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Short Communication

Sugarcane yeast inclusion for broilers at post-hatch

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ABSTRACT - A total of 450 one-day-old male broiler chicks were used to evaluate the effect of the sugarcane yeast on performance, body composition, and development of the intestinal mucosa. The experiment was carried out in a completely randomized design with five treatments and six replicates of 15 birds. Sugarcane yeast was included in the experimental diets at the levels of 0, 12.5, 25.0, 37.5, and 50.0 g kg^{-1}. Body weight, weight gain, feed intake, and feed conversion were determined. At the end of the experiment, four broiler chicks were slaughtered per experimental unit: two were used for evaluation of moisture content, crude protein, fat, and body ash and the other two were used in the collection of small-intestine segments for evaluation of villus height and crypt depth. The increasing yeast levels resulted in a linear increase in feed intake and feed conversion. Inclusion of more than 14.4 g kg^{-1} yeast resulted in a reduction of body ash content. Villus height and crypt depth in the jejunum showed maximum values at the sugarcane yeast levels of 20.9 and 20.6 g kg^{-1}, respectively. In the ileum, the crypt depth reduction at the level of 25.6 g kg^{-1} also resulted in an increase in villus:crypt ratio. Yeast inclusion increases feed intake and feed conversion, improves body mineral absorption, and increases villus height in the jejunum and the villus:crypt ratio in the ileum of broiler chicks.

Key Words: body composition, broiler, intestinal morphology, performance, *Saccharomyces cerevisiae*

Introduction

In virtue of the seasonality of production and the price variation of corn and soybean meal, many researchers have evaluated agroindustrial byproducts that can be used as alternative ingredients to feed broilers. Among these ingredients, sugarcane yeast (*Saccharomyces cerevisiae*) takes a prominent position for being a protein source of high biological value with components that act on the intestinal mucosa, improving nutrient absorption and, consequently, the performance of broilers.

In the small intestine, the villus, an intestinal mucous membrane, increases the nutrient absorption area. The cell wall of *Saccharomyces cerevisiae* has mannan-oligosaccharides (MOS), which block the fixation of certain pathogenic bacteria in the intestinal walls, favoring the growth of beneficial bacteria and preserving the intestinal mucous membrane integrity. Additionally, the extract of yeast has nucleotides and inositol, which help the cell synthesis process in the villus by increasing its size.

Lopes et al. (2011) worked with whole yeast cell and observed greater villus heights in the segments of the small intestine on the 7th day of age, without any effects on performance.

Based on the above-described considerations, this study was conducted to evaluate the effect of addition of sugarcane yeast (*Saccharomyces cerevisiae*) on performance, intestinal morphometry, and body composition of broilers from one to eight days of age.

Material and Methods

This experiment was conducted according to the recommendations of the local Committee of Ethics in Animal Use (License no. 078/2014), in Recife, PE, Brazil. The experimental period was eight days.

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Four hundred and fifty one-day-old Cobb 500 male chicks were used. Birds were placed in masonry boxes with wood shavings covering the concrete floors equipped with an automatic drinker, a semi-automatic feeder, and a heating system. The photoperiod was 24 h of light. Temperature and relative humidity were maintained within the comfort of the birds.

Chicks were distributed in a completely randomized design with five treatments and six replicates, each replicate with 15 birds. Treatments (diets) consisted of inclusion of 0, 12.5, 25.0, 37.5, and 50.0 g sugarcane yeast per kilogram of diet. The sugarcane yeast had the following chemical composition: 868.4 g kg^{-1} dry matter, 171.3 g kg^{-1} crude protein, 9.4 g kg^{-1} ether extract, 75.1 g kg^{-1} mineral matter, 128.5 g kg^{-1} crude fiber, 6.61 MJ/kg apparent metabolizable energy, 2.8 g kg^{-1} methionine, 1.3 g kg^{-1} cysteine, 4.1 g kg^{-1} methionine + cysteine, 12.9 g kg^{-1} lysine, 11.0 g kg^{-1} threonine, 7.9 g kg^{-1} arginine, 8.9 g kg^{-1} isoleucine, 13.2 g kg^{-1} leucine, 10.2 g kg^{-1} valine, 3.9 g kg^{-1} histidine, and 8.1 g kg^{-1} phenylalanine. Amino acids were analyzed by the company Evonik Brazil - Degussa Hulls.

