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Performance and economic viability of broiler chicken fed diets with multienzyme complexes

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ABSTRACT. This study evaluated the effect of multienzyme complexes (EC1 and EC2) in low nutritional density diets on performance and economic viability of broilers. A total of 840 day-old chicks were assigned to 7 treatments, distributed in a completely randomized design: (1) PC: positive control, basal diet formulated to meet nutritional requirements; (2) NC1: negative control, reduced energy and nutrient density diet without enzymes; (3) NC1+EC1; (4) NC2: negative control, diet formulated with 7% over-estimated crude protein and amino acids of soybean meal without enzymes; (5) NC2+EC2; (6) NC3: negative control, reduced energy and nutrient density diet and over-estimation of crude protein and amino acids of soybean meal; (7) NC3+EC1+EC2. Feeding NC1 or NC3 impaired feed conversion ratio at 7, 21 and 42 days, and NC2 at 21 days. Inclusion of EC2 in NC2 diet improved feed conversion ratio and kept it similar to basal diets from 1 to 21 days. Association of EC1 with EC2 in NC3 diet did not improve performance. In summary, inclusion of EC2 in diets with reduced nutrient density keep feed conversion ratio similar to basal diets from 1 to 21 days but does not improve performance of broiler chicken from 1 to 42 days post-hatch.

Keywords: exogenous enzymes, poultry, enzyme complexes.

Desempenho e viabilidade econômica com utilização de complexos enzimáticos em dietas para frangos de corte

RESUMO. Avaliou-se o efeito da inclusão de complexos enzimáticos (CE1 e CE2) em dietas com níveis reduzidos sobre desempenho e viabilidade econômica de frangos. Foram utilizados 840 pintos, distribuídos em delineamento inteiramente casualizado com sete tratamentos e quatro repetições: 1) controle positivo (CP), dieta formulada para atender às exigências nutricionais; 2) controle negativo 1 (CN1), dieta com níveis nutricionais reduzidos; 3) CN1+CE1; 4) CN2: dieta com proteína e aminoácidos do farelo de soja valorizados em 7%; 5) CN2+CE2; 6) CN3: dieta com níveis reduzidos, e farelo de soja valorizado em 7% para proteína e aminoácidos; 7) CN3+CE1+CE2. A conversão alimentar foi maior em aves que receberam dietas CN1 ou CN3 aos sete, 21 e 42 dias, e CN2 aos 21 dias. A inclusão de CE2 na dieta CN2 melhorou a conversão alimentar em relação a CN2, tornando-a semelhante à de aves alimentadas com dieta CP aos 21 dias. A associação de CE1+CE2 na dieta CN3 não favoreceu o desempenho. Portanto, o uso de complexo enzimático (CE2) em dieta com níveis reduzidos mantém a conversão alimentar similar à de aves recebendo dieta-padrão no período de um a 21 dias, porém, no período de um a 42 dias, não melhora o desempenho de frangos.

Palavras-chave: enzimas exógenas, aves, complexos multienzimáticos.

Introduction

The inclusion of exogenous enzymes in broiler diets has been increasingly intensified with the objective of maximizing nutrient utilization and reducing feed costs, thus improving dietary nutritional and energy levels (Adeola & Cowieson, 2011).

Exogenous enzymes improve the nutritional value of feed ingredients due to the degradation of specific bonds not efficiently hydrolyzed by the endogenous digestive enzymes of birds and to the degradation of antinutritional factors that may impair the digestion of nutrients. Enzymes cause the disruption of the plant cell wall integrity and consequent release of nutrients encapsulated by the cell wall (Ravindran, 2013).

