Effects of feed additives with synbiotic activity in broiler chickens on nutrient digestibility

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SUMMARY

The purpose of this study was to evaluate the effects of synbiotic and organic acids supplements, in the presence of chelated Zn, on digestibility of major nutrients of diets. The trial was conducted on 150 Ross chicks aged 2 days, assigned to 5 experimental groups, with 30 chicks/group. The birds were housed in metabolic cages (6 chicks/cage) in the poultry experimental hall of the Laboratory of Nutrition Physiology within IBNA Balotesti. The experimental diets (E1-E4) differed from the control diet (C) (conventional diet) by the replacement of the inorganic Zn with an organic source (chelated Zn). On top of that, group E2 received 1% synbiotic supplement, group E3 received 0.15% organic acids supplement, while group E4 received a mixture of 1% synbiotic and 0.15% organic acids.

During the final week of the experiment, for 5 days per week, the amount of given feed, the feed leftovers and the droppings were recorded with accuracy for each individual cage, as data for the nutrients balance. No significant differences were noticed for Cu, Fe, Mn digestibility parameters, but increasing values of absorption coefficients for Zn were noticed under organic source influence (absorption: 20.72% for C and 27.60% for E1, 29.21% for E2, 30.41% for E3, 30.46% for E4 respectively).

Keywords: synbiotics, organic acids, chelated zinc, broiler, digestibility.

INTRODUCTION

Gut health plays an important role in the digestion and absorption of nutrients, while also exerting a barrier function. Poor gut health has been led the broiler industry to new research for improvements. An alternative to antibiotics used as growth promoters are organic acids and synbiotics (Huyghebaert et al., 2011).

Organic acids and their salts are generally regarded as safe for animal production, and they are approved in many EU states. The use of organic acids has been reported to enhancement of nutrient utilization, growth and feed conversion efficiency (Denli et.al., 2003). Organic acids have antibacterial effects, acting on cells by penetrating the cell wall and disrupt the normal physiology of certain types of bacteria (Dhawale, 2005). Organic acids reduce the pH of digesta, increase the pancreatic secretion and have trophic effects on the gut (Dibner and Buttin, 2002). Acidification with organic acids has been reported to improve the digestibility of calcium, phosphorus, magnesium, zinc (Kirchgessner and Roth, 1988) and reduce the production of toxic compounds produced by bacteria (Langhout, 2000).

By a simple definition, synbiotics are a mixture of probiotics and prebiotics (Schrezenmeir and de Vrese, 2001). According to reports, probiotic products prevent colonization of the gut with pathogenic bacteria such as *Salmonella* through the competitive exclusion mechanism (Abudabos et al., 2013, Teo and Tan, 2006). According to research studies, synbiotic products improve the immune system of broilers (Zhang et al., 2006). Synbiotics product can improve the absorption of glucose and lead to a better performance in poultry production (Awad et al., 2008).

The purpose of this study was to evaluate the effects of synbiotic and organic acids supplements, in the presence of chelated Zn, on digestibility of major nutrients of diets.

Material and Methods

The experiment was performed comply with Directive 2010/63/EU on the protection of animals used for scientific purposes and all procedures described, were approved by Ethical Commission of National Research and Development Institute for Biology and Animal Nutrition.

Experimental design

The experiment was conducted on 150, Ross 308 chicks aged 2 days assigned to 5 experimental groups with 30 chicks per group. The chicks were housed in 5 metabolic cages/group (6 chicks/cage) in the poultry experimental hall of the Laboratory of Nutrition Physiology within IBNA Balotesti. The chickens had free access to the feed and water.

The experiment was conducted for 40 days, in the last 5 days samples of manure were collected in order to perform the nutritional balance. A daily recording of feed consumption, feed leftovers and excreta were registered. Absorption coefficients assessment of dry matter, organic matter, crude protein, crude fat, crude fiber, crude ash, Cu, Fe, Mn and Zn from feed were calculated based on chemical determinations of ingesta and excreta samples, corroborated with daily recordings of feed consumption and excreta quantity. Apparent absorption coefficient represents the ratio:

(absorbed nutrients / ingested nutrients quantity)*100, where the absorbed quantity represents the difference between the ingested amount and the excreted amount (Khan et al., 2003).

Diets

In accordance with the objectives of the experiment, the five experimental diets were similar in their proximate composition. The experimental diets differed from the control diet (C) (conventional diet) by the replacement of the inorganic Zn with an organic source (chelated Zn) for group E1. Group E2 received E1 diet and 1% synbiotic supplement, group E3 received E1 diet and 0.15% organic acids supplement, while group E4 received E1 diet and a mixture of 1% synbiotic and 0.15% organic acids.

