

Post-print of Comparison of Nutritional Values of White Spirit Lees, Brewer' s Grains, and Rice Wine Lees for Broiler Chickens

Authors: Lei Han, Yang Can, Siyuan Chen, He Yu, Bin Dongmei

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Abstract

This experiment aimed to compare the nutritional value of white spirit lees, brewer' s grains, and rice wine lees in broiler chickens. Twenty-four Xianghuang broiler roosters at 42 days of age with an average body weight of (1.00 ± 0.12) kg were selected and randomly allocated into 4 groups with 6 replicates per group and 1 bird per replicate. Latin square design, the 4 groups of broilers were fed 100% basal diet, 80% basal diet + 20% white spirit lees, 80% basal diet + 20% brewer' s grains, and 80% basal diet + 20% rice wine lees, respectively. After a 7-day adaptation period, feces were collected continuously for 4 days, the nutrient contents of distiller' s grains, diets, and feces were determined, and the substitution method was applied to calculate the apparent digestibility of nutrients in white spirit lees, brewer' s grains, and rice wine lees. The results showed that the apparent digestible energy of rice wine lees, white spirit lees, and brewer' s grains were 7.11, 8.39, and 12.26 MJ/kg, respectively; crude fat contents were 8.65%, 7.66%, and 0.44%, respectively; crude fiber contents were 11.22%, 4.78%, and 21.61%, respectively. The apparent digestibility of crude fat in brewer' s grains was 25.64%, which was not significantly different from that in white spirit lees (28.54%) ($P > 0.05$), but was significantly lower than that in rice wine lees (59.56%) ($P < 0.05$). The apparent digestibility of crude fiber in white spirit lees was 55.41%, which was significantly higher than that in brewer' s grains (38.74%) and rice wine lees (30.05%) ($P < 0.05$). The apparent digestibility of amino acids in white spirit lees ranged from 25.67% to 62.27%, that in rice wine lees ranged from 15.22% to 79.04%, while that in brewer' s grains was slightly higher, ranging from 50.72% to 90.10%. In conclusion, there were substantial differences in nutrient content and apparent nutrient digestibility among different distiller' s grains; although brewer' s grains had high crude fiber content, its apparent amino acid digestibility was generally higher.

Full Text

Comparison of Nutritional Value among White, Beer, and Rice Distiller' s Grains for Broilers

Authors: LEI Han, YANG Can, *CHEN Siyuan, HE Yu, BIN Dongmei*

Affiliation: *College of Life and Environment Science, Hengyang Normal College, Hengyang 421008, China*

Corresponding author: lecturer, E-mail: yangcansky@163.com

Abstract

This experiment was conducted to compare the nutritional value of white, beer, and rice distiller' s grains for broilers. A total of 24 Xianghuang male broilers with an average body weight of $(1.00 \pm 0.12) \text{ kg}$ were randomly divided into 4 groups with 6 replicates per group and 1 Latin square design, broilers in the 4 groups were fed 100% basal diet, 80% basal diet + 20% white distiller' s grains, 80% basal diet + 20% beer distiller' s grains, and 80% basal diet + 20% rice distiller' s grains. After 7 days of pre-feeding, feces were collected for 4 consecutive days. The nutrient contents of distiller' s grains, diets, and feces were measured, and the apparent digestibility of nutrients in white, beer, and rice distiller' s grains was calculated using the substitution method. The results showed that the apparent digestible energy of rice, white, and beer distiller' s grains was 7.11, 8.39, and 12.26 MJ/kg, respectively; the crude fat content was 8.65%, 7.66%, and 0.44%, respectively; and the crude fiber content was 21.61% for beer distiller' s grains, 11.22% for rice distiller' s grains, and 4.78% for white distiller' s grains. The apparent digestibility of ether extract was 25.64% for beer distiller' s grains, which was not significantly different from white distiller' s grains (28.54%) ($P > 0.05$) but significantly lower than that for rice distiller' s grains (59.56%) ($P < 0.05$). The apparent digestibility of crude fiber for white distiller' s grains was 55.41%, which was significantly higher than that for beer distiller' s grains (38.74%) and rice distiller' s grains (30.05%) ($P < 0.05$). The apparent digestibility of different amino acids ranged from 25.67% to 62.27% in white distiller' s grains, from 15.22% to 79.04% in rice distiller' s grains, and was slightly higher in beer distiller' s grains, ranging from 50.72% to 90.10%. In conclusion, there are substantial differences in nutrient contents and their apparent digestibility among different distiller' s grains. Although beer distiller' s grains have higher crude fiber content, they generally exhibit higher apparent digestibility of amino acids.