The use of exogenous enzymes in feed for monogastric animals can be done on top, that is, without considering the nutritional contribution promoted by the activity of enzymes in the nutritional matrix of the enzymatic product. Another way of including enzymes in the diet is to reformulate the diets considering the nutritional matrix of the product. When using exogenous enzymes in monogastric diets, with the expected improvement in nutrient digestion, it is possible to reduce the inclusion of high-cost ingredients like the soybean oil and soybean meal, thus allowing a reduction in feed cost, while maintaining the performance of poultry similar to that of achieved with a standard diet (Zhang, Yang, Zhang, Yang, & Jiang, 2012; Zou, Zheng, Zhang, Ding, & Bai, 2013; Romero et al., 2014). Nevertheless, the strategic use of enzymes should be done taking into account the nutritional equivalence of the enzymatic products, because the use of inadequate (high) nutritional matrices, that is, the reformulation of the diet with nutritional and energy reductions wrongly performed, can disguise or even impair the benefit generated by the inclusion of enzymes (Adeola & Cowieson, 2011).

Studies have indicated that the values of metabolizable energy and digestible amino acids of soybean can be over-estimated by 5 to 9% when exogenous enzymes are included in diets for broilers (Garcia, Murakami, Branco, Furlan, & Moreira, 2000).

In studies conducted by Zhou, Jiang, Lv, and Wang (2009), for example, the inclusion of an enzymatic product containing xylanase, protease and amylase improved the energy utilization of the diets, especially in diets formulated with the lowest energy levels. On the other hand, Yegani and Korver (2013) did not find benefits with the inclusion of different enzymes in broiler diets, assigning the inconsistency of effects to the nutritional matrix used in the enzymatic products.

With the widespread use of several enzymes in diets for monogastric animals, there is an increasing tendency to use different enzymatic products in the diets, which requires the use of nutritional matrices appropriate to the enzymatic complexes, that is, an adjusted reformulation of the nutritional and energy levels to avoid possible damages to the performance or economic viability of production.

In this context, this study evaluated the inclusion of two enzymatic complexes, combined or not, in diets based on corn and soybean meal, reformulated with reduced energy and nutritional levels, on the performance and economic viability of broilers.

Material and methods

All the experimental procedures performed in this study were approved by the Ethics Committee on Animal Use (CEUA) of Unesp, Dracena campus (protocol 19/2011).

A total of 840 day-old male broilers (Cobb-500) were distributed in 2.5 m^2 boxes equipped with a pendulum drinker and a tubular feeder. The experimental design was completely randomized with seven treatments and four floor pens of 30 birds each per treatment.

The dietary treatments consisted of: (1) PC: positive control, diet formulated according to the recommendations of Rostagno et al. (2011), with no enzymes; (2) NC1: negative control, diet with reductions of 75 kcal kg^{-1} AME, 0.20 CP, 0.029% of digestible lysine, 0.020% digestible methionine + cystine, 0.014% digestible threonine, 0.10 Ca and 0.10% available P with no enzymes; (3) NC1 + EC1: diet NC1 with enzyme complex 1 (EC1); (4) NC2: negative control, with 7% over-estimated crude protein and amino acids of soybean meal, with no enzymes; (5) NC2+EC2: diet NC2 with enzyme complex 2 (EC2); (6) NC3: negative control, with nutritional reductions similar to NC1 and over-estimation of soybean meal (+7% for crude protein and amino acids), with no enzymes; (7) NC3+EC1+EC2: diet NC3 with enzyme complexes 1 and 2 (EC1 and EC2). Nutritional and energy modifications, as well as the inclusion rates of the enzyme products in the feed, were performed according to the recommendation of the manufacturer of the enzymatic complexes. The EC1, used at 200 g ton^{-1} feed, consists of pectinase (4000 AJDU g^{-1}), protease (700 HUT g^{-1}), phytase (300 SPU g^{-1}), beta-glucanase (200 BGU g^{-1}), xylanase (100 XU g^{-1}), cellulase (40 CMCU g^{-1}) and amylase (30 FAU g^{-1}), obtained from the fermentation of *Aspergillus niger*. The EC2, used at a dose of 500 g ton^{-1} feed, consists of protease (7500 HUT g^{-1}) and cellulase (45 CMCU g^{-1}), obtained from the fermentation of *Aspergillus niger* and *Trichoderma longibrachiatum*.

Proximate and calculated composition of experimental diets at pre-starter (1 to 7 days), starter (8 to 21 days), grower (22 to 33 days) and finisher (34 to 42 days) phases are listed in Tables 1 and 2.

