Brazilian Journal of Poultry Science
Revista Brasileira de Ciência Avícola

ISSN 1516-635X 2023 / v.25 / n.1 / 001-008

http://dx.doi.org/10.1590/1806-9061-2022-1650

Original Article

The Effects of Yucca Schidigera Extract and Multi-carbohydrase in Different Crude Protein Diets on Growth Performance, Nutrient Digestibility, Carcass Parameters and Excreta Noxious Gas Contents in Broilers

■Author(s)

Munezero O[I] https://orcid.org/0000-0003-4574-0494
Zhang ZF[I,II] https://orcid.org/0000-0002-0993-8025
Kim IH[I] https://orcid.org/0000-0001-6652-2504

[I] Department of Animal Resource & Science, Dankook University, Cheonan-si, Chungnam 31116, South Korea.
[II] Hubei Key Laboratory of Animal Nutrition and Feed Science, Wuhan Polytechnic University, Wuhan 430023, China.

Olivier Munezero and Z.F. Zhang contributed equally to this work.

■Mail Address

Corresponding author e-mail address
In Ho Kim
Department of Animal Resource and Science, Dankook University, Cheonan, Cheonan, 31116, Republic of Korea.
Phone: 82 41-550-3652
Email: inhokim@dankook.ac.kr

■Keywords

Broiler, carbohydrase, crude protein, growth performance, yucca.

Submitted: 22/March/2022
Approved: 22/August/2022

ABSTRACT

The scarcity and increase in the price of animal feeds have attracted the attention of nutritionists to address this issue. The inclusion of plant extracts and enzymes to protein-reduced diet could be a feasible strategy to reducing the feed cost. Therefore, the purpose of this study was to assess the impacts of Yucca schidigera extract and multi-carbohydrase in low crude protein (CP) diets of broiler on growth performance, nutrient digestibility, carcass metrics, and noxious gas levels in the excreta. A total of 480, 1-d-old ROSS 308 were randomly allocated into 4 dietary treatments, six replication, and 20 birds/cage. Phase 1, T1(CP 21%, ME 2,969 kcal/kg); T2 (CP 19%, ME 2,863 kcal/kg + 0.02% Yucca); T3 (CP 17%, ME 2,865 kcal/kg + 0.02% Yucca); T4 (CP 17%, ME 2,861 kcal/kg + 0.02% Yucca + 0.1% multi-carbohydrase). Phase 2, T1 (CP 19%, ME 3,086 kcal/kg); T2 (CP 17%, ME 2,977 kcal/kg + 0.02% Yucca); T3 (CP 15%, ME 2,978 kcal/kg + 0.02% Yucca); T4 (CP 15%, ME 2,978 kcal/kg + 0.02% Yucca + 0.1% 0.1% multi-carbohydrase). Although the addition of YS and multi-carbohydrase to the low CP diets on the growth performance did not improve, it revealed the positive result on the nutrient digestibility, carcass parameters, and noxious gas emission. Overall, broilers supplemented with YS 0.02% and multi-carbohydrase (0.1%) demonstrated the best production performances compared to the other treatment groups. Thus, a combination of YS and multi-carbohydrase could be added to the diets with low CP to boost broiler production performance.