The following supplements were considered for utilization:

- A commercial product, BiotronicR SE Forte, produced by BIOMIN, GmbH Austria. According to the manufacturer, it is a synergic combination of organic acids, inorganic acids and their salts; the combination with plant extracts aims to prepare the digestive tract of poultry, improving digestibility and inhibiting the proliferation of gram-negative bacteria. According to the technical specification, the product contains formic acid (19.2%); propionic acid (19.2%); lactic acid; citric acid; sorbic acid; it has a pH of 4.0.

- A commercial product, BiominR IMBO Pro/prebiotic, produced by BIOMIN, GmbH Austria. According to the manufacturer, the essential concept is the principle of competitive exclusion, being an alternative to antibiotics and growth promotors. The product is a combination of 4 products with synergic action: "Enterococcus faecium" probiotic; "fructo-oligosaccharide – inulin" prebiotic; cell walls fragments; phycophytic substances (derived from sea algae).

- A commercial product, chelated Zn, E.C.O.Trace® Trace minerals, produced by Biochem Zusatzstoffe Handels- und Produktionsgesellschaft mbH Küstermeyerstr, Germany.

Chemical analysis

The samples (feed, faeces) were dried at 650C using a stove BMT model ECOCELL Blueline Comfort (Nuremberg, Germany) and grounded using laboratory mill Grindomix GM 200 (Retsch, Germany).

The crude protein of the feed and droppings samples, was determined with Kjeldahl reference method using a semiautomatic Kjeltek auto 1030 – Tecator (SR EN ISO 5983-2, 2009). The fat was extracted using an improved version of the classical method by continuous extraction in solvent, followed by fat measurement with Soxhlet after solvent removal (SR ISO 6492, 2001). Trace minerals (Cu, Fe, Mn, Zn) concentrations were determined in collected samples using flame atomic absorption spectrometry (FAAS) as described by Untea et al., (2012) after microwave digestion, by using Thermo Electron – SOLAAR M6 Dual Zeeman Comfort (Cambridge, UK) equipment.

Statistics

The analytical results have been compared with the variance analysis (ANOVA), with WINDOWS StatView (SAS, version 6.0). The differences of the average values were considered significant for $P < 0.05$. The results have been expressed as mean ± SD for all measurements.

RESULTS AND DISCUSSION

As we shown in a previous study of this experiment, the production parameters showed no significant differences between groups, in terms of: total gain (kg); average daily feed intake (g CF/chick/day); feed conversion ratio (kg CF/kg gain), except for the body weight, where group E3 had significantly ($P \leq 0.05$) higher results than group E4 (Untea and Panaite., 2016). No mortality among broilers was recorded during the study.

In order to be able to study nutrient digestibility, the experiment was carried out using digestibility cages for possibility to record daily feed intake and amount of excreted manure. These values, corroborated with the analytical data on nutrient concentrations in feed and manure, allowed the balance calculations to be made. The results obtained for the balance parameters are presented in Tables 1 and 2.

According to statistical data there were no significant differences ($P > 0.05$) between groups for absorption of dry matter, organic matter, crude protein and crude ash. The results obtained in the study of digestibility of dry matter and crude protein are similar with values obtained by Garcia et al., (2007), in a study on broiler chickens, in which the experimental diets were supplemented with plant extracts and organic acids. Other authors have observed in pig studies an increase in digestibility of dry matter, organic matter and crude ash under the influence of organic acid supplements (Doyle et al., 2001). Li et al., (2007) reported increases in digestibility of the protein under the influence of oligosaccharide supplements.

In the present study, a significant decrease in crude fat and crude fiber absorption coefficients was observed for E2 (group supplemented with synbiotic) compared to the other groups studied. Volek et al., 2007 reported in a study on rabbits a decrease in fiber digestibility under the influence of mannose oligosaccharide.

Table 1. Data on digestibility of macronutrients from the broiler chickens.

