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Use of liquor and corn germ meal on broiler diets

El empleo de licor y harina de germen de maíz en dietas para pollos de engorda

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Abstract

The objective of the study was to evaluate in broiler diets, the feeding value of corn germ meal (CGM) mixture at 50% and the addition of 50% corn liquor (CL) without and with carbohydrase enzymes (CH) and fermentation for 24 hours. A trial with CL + enzymes for non-starch polysaccharides (NSP) and CL with fermentation for 24 h was carried out. A total of 240 male Ross 708 broilers were used, from 6 to 50 days of age fed corn + soybean paste based diets (starter, grower and finisher), with 5, 10 and 20 % CGM, with the inclusion of different presentations of CL (0 % CL, natural CL and fermented CL) in percentages equal to those of CGM without and with carbohydrase enzymes (103 000 U/g of xylanases, 128 000 U/g of cellulases and 33 000 U/g of beta-glucanases) at 25 ppm. Weight gain of 6- to 50-day-old chicks improved 5 % (P<0.05) with the addition of natural CL to CGM. The combination of CGM + natural CL increased feed value in broiler diets. The addition of enzymes in diets with CGM + natural CL did not affect broiler performance.

Keywords: corn liquor, corn germ meal, fermentation, enzymes, broiler chickens.

Resumen

El objetivo del estudio fue evaluar en dietas de pollos, el valor alimenticio de la mezcla de harina de germen de maíz (HGM) en 50% y la adición de 50 % de licor de maíz (LM) sin y con enzimas carbohidrasas (CH) y la fermentación durante 24 horas. Se realizó un ensayo con el LM + enzimas para Polisacáridos no amiláceos (PNA) y LM con fermentación por 24 h. Se utilizaron 240 pollos machos Ross 708, de 6 a 50 días de edad alimentados con dietas base maíz + pasta de soya (iniciación, crecimiento y finalización), con 5, 10 y 20 % de HGM, con la inclusión de diferentes presentaciones de LM (0 % LM, LM natural y LM fermentado) en porcentajes iguales a los de HGM sin y con enzimas carbohidrasas (103 000 U/g de xilanasas, 128 000 U/g de celulasas y 33 000 U/g de beta-glucanasas) a 25 ppm. La ganancia de peso de los pollos de 6 a 50 días de edad mejoró 5 % (P<0.05) con la adición de LM natural al HGM. La combinación HGM + LM natural, incrementó el valor alimenticio en dietas para pollo de engorda. La adición de enzimas en dietas con HGM+LM natural no afectaron el comportamiento productivo de los pollos.

Palabras clave: licor de maíz, harina de germen de maíz, enzimas, pollos de engorda.

INTRODUCTION

Broiler diets are traditionally composed of corn or sorghum as the main energy sources and soybean meal as the protein source (Knudsen, 2014); however, in recent years corn has been diverted for ethanol production, reaching unprecedented prices (Donohue and Cunningham, 2009). Corn germ meal (CGM) and corn liquor (CL) are co-products originating from the wet milling of corn; both can be used alone or in combination as alternative ingredients in poultry and swine diets (Davis, 2001; Rojas *et al.,* 2013, Albuquerque *et al*., 2014). A wide variety of co-products can be used in poultry and swine diets (Rojas *et al*., 2013); their inclusion can help reduce feed cost (Rochell *et al*., 2011). However, the abundant availability of these co-products in agribusiness due to their low prices and their inclusion in poultry diets has been limited due to the presence of non-starch polysaccharides (NSPs), because they increase intestinal viscosity, affect growth and productive performance of poultry (Malathi and Devegowda, 2001). NSPs consist of a series of soluble and insoluble polysaccharides present in the cell wall (Vincken *et al*., 2003). The main polysaccharides in cereal grains are arabinoxylans (AX) and β-glucans. With the aim of improving the nutritive value of poultry diets (Kaczmarek *et al*., 2014), exogenous enzymes have been used that act on the polymer chains causing their breakdown into smaller particles (Kaczmarek *et al*., 2014; Castro *et al*., 2020). When a decrease in the energy value of the ingredients that integrate chicken diets occurs, the utilization of enzymes that degrade NSPs such as xylanases are used (O'Neill *et al*., 2012).

Therefore, the objective of this study was to evaluate CGM+CL (50 and 50%), without and with fermentation for 24 hours; also without and with the inclusion of carbohydrases for NSPs, in broiler diets.

MATERIAL AND METHODS

The work in broilers, was carried out at the ADM Research Center in Quincy, Illinois, United States of America. Coordinates 39° 55 '56' 'of NL and 91° 23' 19'' WL, altitude 193 m a.s.l.