Diets were formulated to meet the nutritional requirements recommended by the Cobb 500 guidelines, to be isoenergetic and isonutritive (Table 1). Feed and water were supplied *ad libitum*.

Feed intake, weight gain, and feed conversion were calculated at the end of the experiment. Two chicks with the average weight of each experimental unit were fasted for 8 h and slaughtered by cervical dislocation for evaluation of body composition, in which the dry matter, ether extract, crude protein, and mineral matter contents were analyzed (AOAC, 2005).

Two chicks per experimental unit were slaughtered by cervical dislocation for the collection of duodenum, jejunum, and ileum segments to be examined with a light microscope. Histological sections were photographed and

Table 1 - Composition and nutritional values of experimental diets

	Sugarcane yeast inclusion level (g kg^{-1})				
	0	12.5	25.0	37.5	50.0
Ingredient (g kg^{-1})					
Corn	515.00	508.41	501.81	495.22	488.62
Yeast	00.00	12.50	25.00	37.50	50.00
Soybean meal	394.00	390.03	386.05	382.08	378.10
Calcitic limestone	9.80	9.61	9.83	9.84	9.85
Inert	12.51	9.38	6.26	3.13	00.00
Soybean oil	31.90	33.18	34.45	35.73	37.00
Dicalcium phosphate	20.95	20.83	20.72	20.60	20.48
Mineral premix[1]	0.50	0.50	0.50	0.50	0.50
Vitamin premix[2]	1.00	1.00	1.00	1.00	1.00
Salt (NaCl)	5.18	5.12	5.07	5.01	4.95
L-lysine HCl 78.8	0.14	0.17	0.19	0.22	0.24
DL-methionine 99	2.39	2.43	2.47	2.51	2.55
L-threonine 98.5	0.63	0.65	0.67	0.69	0.71
Choline chloride 70	1.00	1.00	1.00	1.00	1.00
Adsorbent[3]	5.00	5.00	5.00	5.00	5.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Energetic and nutritional composition (calculated values)					
Apparent metabolizable energy (MJ/kg)	12.24	12.24	12.24	12.24	12.24
Crude protein (g kg^{-1})	210.0	210.0	210.0	210.0	210.0
Calcium (g kg^{-1})	10.0	10.0	10.0	10.0	10.0
Available phosphorus (g kg^{-1})	5.00	5.00	5.00	5.00	5.00
Sodium (g kg^{-1})	2.24	2.24	2.24	2.24	2.24
Chlorine (g kg^{-1})	3.54	3.50	3.46	3.42	3.38
Potassium (g kg^{-1})	8.65	8.70	8.75	8.80	8.85
Ether extract (g kg^{-1})	55.30	56.27	57.21	58.14	59.08
Crude fiber (g kg^{-1})	30.23	29.97	29.70	29.43	29.17
Digestible amino acids (g kg^{-1})					
Lysine	10.80	10.80	10.80	10.80	10.80
Methionine + cystine	8.00	8.00	8.00	8.00	8.00
Methionine	5.25	5.25	5.25	5.25	5.25
Threonine	7.80	7.80	7.80	7.80	7.80
Tryptophan	2.41	2.40	2.39	2.38	2.37

[1] Quantity per kg of products: vitamin A, 10,000,000 IU; vitamin D3, 2,000,000 IU; vitamin E, 20,000 mg; vitamin K3, 4,000 mg; vitamin B1, 1,800 mg; vitamin B2, 5,000 mg; vitamin B6, 2,000 mg; vitamin B12, 10,000 mcg; niacin, 30,000 mg; pantothenic acid, 13,500 mg; folic acid, 500 mg; selenium, 250 mg; antioxidant, 100,000.
[2] Quantity per kg of products: manganese, 150,000 mg; zinc, 140,000 mg; iron, 100,000 mg; copper, 16,000 mg; iodine, 1,500 mg.
[3] Azomite Adsorbent.

analyzed using image software Motic Images Plus 2.0. Fifteen villi and 15 crypts of each intestinal region were randomly selected and villus height and crypt depth were measured in a straight line. The ratios between villus height and crypt depth were calculated after this measurement.