Keywords: distiller' s grains; apparent digestibility of nutrients; broilers

Introduction

The rapid development of animal husbandry has led to a shortage of feed resources. Meanwhile, the expansion of alcohol production capacity has resulted in continuously increasing outputs of distiller' s grains. While extensive research

has been conducted abroad on the utilization value of distiller' s grains, domestic reports on this topic remain limited, and most production practices rely on foreign research data [?]. Distiller' s grains in foreign countries are primarily by-products of industrial ethanol production, whereas those in China are mainly by-products of beverage alcohol production. China produces enormous quantities of distiller' s grains annually, but the utilization rate is low. Therefore, it is necessary to evaluate the nutritional value of domestic distiller' s grains to provide accurate data for their application in the feed industry. This study aims to investigate the nutritional value and digestibility in broilers of Chinese distiller' s grains from different raw materials and fermentation processes (white distiller' s grains, beer distiller' s grains, and rice distiller' s grains), thereby providing data support for the application of domestic distiller' s grains in animal production.

1.1 Distiller' s Grains Sources

The white and rice distiller' s grains used in this experiment were sourced from Changde, Hunan, while beer distiller' s grains were obtained from the Beijing Yanjing Beer Factory in Hengyang, Hunan. White distiller' s grains, by-products of workshop-based white spirit production, primarily consisted of corn and rice. Beer distiller' s grains, by-products of industrial beer production, were mainly derived from wheat and rice. Rice distiller' s grains, by-products of workshop-based rice wine production, used rice as the primary raw material. After sampling, the distiller' s grains were immediately stored at -20°C until use. Prior to diet preparation, the distiller' s grains were dried at 60-65°C, ground, and passed through a 40-mesh sieve to produce air-dried samples for feed formulation.

1.2 Experimental Design

Twenty-four healthy 42-day-old Xianghuang male broilers with a body weight of (1.00 ± 0.12) kg were selected and randomly divided into 4 groups with 6 replicates per group and 1 broiler per replicate with ad libitum access to feed and water. The experiment consisted of a 7-day pre-feeding period followed by a 4-day collection period.

Table 1 Basal diet composition and nutrient levels (air-dry basis) %

The premix provided the following per kg of diet: Cu (as copper sulfate) 8 mg, Fe (as ferrous sulfate) 80 mg, Mn (as manganese sulfate) 100 mg, Zn (as zinc sulfate) 80 mg, I (as potassium iodide) 0.7 mg, Se (as sodium selenite) 0.3 mg, VA 6,000 IU, VD 750 IU, VE 10 IU, VK 0.5 mg, VB1 2.0 mg, VB2 5 mg, pantothenic acid 10 mg, nicotinic acid 30 mg, folic acid 0.55 mg, choline 1,000 mg.

1.3 Sample Collection

After the 7-day pre-feeding period, a collection bag was attached to the cloaca of each broiler. Feces were collected continuously for 4 days, weighed, and preserved by adding 5 mL of 10% sulfuric acid per 100 g of fresh sample to

prevent ammonia nitrogen loss, followed by 2-3 drops of toluene as a preservative. The fecal samples were stored at -20°C.

1.4 Index Determination

The distiller' s grains, diets, and fecal samples were dried at 60-65°C, ground, and passed through a 40-mesh sieve prior to routine nutrient analysis. Dry matter, crude fat, crude ash, crude fiber, and acid-insoluble ash contents were determined according to GB/T 6435-2006, GB/T 6433-2006, GB/T 6438-1992, GB/T 6434-1994, and GB/T 23742-2009, respectively. Gross energy (GE) was measured using an IKA-KV600 digital calorimeter. Amino acid composition and content were determined using a Hitachi L-8800 amino acid analyzer after hydrolyzing samples with 6 mol/L hydrochloric acid at 110°C for 24 h, following GB/T 18246-2000.