Laboratory analysis

In the ADM Animal Nutrition Research Laboratory, Illinois, moisture analysis, dry matter (DM), neutral detergent (NDF), acid detergent fiber (ADF), crude protein (CP), ethereal extract (EE) were carried out, lignin and starch. Also of corn liquor for ash analysis, humidity, pH, neutral detergent fiber (NDF), acid detergent fiber (ADF), CP, EE and starch.

A total of 350 males Ross 708 chickens were used, which were acquired from the Welp incubator in Bancroft, Iowa. 240 were selected, based on initial body weight, choosing chickens at 5 days of age between 94 and 114 g. Before starting this study, all birds were identified with individual bands on the wing.

Table 1. Composition of basal diets in three feed phases for fattening chickens

Ingredient %	Initiation	Growth	Finalization
Corn %	49.98	44.38	36.03
Soy paste 47.5 %	37.05	32.45	25.60
Soybean oil (degummed)	2.50	4.50	6.00
CGM	5.00	10.00	20.00
CL	-----	-----	-----
Water	2.35	4.95	9.00
CH, g[1]	-----	-----	-----
L-lysine-HCl 98%	0.12	-----	-----
Dl- methionine 99.5%	0.14	0.08	0.04
L L-treonin 98.5%	0.07	-----	-----
Calcium carbonate 38%	1.40	1.35	1.45
Monocalcium phosphate 21%	1.65	1.55	1.15
Salt	0.35	0.35	0.35
Sodium bicarbonate	0.10	0.10	0.10
Copper sulfate 25.2%[2]	0.00	0.00	0.00
Iron sulfate 30%[2]	0.01	0.01	0.01
Selenium 0.06%	0.05	0.05	0.05
Choline chloride 70%	0.05	0.04	0.03
Coban 200[3]	0.05	0.05	0.05
Premezcla de Minerales*	0.03	0.03	0.03
Premezcla de Vitaminas**	0.10	0.10	0.10
Nutrient		**Calculated analysis**	
ME, $Kcal^{-1}$	2,894	2,885	2,741
Dry Matter %	86.01	83.99	80.76
Humidity %	13.99	16.01	19.24
Crude Protein %	22.27	20.50	19.00
Ethereal Extract%	4.60	6.57	7.88
Crude fiber%	2.73	2.77	3.21
Neutral detergent fiber%	8.52	9.81	12.63
Calcium %	0.98	0.96	0.91
Phosphorus available%	0.46	0.45	0.36
Lysine digestible%	1.23	1.04	0.92
Digestible methionine%	0.46	0.39	0.33

* Premix provides by kg: Copper 25 mg, Iodine 30 mg, Manganese 90 mg, Selenium 0.3 mg, Zinc 100 mg, excipient cbp. 100.0 g; **The premix provides by kg: A vitamin 12 000 IU, D3 vitamin 3 500 IU, E vitamin 16 IU, Biotin 0.2 mg, Choline 300 mg, Folic acid 1 mg, vehicle cbp. 1,000.00 g. [1]Inclusion of enzymes CH was performed without any nutritional value, [2]Aditive promoters of growth, [3]coccidiostat.

It was a total of 60 pens, with 4 chickens each, 56 cm long by 102 cm wide, with wire floors; conditioning wooden chip as a bed material and temperature controlled with thermostat. The chickens were maintained in three feeding phases, the experimental diets were manufactured in the pilot food plant in the form of a meal for initiation, growth and finalization: from 6 to 13, from 14 to 28 to 29 to 50 days (Table 1).

The carbohydrases used had an enzymatic activity of 103,000 U/g of xylanase, 128 000 U/g of cellulase and 33,000 U/g of β-glucanase, with dose of 25 ppm.

The inclusion of corn germ meal and corn liqueur in diets was at 5, 10 and 20 % in the three phases of food: initiation, growth and finalization, respectively they were maintained with a 1: 1 ratio. In foods of treatments 1 and 4, water was added, in order to have the same dilution of energy as in those diets containing corn liquor. In treatment 3, the CGM + CL mixture was performed, adding the Ch enzymes for NSP. In treatment 6, the mixtures were placed in a hermetic plastic container and allowed standing for a period of 24 h at room temperature. All diets had a similar content of nutrients.

Registration of food consumption

The weighing of food and chickens was performed upon reaching the birds to the farm, at the beginning and end of each feeding phase.

Registration of environmental temperatures in the controlled environment booth

Readings of minimum and maximum temperatures at the broiler level with the use of digital thermometers are shown in Table 2. An artificial light calendar was provided, which consisted of giving 23 hours light/day the first Week, 14 the second, 12 the third, 10 the fourth and 8 of the fifth until the end of the test.