The data obtained for all variables were tested for homogeneity using Barlett's test. Intestinal morphology data underwent log-transformation of (x). All results were subjected to regression analysis and differences were considered significant when P<0.05.

Results and Discussion

The increasing yeast inclusion levels did not influence body weight or weight gain, but provided a linear increase (P<0.05) in feed intake, consequently worsening feed conversion (Table 2).

Yeast has a cell wall resistance to degradation by digestive tract enzymes (Albino et al., 2006), which may have made some nutrients unavailable, increasing feed intake and directly affecting feed conversion. Similar results were obtained by Yang et al. (2007) and Lopes et al. (2011), who did not observe effects of MOS or whole yeast cell on body weight and weight gain of 21-day-old and seven-day-old broilers, respectively.

Increasing yeast inclusion levels resulted in a quadratic response (P<0.05) in the body composition of broilers, with the lowest moisture percentage obtained at 24.9 g kg^{-1}, highest ash percentage at 14.4 g kg^{-1}, and highest ash content in grams at 15.5 g kg^{-1} (Table 3).

The inclusion of alternative feeds in the diet of broilers can promote alteration in the body composition of these birds, since the digestibility and absorption of the nutrients contained in the diet can modify their body deposition. The growing broilers need to deposit higher levels of protein and minerals in the carcass to ensure maximum muscle and bone growth. The use of oligosaccharides improves the intestinal absorption of minerals in rats and humans (Ohta et al., 1998; Mineo et al., 2002); however, this effect has been poorly studied in birds (Oliveira et al., 2009). In this study, a greater body retention of minerals was not observed, possibly because whole yeast cell was used instead of isolated MOS, and lower concentrations of MOS are found in the whole yeast cell.

No significant differences were observed in the morphology of the duodenal mucosa (Table 4). In the jejunum, yeast inclusion caused a quadratic effect on villus height and crypt depth, with peaks at 20.9 and 20.6 g kg^{-1}, respectively, without influencing the villus:crypt ratio in this segment. However, there was a decrease in crypt depth

Table 2 - Performance of eight-day-old broilers fed diets with sugarcane yeast

Parameter	Yeast inclusion level (g kg^{-1})					F test	RE	P-value	R^2	CV (%)
	0	12.5	25.0	37.5	50.0					
Body weight (g/bird)	216	219	218	217	217	0.36	ns	0.83	-	1.76
Weight gain (g/bird)	178	171	172	171	171	0.48	ns	0.31	-	5.89
Feed intake (g/bird)	175	178	181	182	183	6.42	L[1]	0.02	0.96	3.00
Feed conversion (g/g)	0.99	1.04	1.05	1.06	1.07	6.37	L[2]	0.02	0.87	5.05

RE - regression equations; R^2 - coefficient of determination; CV - coefficient of variation; ns - not significant; L - linear regression.
[1] Feed intake = 175.8584 + 0.154832X.
[2] Feed conversion = 1.0048 + 0.001504X.

Table 3 - Mean levels of body composition of eight-day-old broilers, expressed in natural matter

Nutrient	Yeast inclusion level (g kg^{-1})					F test	RE	P-value	R^2	CV (%)
	0	12.5	25.0	37.5	50.0					
				Body composition (%)						
Moisture	70.43	70.12	68.91	68.91	71.07	7.21	Q[1]	0.01	0.74	2.07
Crude protein	18.55	18.33	19.57	19.62	19.17	2.08	ns	0.11	-	5.14
Fat	7.76	7.85	8.30	8.62	8.22	1.66	ns	0.19	-	8.16
Ashes	2.69	2.63	2.65	2.64	2.14	11.6	Q[2]	0.00	0.83	6.58
				Body composition (g)						
Moisture	141.11	138.65	139.62	138.67	142.57	0.45	ns	0.77	-	4.16
Crude protein	37.11	36.22	39.70	39.48	38.43	2.64	ns	0.06	-	5.82
Fat	15.53	15.51	16.88	17.35	16.63	1.77	ns	0.17	-	9.15
Ashes	5.39	5.19	5.39	5.32	4.28	12.6	Q[3]	0.00	0.79	6.65

RE - regression equations; R^2 - coefficient of determination; CV - coefficient of variation; Q - quadratic regression; n - not significant.
[1] Moisture (%) = 70.756105 – 0.1402621X + 0.00281356X^2.
[2] Ashes (%) = 2.640819 + 0.0119836X − 0.00041615X^2.
[3] Ashes (g) = 5.256943 + 0.0272758X – 0.00088061X^2.