INTRODUCTION

Feed costs account for 70-80% of farm expenses, making poultry feeding one of the most essential areas of the poultry industry (Olugbenga *et al.*, 2015). Moreover, protein is the most costly component of feed. Lowering crude protein (CP) level in diets is one of the current ways attempted by the poultry industry to address this issue. Evidence shows that feeding broiler chickens with low-CP diets increases nitrogen (N) efficiency and decreases N excretion, consequently this reduces the environmental impact and carbon footprint of poultry production (Belloir *et al.*, 2017). However, changing CP levels in isoenergetic diets is connected with changes in energy-to-protein ratios, and can have significant effects on body composition, such as body fat content (Swennen *et al.*, 2004). Therefore, adding prebiotics, probiotics, toxin binders, Phyto-biotics, enzymes, oligosaccharides, symbiotic, organic minerals, organic acids, and other feed additives to the low CP diets improve the feed energy and they don't harm broilers or consumers (Yadav *et al.*, 2016). Incorporating plant extracts and exogenous enzymes into animal diets that are low in some nutrients, particularly CP, has demonstrated good outcomes. Numerous plants and their derivatives have been studied as a replacer of feed additives in various farm animals (Farag *et al.*, 2018). Among those, *Yucca schidigera* (YS) is considered as one of the possible plant extracts to be used in livestock diet. Normally, YS extract is utilized in the food and beverage industry as a natural medicine and flavor enhancer, whilst in the poultry, swine, and cattle industries is used as a natural feed additive (Cheeke *et al.*, 2005). Supplementing the diet of broilers with YS has shown to improve their growth rate and feed conversion (Ranjbar *et al.*, 2014). Moreover, there are various beneficial effects of YS in livestock and poultry production such as: therapeutic activities like anti-inflammatory, antioxidant, immuno-stimulatory, anticarcinogenic, growth stimulant, hypocholesterolemic, and hypoglycemic (Gupta *et al.*, 2014). YS could also be used to minimize fecal odors and ammonia emissions emanating from poultry farms and their surroundings (Vlckova *et al.*, 2017), thus this might help in improving the animal health by decreasing N emission. Additionally, YS has a growth-promoting impact on animals (Cheeke & Otero, 2005). Cereals and soybean meal are used in poultry feed worldwide, this is due to the rising prices and price of poultry feed ingredients that have resulted in more diets being formulated with high-fiber ingredients. This makes the diet contain a considerable amount of indigestible fractions. In fact, plant-based ingredients contain high amounts of non-starch polysaccharides (NSP, 10 to 20%) (Annison & Choct, 1991), which reduces the digestibility of nutrients in the diets and can result in poor growth and performance of birds. To alleviate this problem, supplementing multi-enzymes into broiler diets can be a possible strategy. Previous studies have reported that the addition of multi-enzymes improves nutrient utilization, resulting in weight gain and improved feed conversion ratio (FCR) (Sharifi *et al.*, 2013). This can reduce feed costs and benefit from local alternative feed ingredients. To the best of our knowledge, no studies on the effects of combination YS extract and multi-carbohydrase in broilers have been conducted. It is reasonable to hypothesize that the inclusion of YS extract and multi-carbohydrase in a low CP diets of broilers could lead to positive changes in carcass parameters and affect health and performance more than YS or multi-carbohydrate alone. Therefore, the present study intention was to investigate the effects of YS extract and multi-carbohydrase in low CP diets on growth performance, nutrient digestibility, carcass traits and excreta noxious gas contents in broilers.

MATERIALS AND METHODS

The experiment was conducted at Dankook University's Swine Research Unit in South Korea. The trial protocol was reviewed by animal care and use Committee of Dankook University in the Republic of Korea (DK-1-2030).

Experimental Design and animal management

In the 35 days trial, a total of 480 1-d-old broilers (ROSS 308), with initial Body weight of 45.2 ± 0.3 g were randomly allotted into 4 dietary treatments with 6 replications and each cage was comprised of 20 birds, which makes a total of 120 birds per treatment. The experiment was divided into 2 phases: phase I (d 0 to 21), phase II (d 22 to 35). The 4 treatments were as follows during the first phase (starter stage): T1 broiler were fed with diets containing (CP 21%, ME 2,969 kcal/kg); T2 (CP 19%, ME 2,863 kcal/kg + 0.02% Yucca); T3 (CP 17%, ME 2,865 kcal/kg + 0.02% Yucca); T4 (CP 17%, ME 2,861 kcal/kg + 0.02% Yucca + 0.1% α-1, 6-galactosidase and β-1,4-mannanase). During the second phase (grower stage), treatments were: T1 (CP 19%, ME 3,086 kcal/kg); T2 (CP 17%, ME 2,977 k/kg + 0.02% Yucca); T3 (CP 15%, ME 2,978 kcal/kg + 0.02% Yucca); T4 (CP 15%, ME 2,978 kcal/kg + 0.02% Yucca + 0.1% α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase). The nutrient content of both first and second phase diets were supplemented with YS and multi-carbohydrase, are presented in Table 1. All of the broilers were grown in stainless steel cages (1.75 × 1.55m^2/cage) equipped with nipple feeders and drinkers. For the first three days, the room's temperature was maintained at 33 ± 1°C, following which it was steadily dropped by 3°C every week until it reached 24°C. For the duration of the experiment, the room temperature was kept at 24°C. Fluorescent lights were used to produce artificial light 24 hours a day and birds had unlimited access to feeds and water.