1.5 Data Calculation

The apparent digestibility of nutrients in distiller' s grains was calculated using the substitution method. Taking amino acids as an example:

$$D = 100 \times (A - B) / F + B$$

Where: D = apparent digestibility of amino acids in the test ingredient (%); A = apparent digestibility of amino acids in the mixed diet (%); B = apparent digestibility of amino acids in the basal diet (%); F = proportion of amino acids from the test ingredient in the mixed diet composition (%).

The apparent digestibility of nutrients in diets was determined using the endogenous indicator method (acid-insoluble ash method). Taking amino acids as an example:

Apparent digestibility of dietary amino acids (%) = $100 - 100 \times (\text{acid-insoluble ash content in diet} \times \text{amino acid content in digesta}) / (\text{acid-insoluble ash content in feces} \times \text{amino acid content in diet})$.

1.6 Statistical Analysis

Experimental data were expressed as mean \pm standard error and analyzed using SAS 8.0 General Linear Model (GLM) for variance analysis.

2.1 Nutrient Content of Distiller' s Grains

The nutrient contents of the three types of distiller' s grains are shown in Table 2. The crude ash content of white distiller' s grains was 7.77%, while rice distiller' s grains contained only 1.85% and beer distiller' s grains contained 2.91%. In terms of crude fat content, rice distiller' s grains had the highest level at 8.65%, followed by white distiller' s grains at 7.66%, while beer distiller' s grains contained only

0.44% crude fat. Beer distiller' s grains had the highest crude fiber content at 21.61%, substantially higher than rice distiller' s grains (11.22%) and white distiller' s grains (4.78%). Among the 16 amino acids detected, glutamic acid, leucine, and aspartic acid were relatively abundant in all distiller' s grains, with contents in white distiller' s grains of 3.18%, 1.91%, and 1.21%, respectively; in beer distiller' s grains of 6.22%, 2.51%, and 2.48%, respectively; and in rice distiller' s grains of 8.15%, 3.72%, and 3.09%, respectively.

Table 2 Nutrient contents in different distiller' s grains (air-dry basis)

2.2 Effects of Dietary Distiller' s Grains on Feed Intake of Xianghuang Broilers

During the 4-day collection period, the average daily feed intake (ADFI) of broilers in the basal diet group was $(50.50 \pm 8.85)g$, while the ADFI of broiler in the white distiller' s grains, beer distiller' s grains, and rice distiller' s grains was $(50.50 \pm 8.85)g$, $(50.50 \pm 8.85)g$, and $(50.50 \pm 8.85)g$, respectively.

2.3 Apparent Digestibility of Nutrients in Distiller' s Grains

The apparent digestibility of nutrients in the three types of distiller' s grains is shown in Table 3. The apparent digestibility of conventional nutrients such as dry matter, crude fat, crude fiber, and crude ash was relatively low in all three distiller' s grains. The apparent digestibility of crude fat in beer distiller' s grains was only 25.64%, which was not significantly different from white distiller' s grains (28.54%) ($P > 0.05$) but significantly lower than that of rice distiller' s grains (59.56%) ($P < 0.05$). The apparent digestibility of crude ash did not exceed 50% in any of the distiller' s grains, with values of 35.26% for white distiller' s grains, 27.02% for beer distiller' s grains, and 25.93% for rice distiller' s grains. The apparent digestibility of crude fiber in white distiller' s grains was 55.41%, significantly higher than that in beer distiller' s grains (38.74%) ($P < 0.05$), and both were significantly higher than that in rice distiller' s grains (30.05%) ($P < 0.05$). The apparent digestibility of amino acids in white distiller' s grains was relatively low, ranging from 25.67% to 62.27%, with glutamic acid showing the lowest digestibility at 25.67% and methionine showing the highest at 62.27%. In contrast, beer distiller' s grains exhibited slightly higher amino acid digestibility, ranging from 50.72% to 90.10%, with arginine reaching 90.10%. The amino acid digestibility in rice distiller' s grains ranged from 15.22% to 79.04%, with tyrosine showing the lowest digestibility at 15.22% and arginine at 79.04%.

Table 3 Apparent digestibility of nutrients in different distiller' s grains (air-dry basis)

Values in the same row with different small letter superscripts indicate significant difference ($P < 0.05$).