Table 4 - Means of the morphological parameters of the intestinal mucous of broilers in the post-hatch stage fed sugarcane yeast (means obtained with 12 birds per treatment)

Parameter (µm)	Yeast inclusion level (g kg^{-1})					F test	RE[1]	P-value	R^2	CV (%)
	0	12.5	25.0	37.5	50.0					
Duodenum										
Villus height	1261.5	1081.3	1172.8	1132.7	1169.4	3.58	ns	0.46	-	3.58
Crypt depth	226.5	251.5	242.0	262.1	235.8	0.96	ns	0.45	-	2.78
Villus:crypt ratio	5.78	4.42	4.92	4.36	5.09	0.94	ns	0.46	-	20.50
Jejunum										
Villus height	846.4	944.6	931.6	855.4	828.3	4.21	Q[2]	0.05	0.85	1.83
Crypt depth	192.5	219.4	203.7	203.2	169.5	5.21	Q[3]	0.03	0.89	3.10
Villus:crypt ratio	4.57	4.44	4.60	4.23	4.91	0.51	ns	0.73	-	11.24
Ileum										
Villus height	599.5	574.8	539.9	628.7	563.9	1.05	ns	0.40	-	2.27
Crypt depth	163.7	197.7	190.7	182.5	172.1	4.14	Q[4]	0.05	0.78	2.92
Villus:crypt ratio	3.68	3.02	2.86	3.45	3.31	5.18	Q[5]	0.03	0.54	14.37

RE - regression equations; R^2 - coefficient of determination; CV - coefficient of variation; Q - quadratic regression; ns - not significant.
[1] Regression equations obtained with data transformed for the log of X.
[2] Quadratic regression equation: $Y = 2.933185 + 0.0032320X – 0.00007713X^2$.
[3] Quadratic regression equation: $Y = 2.278586 + 0.0046826X – 0.00011319X^2$.
[4] Quadratic regression equation: $Y = 2.221327 + 0.0047948X − 0.00009351X^2$.
[5] Quadratic regression equation: $Y = 0.549438 – 0.0060518X + 0.00011563X^2$.

in the ileum at levels above 25.6 g kg^{-1} and an increase in the villus:crypt ratio at yeast addition levels above 26.1 g kg^{-1} in the diets.

The duodenum parameters may have not been influenced by yeast inclusion levels, because this segment is responsible especially for feed digestion, with low absorption in this region. A lack of effects on the duodenum was also observed by Yang et al. (2007).

Gao et al. (2008), working with yeast inclusion levels from 0 to 0.75% in the diet of broilers from one to 42 days of age, concluded that on the 21st day of age, the yeast inclusion level of 0.25% resulted in higher villus heights in the ileum, lower crypt depths in the jejunum and ileum, and higher villus:crypt ratio in the ileum.

Reinsiger et al. (2012) used 0.1 and 0.2% yeast cell wall and obtained no difference in villus height or crypt depth in the jejunum of broilers at 35 days of age. Zhang et al. (2005) evaluated the mucosa of the ileum of broilers fed whole yeast, yeast extract, or yeast cellular wall and found higher villus height and villus:crypt ratio in broilers fed yeast extract and yeast cell wall, while crypt height was not affected.

Regardless of the increase in feed conversion, yeast inclusion in the diets resulted in higher villus height and crypt depth in the jejunum and villus:crypt ratio in the ileum, important characteristics that benefit the absorption of nutrients derived from diets. Most studies carried out with *Saccharomyces cerevisiae* have used commercial products, MOS, or nucleotides extracted from the whole yeast cell, which elevate feed costs. With this research, it was possible to observe that the yeast whole cell dried by the rolling method can be used in broiler chicks, improving the development of their digestive tract.

Conclusions

The use of the sugarcane yeast increases feed intake and feed conversion, improves mineral absorption, increases villus height and crypt depth in the jejunum, and reduces crypt depth and increases the villus:crypt ratio in the ileum. The best results are obtained with 20.0 g kg^{-1} yeast inclusion in the diet of broilers chicks in the pre-starter phase.

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