The performance variables evaluated were weight gain (WG), feed intake (FI) and feed conversion ratio (FCR), which were obtained by weighing broilers and feed, at 7, 21 and 42 days of age. Viability (VB) was calculated with the following formula: (100 - mortality in percent).

The economic profitability assessment took into account the average cost of feed, cost per bird, profit per bird and profitability index (Martin, Serra, Oliveira, Angelo, & Okawa, 1998).

Table 1. Ingredients and calculated composition of diets at pre-starter and starter phases.

Ingredients (%)	Pre-starter				Starter			
	CP	CN1	CN2	CN3	CP	CN1	CN2	CN3
Corn	54.71	58.15	58.41	59.72	58.90	62.35	62.25	63.56
Soybean meal[1]	38.51	37.53	35.37	34.81	34.95	33.97	32.11	31.54
Soybean oil	2.32	0.41	1.67	0.48	2.27	0.36	1.68	0.49
Limestone	0.92	1.17	0.92	1.16	0.91	1.16	0.91	1.15
Dicalcium phosphate	1.89	1.11	1.92	1.15	1.53	0.74	1.55	0.78
Common salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Sodium bicarbonate	0.23	0.23	0.23	0.23	0.19	0.19	0.19	0.19
DL-methionine	0.35	0.33	0.35	0.33	0.28	0.26	0.28	0.26
L-lysine	0.22	0.21	0.23	0.21	0.16	0.15	0.17	0.16
L-threonine	0.10	0.09	0.10	0.09	0.06	0.05	0.06	0.05
Premix[2,3]	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Inert	-	0.02	0.05	1.07	-	0.02	0.05	1.07
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Composition								
AMEn (kcal kg^{-1})	2.950	2.875	2.950	2.875	3.000	2.925	3.000	2.925
Crude protein (%)	22.20	22.00	22.20	22.00	20.80	20.60	20.80	20.60
Dig. Methionine (%)	0.63	0.62	0.63	0.62	0.55	0.54	0.55	0.54
Dig. Met+Cys (%)	0.92	0.90	0.92	0.90	0.83	0.81	0.83	0.81
Dig. Lysine (%)	1.31	1.28	1.31	1.28	1.17	1.14	1.17	1.14
Dig. Threonine (%)	0.84	0.83	0.84	0.83	0.80	0.79	0.80	0.79
Calcium (%)	0.92	0.82	0.92	0.82	0.82	0.72	0.82	0.72
Av. Phosphorus (%)	0.40	0.30	0.40	0.30	0.34	0.24	0.34	0.24
Sodium (%)	0.22	0.22	0.22	0.22	0.21	0.21	0.21	0.21

[1]In diets CN2 and CN3, soybean meal was over-estimated by 7% for crude protein and amino acids, according to nutritional matrix of EC2. [2]Vitamin and mineral premix for pre-starter phase (guarantee levels per kg feed): vitamin A: 8,000 IU, vitamin D3: 2,400 IU, vitamin E: 12.00 IU, vitamin K3: 2.00 mg, vitamin B1: 2.40 mg, vitamin B2: 6.00 mg, vitamin B6: 4.00 mg, vitamin B12: 14.00 μg, niacin: 40.00 mg, pantothenic acid: 15.00 mg, folic acid: 1.00 mg, copper: 10.00 mg, iron: 50.00 mg, manganese: 70.00 mg, zinc: 50.00 mg, iodine: 1.20 mg, selenium: 0.20 mg, halquinol: 30.00 mg, monensin: 100 mg. [3]Vitamin and mineral premix for starter phase (guarantee levels per kg feed): vitamin A: 7,000 IU, vitamin D3: 2,200 IU, vitamin E: 11.00 IU, vitamin K3: 1.60 mg, vitamin B1: 2.00 mg, vitamin B2: 5.00 mg, vitamin B6: 3.00 mg, vitamin B12: 12.00 μg, niacin: 35.00 mg, pantothenic acid: 13.00 mg, folic acid: 0.80 mg, copper: 10.00 mg, iron: 50.00 mg, manganese: 70.00 mg, zinc: 50.00 mg, iodine: 1,20 mg, selenium: 0.20 mg, halquinol: 30.00 mg, monensin: 100 mg.