	C	E1	E2	E3	E4
Dry matter					
Ingested (g/day)	133.46 ± 18.8	131.23 ± 14.4	124.09 ± 10.9	133.36 ± 10.8	134.52 ± 19.7
Excreted (g/day)	29.43 ±3.8	29.07 ± 2.8	28.22 ± 2.0	30.38 ± 2.7	29.28 ±2.6
Absorbed(g/day)	104.03 ± 15.1	102.16 ± 11.9	95.87 ± 9.0	102.98 ± 8.9	105.24 ± 17.7
Absorption (%)	77.91 ± 0 8	77.81 ± 1.0	77.23 ± 0.7	77.20 ±1.0	78.07 ± 1.8
Organic matter					
Ingested (g/day)	125.96 ± 17.8	123.86 ± 13.6	117.11 ± 10.3	125.87 ± 10.2	126.96 ± 18.6
Excreted (g/day)	29.43 ± 3.8	29.07 ± 2.8	28.22 ± 2.0	30.38 ± 2.4	29.28 ± 2.6
Absorbed(g/day)	96.53 ± 14.1	94.79 ± 11.2	88.89 ± 8.4	95.49 ± 8.3	97.68 ± 16.5
Absorption (%)	76.60 ± 0.8	76.49 ± 1.1	75.87 ± 0.8	75.84 ± 1.1	76.8 ± 1.90
Crude protein					
Ingested (g/day)	26.89 ± 0.3	26.44 ± 0.3	25.0 ± 0.2	26.87 ± 0.2	27.1 ± 0.4
Excreted (g/day)	7.89 ± 0.1	7.63 ± 0.1	7.18 ± 0.1	7.79 ± 0.1	7.94 ± 0.1
Absorbed(g/day)	19.0 ± 0.2	18.81 ± 0.2	17.82 ± 0.2	19.08 ± 0.2	19.16 ± 0.3
Absorption (%)	70.57 ± 1.7	71. 12 ± 2.2	71.16 ± 2.6	70.98 ± 1.7	70.46 ± 2.8
Crude fat					
Ingested (g/day)	10.18 ± 0.1	10.01 ± 0.1	9.46 ± 0.1	10.17 ± 0.1	10.26 ± 0.1
Excreted (g/day)	0.95 ± 0.1	0.93 ± 0.0	1.02 ± 0.0	0.97 ± 0.0	0.92 ± 0.0
Absorbed(g/day)	9.23 ± 0.1	9.07 ± 0.1	8.44 ± 0.1	9.2 ± 0.1	9.34 ± 0.1
Absorption (%)	90.61 ± 0.6[a]	90.64 ± 0.6[a]	89.21 ± 0.8[b]	90.45 ± 0.6[a]	90.94 ± 0.9[a]
Crude fiber					
Ingested (g/day)	5.56 ± 0.1	5.47 ± 0.1	5.17 ± 0.1	5.56 ± 0.1	5.6 ± 0.1
Excreted (g/day)	3.59 ± 0.1	3.42 ± 0.0	3.61 ± 0.1	3.57 ± 0.0	3.51 ± 0.0
Absorbed(g/day)	1.97 ± 0.1	2.04 ± 0.1	1.56 ± 0.0	1.99 ± 0.0	2.09 ± 0.1
Absorption (%)	35.34 ± 1.4[ab]	37.12 ± 3.3[a]	30.29 ± 2.6[b]	35.50 ± 5.6[ab]	36.64 ± 6.6[a]
Crude ash					
Ingested (g/day)	6.75 ± 0.1	6.64 ± 0.1	6.28 ± 0.1	6.75 ± 0.1	6.81 ± 0.1
Excreted (g/day)	4.4 ± 0.1	4.14 ± 0.0	3.99 ± 0.0	4.39 ± 0.0	4.22 ± 0.0
Absorbed(g/day)	2.36 ± 0.1	2.5 ± 0.1	2.29 ± 0.0	2.36 ± 0.0	2.59 ± 0.1
Absorption (%)	34.69 ± 2.5	37.46 ± 3.5	36.36 ± 2.1	34.83 ± 2.6	37.63 ± 5.0

Note: Means within a row with no common superscript differ (P < 0.05)

Lipinski et al., 2005 observed the same effect of mananoligosaccharide on fiber absorption in a study on piglets. The authors mentioned attribute this effect to the poor activity of the cellulosic enzymes present in the caecum. Some authors considered that the use of non-digestible oligosaccharides in pigs diets produce proteins degradation in the large intestine. This process leads to production of branch chain fatty acids and release of ammonia which is harmful to animals (Verstegen et al., 2001).

The digestibility parameters of copper showed a significant decrease in the amount of eliminated copper (P≤0.05), in the case of the group supplemented with synbiotic (E2) compared cu C group. The highest absorption coefficient was calculated for E2, but the differences from the other groups were not statistically supported.

Table 2. Data on digestibility of micronutrients from the broiler chickens.

