus*, *Bifidobacterium bifidum*, *Lactobacillus casei* bacteria, and the fungi *Aspergillus oryzae* and *Torulopsis*, MOHAN et al. (1996) observed higher live weight gains as opposed to feeding flavomycin antibiotics. However, conversely to these reports and to our observations, there are a few reports that failed to demonstrate significant improvement in body weight gain of broilers fed diets containing probiotics (KARIMI and RAHIMI, 2003; KHAKSEFIDI and RAHIMI, 2004). In a more recent study on the effect of probiotics on bird performance, KABIR et al. (2004) reported a significant increase in live weight of broilers during their 2–6 WOA. These findings were also in agreement with reports of KALAVATHY et al. (2003) and ISLAM et al. (2004) and ASHAYERIZADEH et al. (2010). In our study, correlations between body weight gain and both the ME and CP conversion ratios were negative and significant. This implies that the efficiency of utilization of dietary ME and CP, which was due in part to the inclusion of Biomin®IMBO into broiler feed, was directly associated with the improvement in BW gain of the broilers. Feed conversion ratio was also significantly lower during the starter phase and at 3 WOA in broilers fed diets containing the Biomin®IMBO when compared with the control. This improvement was also associated with dietary synbiotic as demonstrated by the negative and highly correlations between dietary synbiotic and FCR. Findings of MOUNTZOURIS et al. (2007) indicated that the inclusion of a probiotics in broiler diet significantly lowered feed conversion ratio.

Contrary to these findings, O'DEA et al. (2006) did not observed any significant differences in feed efficiency between the probiotics treated birds and control. However, data reported by ECKERT et al. (2010) were in agreement with our observations. They reported that broilers fed probiotics by intermittent drinking water application had increased body weight and improved FCR from hatch to 40 days when compared with control birds. In other reports, in disagreement to our findings, KHALAJI et al. (2010) investigating the effect of prebiotics on broiler performance reported that there were no differences in feed efficiency between the birds fed probiotics and control. Recently, HAJATI (2010) evaluated the effect of probiotics on growth performance in Mazandaran native broiler, reporting improvement in feed intake, live weight gain as well as feed conversion ratio in when fed probiotics.

The improvement in feed conversion ratios and body weight gain of broilers fed the synbiotic Biomin®IMBO may have been associated with increased intake of dietary protein. NAHASHON et al. (1994) reported a significant increase in retention of nitrogen when Single Comb White Leghorn chickens were fed diets supplemented with a probiotics containing *Lactobacillus acidophilus*. In more recent findings, while evaluating the effect of antibiotics, probiotics and prebiotics on growth response of broilers at 42 days, ASHAYERIZADEH et al. (2010) reported significant improvement in live weight gain and feed conversion ratio of birds fed the probiotics, prebiotics when compared with the control treatment ($P < 0.05$). AWAD et al. (2008) demonstrated that feeding the synbiotics Biomin®IMBO containing *Enterococcus faecium* and oligosaccharide to broiler chickens significantly improved feed conversion ratios ($P < 0.05$) of the broilers. On the other hand, AWAD et al. (2009) fed probiotics and synbiotics Biomin IMBO each at 0.1% and 0.05% to broiler starter and grower diets, respectively and reported a significant decrease ($P < 0.05$) in average feed conversion ratios. These reports indicate that the differences in bird strains and also the types of probiotics or synbiotics (depending on the constitution of microorganisms) produce varying responses in performance. The time and location and climatic conditions specific to those regions where these studies are carried out may also be a contributing factor to these variations in response to feeding the probiotics or synbiotics. Since in our study feeding synbiotic Biomin®IMBO to broilers exhibited significant improvement in growth performance especially during the starter period; thus, the synbiotic could be utilized in broiler feeds to enhance nutrient utilization and efficiency as well as to minimize production cost. In fact, in this study feeding broilers with diet containing the 0.075 and 0.0375% Biomin®IMBO during the starter and grower periods improved production index and revenue margin per broiler.

Conclusions

In conclusion, feeding the synbiotic Biomin®IMBO at 0.1, 0.15 and 0.125% of diet to broilers improved BW gain and decreased feed, ME and CP conversion ratios during the starter period. Although during the grower period, the synbiotic at 0.0375 and 0.075% of diet seemed to increase feed consumption of broilers, differences in BW gain, feed consumption, and ME and CP conversion ratios were not significant. The consumption of the synbiotic did not seem to have any deleterious effect on broiler performance during the duration of this study. Thus, Biomin®IMBO may be recommended for inclusion into broiler feed based on the potential to improve performance as reported in this and other studies. Moreover, in overall, synbiotic Biomin®IMBO may be considered as a valuable alternative to antibiotics, especially during the starter period because of most studies including this synbiotic reported improved bird performance. Also, according to this study feeding broiler with 0.075% synbiotic Biomin®IMBO seems to be more cost effective level.