Discussion

The gross energy of white distiller' s grains measured in this experiment was 18.76 MJ/kg, with crude fat content of 7.66%, which was significantly lower than the data reported by Xu et al. [?] (the gross energy was only approximately half of their values) but closely matched the crude fat content of 8-14% reported for Ningxia white distiller' s grains by Wang et al. [?]. Li [?] reported that white distiller' s grains contained 7-10% moisture, 4.2-6.9% crude fat, 16.8-21.2% crude fiber, and 3.9-15.1% crude ash. Except for crude fiber content, which was substantially lower than Li' s [?] findings, other nutrient contents in our study were similar. Overall, white distiller' s grains exhibited moderate crude fat and crude fiber contents but were deficient in certain amino acids, particularly lysine at only 0.69% and methionine + cysteine at 0.53%. The lysine content of dried corn distiller' s grains (a type of white distiller' s grains) from Jilin Province was consistent with our findings, but the sulfur-containing amino acid content was slightly higher at 0.98% [?].

The crude fiber content of beer distiller' s grains in this experiment was 21.61%, approximately double the values reported in other studies [?, ?], while the crude fat content was far lower than other reports [?, ?, ?]. The energy value was similar to wheat-based dried distillers grains with solubles (DDGSw) from the United States [?]. Except for histidine, cysteine, and methionine, all other amino acid contents were higher than those reported by Xia et al. [?] but consistent with the findings of Deng et al. [?]. Compared with previous reports, beer distiller' s grains in this study had higher crude fiber content and lower crude fat content, possibly due to differences in production processes at the Yanjing Beer Factory. The rice distiller' s grains tested in this experiment had lower total and individual amino acid contents compared with other reports [?, ?], but higher levels of lysine, methionine, cysteine, and threonine than those found in rice wine lees [?]. The crude fiber content of rice distiller' s grains was 11.22%, substantially higher than the 0.93% reported by Yuan et al. [?]. Overall, the rice distiller' s grains in this experiment had relatively high crude fat content and could serve as an energy supplement, but the high crude fiber content may affect poultry digestibility and consequently impact production performance. Limited research exists domestically and internationally on the nutritional value and digestibility of rice distiller' s grains, making the data from this experiment valuable for future research.

This experiment compared the effects of dietary distiller' s grains on broiler feed intake. Compared with the basal diet, beer distiller' s grains supplementation promoted feed intake, while white and rice distiller' s grains supplementation negatively affected feed intake to varying degrees. This may be attributed to the pure aroma of beer distiller' s grains, which stimulated broiler appetite. Distiller' s grains provide certain energy values, with digestible energy data similar to other reports [?]. Ma et al. [?] fed roosters beer distiller' s grains processed by three different methods (grinding, extrusion, and unprocessed), reporting dry matter apparent digestibility values of 54.86%, 54.97%, and 53.30%, respec-

tively. The dry matter apparent digestibility of beer distiller's grains for broilers in this experiment was 58.24%, showing little difference. However, the crude fiber apparent digestibility values of 45.36%, 45.43%, and 31.10% reported by Ma et al. [?] were significantly higher than the 38.74% observed in this experiment for unprocessed beer distiller's grains. Limited domestic research exists on amino acid apparent digestibility of dried distillers grains with solubles (DDGS) in chickens. Li et al. [?] reported an average apparent digestibility of 77.12% for major essential amino acids in roosters fed eight types of corn-based DDGS, while the average apparent digestibility of major amino acids in beer distiller's grains for Xianghuang broilers in this experiment was 72.21%. The amino acid digestibility data in this experiment were slightly higher but not substantially different from those obtained by Xia et al. [?] using DDGSw in Huainan partridge chickens.

Conclusion

Through nutrient content determination and apparent digestibility calculation of white, beer, and rice distiller's grains, the following conclusions were drawn: The apparent digestible energy of rice, white, and beer distiller's grains was 7.11, 8.39, and 12.26 MJ/kg, respectively; crude fat content was 8.65%, 7.66%, and 0.44%, respectively; and crude fiber content was 11.22%, 4.78%, and 21.61%, respectively. The apparent digestibility of amino acids in white and rice distiller's grains ranged from 25.67% to 62.27% and 15.22% to 79.04%, respectively, while beer distiller's grains exhibited slightly higher amino acid digestibility, ranging from 50.72% to 90.10%.

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