The average cost (R$) per kilogram of feed was calculated considering the average cost of feed in all phases, according to the prices of ingredients, based on quotations made in July 2015. Prices per kilogram of ingredient used were: corn, R$ 0.46; soybean meal, R$ 0.73; soybean oil, R$ 2.25; limestone, R$ 0.10; dicalcium phosphate, R$ 1.45; common salt, R$ 0.42; sodium bicarbonate, R$ 1.38; DL-methionine, R$ 9.25; L-lysine, R$ 4.51; L-threonine, R$ 4.70; vitamin-mineral premix, R$ 10.77; EC1, R$ 28.50; EC2, R$ 11.00. The cost per bird was calculated considering feed cost (feed intake x feed cost) + cost of one-day-old chick (R$ 1.60 per bird) + estimated variable costs (disinfection, vaccines, medicines, electricity, labor and charges). The profit per bird was estimated from the difference between the gross treatment revenue (total number of live broilers, in kg, per treatment x average price of kg live broilers - R$ 2.20 kg^{-1}) and cost per bird. The profitability index was determined by the ratio of total treatment profit (total revenue - total cost) to total treatment revenue.

The performance data were subjected to analysis of variance (ANOVA) by the MIXED procedure of Statistical Analysis System (SAS, 2002) and, whenever necessary, the means of the treatments were compared by the Tukey's test at 5% of probability.

Table 2. Ingredients and calculated composition of diets at grower and finisher phases.

Ingredients (%)	Grower				Finisher			
	CP	CN1	CN2	CN3	CP	CN1	CN2	CN3
Corn	61.51	64.96	64.54	67.90	66.15	69.61	68.78	72.14
Soybean meal[1]	31.73	30.74	29.15	28.25	27.55	26.56	25.31	24.41
Soybean oil	3.26	1.35	2.73	0.83	3.10	1.19	2.65	0.75
Limestone	0.82	1.07	0.82	1.07	0.77	1.01	0.77	1.01
Dicalcium phosphate	1.33	0.55	1.36	0.58	1.07	0.29	1.09	0.31
Common salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Sodium bicarbonate	0.16	0.16	0.16	0.15	0.14	0.14	0.14	0.14
DL-methionine	0.25	0.23	0.25	0.23	0.24	0.22	0.23	0.21
L-lysine	0.15	0.14	0.15	0.14	0.18	0.17	0.18	0.17
L-threonine	0.04	0.03	0.04	0.03	0.05	0.04	0.05	0.04
Premix[2,3]	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Inert	-	0.02	0.05	0.07	-	0.02	0.05	0.07
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Composition								
AMEn (kcal kg^{-1})	3.100	3.025	3.100	3.025	3.150	3.075	3.150	3.075
Crude protein (%)	19.50	19.30	19.50	19.30	18.00	17.80	18.00	17.80
Dig. Methionine (%)	0.52	0.51	0.52	0.51	0.48	0.47	0.48	0.47
Dig. Met+Cys (%)	0.79	0.77	0.79	0.77	0.74	0.72	0.74	0.72
Dig. Lysine (%)	1.08	1.05	1.08	1.05	1.01	0.98	1.01	0.98
Dig. Threonine (%)	0.70	0.69	0.70	0.69	0.66	0.65	0.66	0.65
Calcium (%)	0.73	0.63	0.73	0.63	0.64	0.54	0.64	0.54
Av. Phosphorus (%)	0.31	0.21	0.31	0.21	0.27	0.17	0.27	0.17
Sodium (%)	0.20	0.20	0.20	0.20	0.19	0.19	0.19	0.19