Summary

The aim of this study was to determine the effect of a synbiotic (Biomin®IMBO) on growth performance of broiler chickens and to determine the minimum optimal and cost effective dietary concentration of the synbiotic in diet. A total of 200 day-old male Ross-308 chickens were randomly assigned from hatch to six weeks of age (WOA) to five dietary treatments included: (T1) a basal diet without synbiotics (control), (T2) a basal diet with synbiotic levels proposed by the manufacturer (0.1%), (T3) a basal diet with synbiotic levels 25% lower than those proposed by the manufacturer (0.075%), (T4) a basal diet with synbiotic levels 50% higher than those proposed by the manufacturer (0.15%), and (T5) a basal diet with synbiotic levels 25% higher than those proposed by the manufacturer (0.125%). A three phase feeding regime consisting of starter (0–2 WOA), grower (2–5 WOA) and finisher (5–6 WOA) diets were used. Feed and water were provided at free choice and each dietary treatment was replicated four times.

Body weight (BW) gain of broilers fed diets containing the synbiotic was significantly higher ($P < 0.05$) than in birds fed control diet, especially at 0–2 WOA. Although feeding the synbiotic increased feed intake during the first WOA, it improved significantly feed efficiency of broilers during the started phase. Feeding the synbiotic at 0.075 and 0.15% of diet increased ($P < 0.05$) the consumption of metabolizable energy (ME) and crude protein (CP) of broilers. Further, although only birds fed the 0.075% of the synbiotic exhibited higher production index and revenue margin ($P < 0.05$), the live weight and feed efficiency were higher ($P < 0.05$) in broilers fed starter diets containing 0.1, 0.15 and 0.125% of the synbiotic compared to control diet. In overall, based on our findings it can be concluded that feeding broilers with 0.075% Biomin®IMBO (25% lower than proposed levels) in diet seemed to be the most cost effective level supporting also growth traits compared to the recommended levels.

Key words

Broiler, nutrition, synbiotic, growth, performance

Zusammenfassung

Einfluss eines Synbiotikums (Biomin®IMBO) auf die Mastleistung von Broilern

Das Ziel der Studie war die Untersuchung des Einflusses des Zusatzes des Synbiotikums Biomin®IMBO zum Futter auf die Leistung von Broilern sowie die Ermittlung der minimalen, optimalen und wirtschaftlichen Dosierung des Synbiotikums. Hierzu wurden insgesamt 200 männliche Eintagsküken der Herkunft Ross 308 zufällig auf 5 Behandlungsgruppen verteilt: T1 – Basisration ohne den Zusatz des Synbiotikums (0 Kontrolle), T2 – Basisration mit einem Zusatz des Synbiotikums nach Herstellerempfehlung (0,1%), T3 – Basisration mit einem gegenüber der Herstellerempfehlung um 25% geringeren Zusatz des Synbiotikums (= 0,075%), T4 – Basisration mit einem gegenüber der Herstellerempfehlung um 50% höheren Zusatz des Synbiotikums (= 0,15%), T5 – Basisration mit einem gegenüber der Herstellerempfehlung um 25% höheren Zusatz des Synbiotikums (= 0,125%). Über die Gesamtversuchsdauer von 6 Wochen wurde ein dreiphasiges Fütterungsprogramm eingesetzt: Starter (bis 2. Lebenswoche), Grower (3.–5. Lebenswoche), Finisher (5.–6. Lebenswoche). Die Futterbehandlungen wurden viermal wiederholt. Wasser und Futter standen *ad libitum* zur Verfügung.

Die Lebenstagszunahmen waren beim Zusatz des Synbiotikums signifikant höher als in der Kontrollgruppe ($P < 0,05$), vor allem in der Starterphase. Obwohl die Futteraufnahme durch den Zusatz des Synbiotikums in der ersten Lebenswoche erhöht war, war die Futterverwertung in der Starterphase besser als bei der Kontrollgruppe. Die Zulage des Synbiotikums in Höhe von 0,075 und 0,15% zum Futter erhöhte die Aufnahme an Umsetzbarer Energie (ME) und an Rohprotein (CP) signifikant ($P < 0,05$). In der Behandlungsgruppe mit einer Zulage von 0,075% des Synbiotikums wurden zwar der höchste Produktionsindex und das höchste Betriebseinkommen ermittelt, dennoch waren die erzielte Lebendmasse und die Futterverwertung in den Behandlungsgruppen mit einem Zusatz von 0,1, 0,15 sowie 0,125% des Synbiotikums im Vergleich zur Kontrollgruppe signifikant höher ($P < 0,05$). Es wurde der Schluss gezogen, dass ein Zusatz von Biomin®IMBO in Höhe von 0,075% zum Futter (dies ist 25% weniger als die Herstellerempfehlung) auch unter Berücksichtigung der erzielten Wachstumsleistung effektiver als die empfohlene Dosierung ist.

Stichworte

Broiler, Fütterung, Synbiotikum, Wachstum, Leistung

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