Table 2. Minimum and maximum temperatures registered in the experiment *in vivo* with broilers

Age (days)	Minimum (°C)	Maximum (°C)
1 – 8	29	32
9 – 15	27	29
16 – 24	24	26
25 – 32	22	24
33 – 50	19	21

Zootechnical parameters evaluated

They were carried out during the course of the study, records of body weight gain (G), food consumption (G) and food conversion (G/G); which was obtained by dividing the amount of food consumed between the weight gain obtained in each feed phase.

Disposal of animals

Sick or dead birds were excluded from the experiment; subsequently, all the birds in the pen and the feeder were individually weighed to calculate the adjustment of the productive variables. Feed consumption corrected for mortality was calculated by subtracting the feed consumption of the dead birds from the total feed consumption.

Statistical analysis

The results obtained for weight gain, food consumption and food conversion in each feed phase were analyzed with an experimental design completely randomly with 2 x 3 factorial arrangement, factor A (with and without enzyme) and factor B (CL 0 %, Natural CL and CL fermented). Comparison of means was performed using Tukey's test (P≤0.05). The SAS statistical package (SAS, 2012) was used to analyze the data.

RESULTS

The nutrition profile of ingredients used in the assay showed for corn 8.3 % CP, 94.9% of DM, 5.1% moisture, 82.7% starch and featured a low amount of fiber (2.9% DNF and 8.0% of ADF) CGM with 25.7% CP, 92.0% DM, a considerable percentage of starch (26.2%), oil (1.7%); In addition, if it is a fiber rich ingredient because it has 13.0% DNF and 38.3% ADF. On the other hand, CL is a liquid ingredient with 48.9% moisture, a pH of 3.58 provided by the amount of lactic acid with which this account (11.6%). Likewise, it has a high amount of CP (30.0%) and oil (4.5%). The combination of 50% CGM and 50% CL (one by one), is attractive in the chemical analyzes carried out by its average concentration as soon as CP (27.9%) and starch (18.9%).

Table 3, the results for weight gain of 6 to 50 days of age are presented. No statistical difference is observed (p> 0.05) for the enzyme factor in the different feeding phases; However, for the diet factor it is appreciated that the CL + CGM mixture increased significantly (p <0.05) weight gain as of 29 days of age, this effect being better when the combination was not fermented. No interaction effects were found (p> 0.05) of enzymes x diets in the feed phases.

Table 4 shows data from food consumption from 6 to 50 days of age. For the enzyme factor there was no statistical difference (p> 0.05); however, for the diet factor it is appreciated that the mixtures of CL+CGM increased food consumption significantly (p

<0.05) from 29 days of age. No interaction effects were found (p> 0.05) of enzymes x diets in the feed phases.

Table 5, the values obtained for food conversion from 6 to 50 days of age are presented. No statistical difference is observed (p> 0.05) for the enzyme factors and diets or effects of interaction between them. The observed difference (p <0.05), was in the growth phase in favor of the control diet.

Table 3. Results on broiler chickens from 6 to 50 days of age, powered by the mixture of CL + CGM with and without enzymes

Weight gain (G)				
Enzymes CH	**Control**	**CL+CGM**	**CL+CGM Fermented**	**Average**
Initiation phase				
Without	193	192	195	193±2[a]
With	189	192	194	191±2[a]
Average	191±3[a]	192±3[a]	194±3[a]	
Growth phase				
Without	882	881	869	877±6[a]
With	867	864	872	868±6[a]
Average	874±7[a]	872±8[a]	871±7[a]	
Finalization phase				
Without	1702	1845	1723	1756±21[a]
With	1688	1839	1786	1771±22[a]
Average	1695±26[a]	1842±26[b]	1754±27[a]	
Accumulated				
Without	2776	2917	2787	2827±35[a]
With	2744	2904	2856	2835±35[a]
Average	2760±30[a]	2911±30[b]	2821±31[ab]	

[a, b] in the same row indicates different values (p <0.05)

DISCUSSION

The CGM is a fibrous ingredient with a low *in vitro* digestibility of dry matter (61.25%), which has a metabolizable energy of 1 650 kcal/kg (Archer Daniels Midland Company, 2016). Due to the presence of the germ in the CGM, a percentage of 26.23% starch is determined in the laboratory analyzes in this sample, higher than obtained by Rochell *et al*. (2011) of 15.29%. It also has a 1.65% oil, characterizing it as an energy ingredient, as did Milošević *et al*. (2011). In another study conducted by Rochell *et al*. (2011) determined that CGM has 10.87% humidity, value similar to the reported in this analysis (7.93%). On the other hand, Rojas *et al*. (2013) carried out a study where they determined the value of EB of the CGM, which was 4 184 kcal^{-1}, a lower value than obtained by Rochell *et al*. (2011) of 4 767 kcal^{-1}, having the sample of this study an intermediate value to these results that was 4 573 kcal^{-1}.