[1]In diets CN2 and CN3, soybean meal was over-estimated by 7% for crude protein and amino acids, according to nutritional matrix of EC2. [2]Vitamin and mineral premix for grower phase (guarantee levels per kg feed): vitamin A: 6,000 IU, vitamin D3: 2,000 IU, vitamin E: 10.00 IU, vitamin K3: 1.60 mg, vitamin B1: 1.40 mg, vitamin B2: 4.00 mg, vitamin B6: 2.00 mg, vitamin B12: 10.00 μg, niacin: 30.00 mg, pantothenic acid: 11.00 mg, folic acid: 0.60 mg, copper: 100 mg, iron: 50.00 mg, manganese: 70.00 mg, zinc: 50.00 mg, iodine: 1.20 mg, selenium: 0.20 mg, halquinol: 30.00 mg, salinomycin: 100 mg. [3]Vitamin and mineral premix for finisher phase (guarantee levels per kg feed): vitamin A: 5,000 IU, vitamin D3: 1,000 IU, vitamin E: 8.00 IU, vitamin K3: 1.60 mg, vitamin B1: 2.00 mg, vitamin B2: 2.00 mg, vitamin B12: 5.00 μg, niacin: 20.00 mg, pantothenic acid: 9.00 mg, copper: 8.00 mg, iron: 50.00 mg, manganese: 70.00 mg, zinc: 50.00 mg, iodine: 1,20 mg, selenium: 0.20 mg.

Results and discussion

The results of performance in the periods 1-7, 1-21 and 1-42 days are shown in Table 3. The inclusion of enzymes did not improved weight gain, which was impaired by the reduction of energy and nutritional density and by over-estimation of soybean meal, considering the periods 1-21 and 1-42 days. The lower weight gain of the birds can be attributed to the nutritional reductions of these feed, promoting nutritional deficit, thus impairing the animal growth. The lack of beneficial effect of enzymes on the weight gain demonstrates that the changes promoted in NC1, NC2 and NC3 diets may not be suitable for all the periods, since even with improved digestibility promoted by the use of enzymes, the weight gain of birds was not similar to the control diet, considering the period 1-42 days. In studies conducted by Vieira et al. (2015), the inclusion of an enzymatic product composed of amylase and glucanase in diets with a reduction of 120 kcal kg^{-1} metabolizable energy improved the weight gain of broiler chickens in the 1-40 day period, but it was not efficient to recover the weight gain similar to that of a diet that meets the requirements of birds.

Table 3. Performance of broilers fed diets containing different enzyme complexes.

Diet	Enzyme complex	WG (g)	FI (g)	FCR	VB (%)
		1 to 7 days			
PC	-	145	156	1.076a	99.22
NC1	-	134	162	1.217bc	99.19
NC1	EC1	138	158	1.156abc	98.39
NC2	-	146	162	1.113ab	100.0
NC2	EC2	138	153	1.110ab	99.19
NC3	-	136	167	1.239c	99.19
NC3	EC1+EC2	137	164	1.208bc	100.0
P-value		0.101	0.196	< 0.05	0.704
CV (%)		5.14	5.18	7.68	1.35
		1 to 21 days			
PC	-	882a	1197	1.365a	97.61
NC1	-	791c	1161	1.480b	97.58
NC1	EC1	823bc	1167	1.426ab	97.58
NC2	-	836abc	1222	1.483b	97.58
NC2	EC2	867ab	1170	1.369a	95.97
NC3	-	803c	1171	1.480b	95.97
NC3	EC1+EC2	814bc	1167	1.440ab	99.19
P-value		< 0.05	0.287	< 0.05	0.741
CV (%)		5.64	3.36	4.91	2.86
		1 to 42 days			
PC	-	2654a	4405	1.673a	96.02
NC1	-	2426cd	4235	1.759b	96.77
NC1	EC1	2498bc	4263	1.723b	95.99
NC2	-	2597ab	4417	1.713ab	96.77
NC2	EC2	2499bc	4238	1.717ab	93.55
NC3	-	2367d	4244	1.813c	95.16
NC3	EC1+EC2	2450cd	4278	1.758b	96.77
P-value		< 0.01	0.086	< 0.01	0.890
CV (%)		4.56	2.81	2.90	3.76

Mean values followed by different letters in the same column are significantly different (5%); CV: coefficient of variation. *PC: positive control; NC1: negative control with reduction of 75 kcal kg^{-1} in ME, 2.0 CP, 1.0 Ca and 1.0 g kg^{-1} P; NC2: negative control with over-estimated soybean meal (+7% in CP and amino acids); NC3: negative control with reduction applied to diet NC1 and over-estimated soybean meal (+7% in CP and amino acids). **EC1: Enzyme complex consisting of pectinase, protease, phytase, betaglucanase, xylanase, cellulase and amylase (0.02% of the diet); EC2: Enzyme complex consisting of protease and cellulose (0.05% of the diet).