	C	E1	E2	E3	E4
Copper					
Ingested (mg/day)	1.34 ± 0.1	1.30 ± 0.2	1.21 ± 0.1	1.30 ± 0.1	1.31 ± 0.2
Excreted (mg/day)	1.05 ±0.1[c]	1.01 ± 0.1	0.89 ± 0.1[ad]	1.05 ± 0.1[c]	0.98 ± 0.1
Absorbed(mg/day)	0.29 ± 0.2	0.29 ± 0.2	0.32 ± 0.1	0.26 ± 0.1	0.33 ± 0.1
Absorption (%)	21.30 ± 10.6	21.40 ±9.8	26.10 ± 6.4	19.47 ±4.2	24.79 ± 8.3
Iron					
Ingested (mg/day)	31.78 ± 3.4	31.27 ± 3.1	28.79 ± 2.5	30.95 ± 2.5	31.21 ± 4.6
Excreted (mg/day)	27.71 ± 2.6	26.39 ± 2.9	25.15 ± 1.4	26.80 ± 2.5	25.80 ± 2.6
Absorbed(mg/day)	4.07 ± 1.2	4.88 ± 1.8	3.64 ± 1.1	4.15 ± 0.8	5.40 ± 3.1
Absorption (%)	12.69 ± 2.9	15.57 ±5.3	12.45 ± 2.7	13.44 ±2.7	16.61 ± 8.7
Manganese					
Ingested (mg /day)	12.10 ± 1.3	11.75 ±1.7	10.96 ± 1.0	11.78 ±1.0	11.88 ± 1.7
Excreted (mg/day)	10.09 ± 0.7[c]	9.20 ± 1.2	8.54 ± 0.3[ad]	9.64 ± 1.0	9.27 ± 0.7
Absorbed(mg/day)	2.01 ± 0.8	2.55 ± 1.5	2.43 ± 0.9	2.14 ± 0.6	2.61 ± 1.0
Absorption (%)	16.27 ± 5.1	20.77 ±4.5	21.76 ± 5.7	18.16 ±5.2	21.34 ± 5.2
Zinc					
Ingested (mg /day)	13.91 ± 1.7	14.05 ±2.1	13.10 ± 1.1	14.08 ±1.1	14.20 ± 2.1
Excreted (mg/day)	11.03 ± 1.4	10.15 ±1.5	9.32 ± 1.5	9.84 ± 1.5	9.99 ± 2.5
Absorbed(mg/day)	2.88 ± 0.4[b]	3.90 ± 1.0[a]	3.79 ± 0.5[a]	4.24 ± 0.5[a]	4.22 ± 0.7[a]
Absorption (%)	20.72 ± 1.2[b]	27.60 ± 4.9[a]	29.21 ± 5.8[a]	30.41 ± 5.3[a]	30.46 ± 8.0[a]

Note: Means within a row with no common superscript differ ($P < 0.05$)

The same situation was observed for manganese, the differences between the apparent absorption coefficients being not significant ($P > 0.05$) between groups. No statistically significant differences were observed for iron parameters, although the lower absorption values were calculated for group E2 and the highest for group E4. In the case of zinc, ingested and excreted amounts did not differ significantly. The values obtained for zinc quantities absorbed by animals and the apparent absorption coefficients, were significantly higher ($P \leq 0.05$) for the experimental groups compared to group C. These observations lead to the hypothesis that the determining factor of the increasing absorptions is the administration of the organic form of zinc (chelated) in the diets of broilers from experimental groups. A possible explanation could be the replacing of inorganic zinc with chelating zinc improve the digestibility by thinning the intestinal wall and increasing the size of the villus and decrease crypt depth (Ma et al.,2011). Organic zinc sources are transported to the wall of the intestine without altering the structure, with this mechanism the bioavailability of organic zinc is higher than that of inorganic zinc (Jahanian et al.,2008).

To measure the impact of new nutritional solutions on the environment, determinations of trace mineral concentrations from chicken manure were performed. The results obtained are shown in Table 3.

Table 3. The amount of trace minerals in droppings

Group	Cu (mg/kg)	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
C	35.97 ± 5.8	945.69 ± 47.4	345.31 ± 26.1^{b}	368.27 ± 6.7
E1	34.79 ± 2.9	908.75 ± 71.2	315.87 ± 19.0^{a}	348.82 ± 39.5
E2	31.68 ± 1.9	892.34 ± 25.5	303.37 ± 17.6^{a}	329.16 ± 35.9
E3	34.51 ± 0.8	881.88 ± 39.3	317.51 ± 23.3^{a}	323.21 ± 33.4
E4	33.54 ± 3.1	883.57 ± 78.0	317.30 ± 15.4^{a}	338.28 ± 62.7

Note: Means within a row with no common superscript differ ($P < 0.05$)

For all the studied trace minerals, lower concentrations were determined in the experimental groups compared to C group. In the case of manganese, the differences were significant ($P \leq 0.05$). From the data presented, it can be concluded that the supplements used in experimental diets of the broilers did not increase the elimination of trace minerals through the manure and implicitly the negative impact of animal husbandry on the environment has not been amplified.

CONCLUSIONS

The results of the present study showed a significant negative influence of synbiotic supplements on crude fat and crude fiber digestibility. The organic form of zinc (chelated) used in experimental diets lead to an increased absorption of zinc and the dietary supplements used in the experiment, did not amplified the negative impact of animal husbandry on environment.

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