Table 4. Results on broiler chickens from 6 to 50 days old, powered by the mixture of CL +CGM with and without enzymes

Food consumption (G)				
Enzymes CH	**Control**	**CM+CGM**	**CL+CGM Fermented**	**Average**
Initiation phase				
Without	260	260	261	261±3^{a}
With	249	257	257	254±3^{a}
Average	255±4^{a}	259±4^{a}	259±4^{a}	
Growth phase				
Without	1258	1291	1270	1273±9^{a}
With	1250	1260	1264	1258±9^{a}
Average	1254±11^{a}	1275±11^{a}	1267±11^{a}	
Finalization phase				
Without	3643	3842	3667	3717±38^{a}
With	3546	3858	3797	3734±39^{a}
Average	3595±47^{a}	3850±47^{b}	3732±48^{b}	
Accumulated				
Without	5161	5394	5198	5251±62^{a}
With	5045	5392	5342	5260±62^{a}
Average	5103±53^{a}	5393±53^{b}	5270±55^{b}	

$^{a,\,b}$ in the same row indicates different values ($p < 0.05$)

On the other hand, corn liquor is a highly digestible ingredient as evidenced by the results of the analyzed sample (99.19%) and reports that indicate a metabolizable energy content of 1 595 kcal^{-1} (Tekchandani *et al*., 1999, Sultan et al., 2017.
The use of CH for NSP in diets for fattening chickens did not increase food consumption (Zhang *et al*., 2014), in the same way observed in the present experiment with the inclusion of CH, from 6 to 50 d of age.

On the other hand, the use of 50% CL + 50% CGM stimulated the food consumption from 6 to 50 days, probably due to an increase in palatability of diets. In studies conducted in other species (pigs and livestock) that CL used has observed greater consumption of food related to the increase in diet palatability (Lusby *et al*., 1981), as well as other carbohydrate-rich substrates (Medina *et al*., 2014).

The use of CH for NSP on broiler chickens and its effect on the increase of weight gain (Adeola and Cowieson, 2011) has been widely studied; however, there was no increase in this variable of 6 at 50 days; probably because the dosage of the CH to NSP used in this study was underestimated.

In addition, no differences were found in weight gain, from 6 to 50 days of age, when the inclusion of Fermented CL was used at 24 h. The CL used in this study had a pH of 3.8, probably the lack of effect on weight gain in CL treatment fermented at 24 h, was described above.

Table 5. Results on broiler chickens from 6 to 50 days of age, powered by the mixture of CL + CGM with and without enzymes

Food conversion (g/g)				
Enzymes CH	**Control**	**CL+CGM**	**CL+CGM Fermented**	**Average**
Initiation phase				
Sin	1.35	1.36	1.34	1.35±0.11[a]
Con	1.31	1.34	1.33	1.33±0.11[a]
Promedio	1.33±0.01[a]	1.35±0.01[a]	1.33±0.01[a]	
Growth phase				
Sin	1.43	1.47	1.46	1.44±0.006[a]
Con	1.44	1.46	1.45	1.44±0.006[a]
Promedio	1.43±0.007[a]	1.46±0.007[b]	1.46±0.007[b]	
Finalization phase				
Sin	2.15	2.09	2.13	2.12±0.016[a]
Con	2.10	2.10	2.13	2.11±0.016[a]
Promedio	2.13±0.019[a]	2.10±0.019[a]	2.13±0.020[a]	
Accumulated				
Sin	1.86	1.85	1.87	1.86±0.01[a]
Con	1.84	1.86	1.87	1.86±0.01[a]
Promedio	1.85±0.01[a]	1.85±0.01[a]	1.87±0.01[a]	

[a, b] in the same row indicates different values ($p < 0.05$)

A characteristic of the CGM is the ability to absorb liquid nutrients (Davis, 2001, Giannenas *et al*., 2017). It is worth mentioning that the CL evaluated in this study had a high percentage of CC (29.97%), ethereal extract (4.49%) and starch (11.53%). Probably the use of CL by mixing it with CGM increased the bioavailability of nutrients, which improved the weight gain of chickens in (2911 vs 2760g), which corresponds to 5%; suggesting that this combination has a high potential for use in diets for chickens.

CONCLUSIONS

The 50% combination of CGM + 50% natural CL, in initiation diets (5%), growth (10%) and completion (20%), increased weight gain and food consumption on broiler chickens, due to its digestibility and palatability. The addition of enzymes or fermentation with CGM+CL did not improve the productive behavior of chickens.

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