The feed intake of broilers was not affected by the experimental diets in any of the evaluated periods. Several studies have indicated that the inclusion of exogenous enzymes in broiler diets does not affect feed intake (Cardoso et al., 2011; Lu et al., 2013; Vieira et al., 2015).

The supply of diets with reduced nutrient density (NC1 and NC3) impaired the feed conversion of the birds in all evaluated periods. In the period 1-7 days, the feed conversion of birds fed diets NC1, NC3 and NC3 + EC1 + EC2 was impaired when compared to the broilers that received the control diet. However, the supply of diets NC1 + EC1, NC2 and NC2 + EC2 did not affect feed conversion compared to the control diet. In the period 1-21 days, the supply of diets NC1, NC2 and NC3 diets reduced the feed conversion compared to the birds fed the control diet. Nevertheless, the use of the NC2 diet with enzyme supplementation (EC2) improved the feed conversion in relation to the NC2 diet with no enzymes and did not differ from the control diet, evidencing the benefit of the enzymes by the ability to recover the feed conversion at the starter phase of chickens, impaired by the over-estimated energy and nutrients of soybean meal. Similar results were reported by Lu et al. (2013), who used enzyme complex composed of carbohydrases and phytase and found improved feed conversion in birds receiving diets with lower nutrient and energy density, similar to that of birds fed a standard diet. The lower performance of broilers fed NC1, NC2 and NC3 diets may be related to lower inclusion of ingredients like soybean meal, dicalcium phosphate and soybean oil in these diets. Soybean oil, besides the energetic contribution, has extra-caloric effects such as the increase in retention rate of the diet in the digestive tract, thus improving nutrient digestibility (Mateos, Sell, & Eastwood, 1982). Therefore, it is probable that the lower inclusion of oil in the diets may have impaired the utilization of the nutrients in NC1, NC2 and NC3 diets in the periods 1-7 and 1-21 days, thus reducing the feed conversion of the broilers. The lower inclusion of oil in diets is a natural result when reducing the metabolizable energy of the feed, reliably reflecting what happens when nutritional matrices are applied to the enzymatic products. In addition, the inclusion of EC1, enzymatic product based on carbohydrases, phytase and protease, in the NC1 diet, did not improve feed conversion in these periods.

Similar results were observed by Madrid, Catalá-Gregori, Garcia, and Hernández (2010), when the addition of multienzyme complex consisting of protease, cellulase and amylase did not improve broiler performance, probably because it was added to diets with adequate nutritional and energetic levels and, therefore, meeting the requirements of poultry.

In this study, the combination of enzyme complexes in the NC3 diet improved the feed conversion in relation to the NC3 diet without enzymatic supplementation in the period 1-42 days (1.813 vs. 1.758). However, this improvement was not enough to make feed conversion similar to that of birds fed PC (1.758 vs. 1.673). This result indicates that the application of nutritional matrices of different enzymatic products should be done carefully, not simply adding the values of the matrices indicated by the enzymatic products.

In the present study, the beneficial effects promoted by the use of enzymatic complexes on feed conversion were more evident in the starter phases. This may be related to the lower activity of endogenous digestive enzymes in the first weeks of life of broilers. The activity of enzymes involved in digestion, such as amylase, trypsin and lipase, increases with age, especially after the second week of life (Sakomura, Del Bianchi, Pizauro Jr., Café, & Freitas, 2004). Thus, the benefits generated by the use of exogenous enzymes are likely to be more expressive when there is lower activity of endogenous enzymes involved in digestion. Similar results were verified by Kocher, Hower, and Moran (2015), when the inclusion of an enzymatic product composed of protease and xylanase improved the performance of broilers, especially in the first three weeks of age.

Diets with reduced nutritional and energy levels showed lower cost per kg of feed and cost per bird, in relation to the control diet (Table 4). This is due to the lower level of inclusion of high-cost ingredients in these diets, such as soybean meal and soybean oil, thus promoting the reduction of feed costs. Despite the reduction in feed cost, the performance of broilers fed these diets was impaired in relation to the control diet. The control diet presented a higher cost feed (R$ 0.68 kg^{-1}), and the NC1, NC2 and NC3 diets, when supplemented with enzymes, showed a small increase in cost over those not supplemented. This small increase in the cost of feed is due to the cost of enzymatic products.

Table 4. Economic analysis on the use of multienzyme complexes in diets with reduced nutritional density for broilers from 1 to 42 days post-hatch.

Diet	Enzyme complex	Feed cost (R$ kg^{-1})	Cost per bird (R$ $bird^{-1}$)	Profit per bird (R$ $bird^{-1}$)	Profitability Index (%)
PC	-	0.68	5.15	0.99	13.2
NC1	-	0.63	4.77	0.81	12.1
NC1	EC1	0.64	4.85	0.94	13.4
NC2	-	0.67	5.06	0.86	9.4
NC2	EC2	0.67	5.07	0.91	12.9
NC3	-	0.63	4.80	0.74	9.5
NC3	EC1+EC2	0.64	4.82	0.83	12.2

*PC: positive control; NC1: negative control with reduction of 75 kcal kg^{-1} in ME, 2.0 CP, 1.0 Ca and 1.0 g kg^{-1} P; NC2: negative control with over-estimated soybean meal (+7% in CP and amino acids); NC3: negative control with reduction applied to diet NC1 and over-estimated soybean meal (+7% in CP and amino acids). **EC1: Enzyme complex consisting of pectinase, protease, phytase, betaglucanase, xylanase, cellulase and amylase (0.02% of the diet); EC2: Enzyme complex consisting of protease and cellulose (0.05% of the diet).

The PC diet presented the highest cost per bird (R$ 5.15), superior to all diets containing enzyme complexes, evidencing the use of enzymes as a tool to reduce the cost of production. The profit per bird was higher in the PC diet (R$ 0.99) due to the greater weight gain of birds fed with this diet. However, the inclusion of enzyme complexes increased the profit per bird in relation to the diets NC1, NC2 and NC3.

The cost per kg feed of the NC1 + EC1 diet was lower in relation to the PC diet, and the profitability index was higher in the NC1 + EC1 diet compared to the PC diet. This result can be explained by the differences in costs and profits between treatments. The PC diet presented a final cost per bird 5.83% higher than the NC1 + EC1 diet (R$ 5.15 vs. 4.85), while the profit per bird was only 5.05% higher (R$ 0.99 vs. 0.94). With this, the profitability index was slightly higher in the diet containing EC1. In studies developed by Toledo, Costa, Silva, Ceccantini, and Poletto Junior (2007), the savings from the use of exogenous enzymes in low-density diets was 7.02% in relation to the standard diet, considering an industrial production scale of 1,000 tons body weight.

The negative control diets (NC1, NC2 and NC3) presented higher values of profitability index when supplemented with enzyme complexes (EC1, EC2 and EC1 + EC2, respectively). However, only the NC1 + EC1 diet had a higher profitability index than the PC diet. In studies conducted by Cardoso et al. (2011), the use of enzyme complex composed of carbohydrases in diets with a reduction of 117 and 233 kcal kg^{-1} metabolizable energy did not present economic advantages in broiler production.

Conclusion

The use of enzyme complex composed by protease and cellulase in diets with over-estimated crude protein and energy of soybean improves feed conversion of broilers from 1 to 21 days, keeping it similar to that attained with use of a standard diet, however does not improve performance from 1 to 42 days.

Nutritional matrices of enzyme complexes EC1 and EC2 are over-estimated and enzymatic products are not sufficient to compensate for nutritional reductions employed from 1 to 42 days.

Associated use of enzyme complexes with joint application of nutritional matrices does not favor performance and economic viability of broiler chicken.

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