Sampling and Measurements

At 1, 21, and 35 days of age, broiler chicks were weighed per cage. Feed intake (FI) was also observed over the study period. Body weight gain (BWG), FI, and FCR ratio were all calculated using this data.

12 broilers (3 chicks per cage) were randomly selected from each treatment group one week prior to the completion of the experiment and caged in line with treatments for the measurement of nutrient digestibility. Chromium oxide (Cr_2O_3) as an indigestible

Table 1 – Composition of experimental diets.

Ingredient, %	Phase 1				Phase 2			
	T1	T2	T3	T4	T1	T2	T3	T4
Corn	62.101	65.784	71.593	71.473	65.281	69.754	75.966	75.757
Soybean meal	22.160	25.220	19.220	19.240	18.440	20.140	14.340	14.380
SBM premium	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000
Corn gluten meal	3.840	-	-	-	3.500	-	-	-
Meat & Bone Meal	3.160	-	-	-	2.700	0.300	-	-
Salt	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Limestone	1.040	1.660	1.680	1.680	1.100	1.660	1.700	1.700
Tri-calcium phosphate	-	0.560	0.580	0.580	-	0.320	0.440	0.440
Tallow	1.588	0.468	-	-	3.048	1.616	0.754	0.826
Vitamin premix[1]	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
Choline liquid	-	-	0.021	0.021	0.020	0.020	0.049	0.049
Mineral permix[2]	0.120	0.120	0.120	0.120	0.120	0.120	0.120	0.120
Yucca	-	0.020	0.020	0.020	-	0.020	0.020	0.020
$NaHCO_3$	0.136	0.172	0.170	0.170	0.146	0.200	0.168	0.168
Carbohydrase	-	-	-	0.100	-	-	-	0.100
DL-methionine	0.242	0.314	0.366	0.368	0.164	0.236	0.288	0.288
Lysine (78.4%)	0.263	0.276	0.453	0.453	0.159	0.191	0.368	0.367
Tryptophan (10%)	-	-	0.289	0.288	-	0.041	0.324	0.323
Threonine (98.5%)	0.030	0.086	0.168	0.167	0.002	0.062	0.143	0.142
Chemical composition[3]								
ME, kcal/kg	2,969	2,863	2,885	2,881	3,086	2,977	2,978	2, 978
Crude protein, %	21.01	18.98	17.00	17.00	19.00	16.99	15.00	15.00
EE, %	4.74	3.26	2.87	2.86	6.15	4.48	3.67	3.74
Lys, %	1.22	1.21	1.19	1.19	1.02	1.02	1.00	1.00
Met + Cys, %	0.92	0.91	0.91	0.91	0.80	0.79	0.78	0.78
Calcium, %	0.90	0.90	0.90	0.90	0.85	0.85	0.85	0.85
Phosphorus, %	0.51	0.43	0.42	0.42	0.46	0.39	0.37	0.37

[1] Provided per kg of diet: 15,000 IU of vitamin A, 3,750 IU of vitamin D_3, 37.5 mg of vitamin E, 2.55 mg of vitamin K_3, 3 mg of vitamin B_1, 7.5 mg of vitamin B_2, 4.5 mg of vitamin B_6, 24 mg of vitamin B_{12}, 51 mg of niacin, 1.5 mg of folic acid, 126 mg of biotin and 13.5 mg of pantothenic acid.

[2] Provided per kg of diet: 37.5 mg of Zn, 37.5 mg of Mn, 37.5 mg of Fe, 3.75 mg of Cu, 0.83 mg of I, 62.5 mg of S and 0.23 mg of Se.

[3] Calculated values.

marker, was supplemented to the diets of broilers at a level of 0.2%. Excreta samples were collected at the end of the trial (day 35) and stored at -20°C until further examination. Excreta samples were dried in a forced-air drying oven (70°C) for 72 hours before being ground through a 1-mm screen sieve to determine dry matter (DM) and N digestibility. The AOAC's methods for analyzing DM were followed (2007). UV absorption spectrophotometry was used to investigate chromium (Shimadzu, UV-1201, Shimadzu, Kyoto, Japan). A Kjeltec 8600 analyzer was used to determine the N (protein) content (Foss Tecator AB, Hoeganaes, Sweden). The digestibility of nutrients was determined according to the formula used by (Munezero & Kim, 2022). An amino acid (AA)analyzer was used to evaluate the AA contents in the excreta and experimental diet after 24 hours of acid hydrolysis with 6 N HCl at 110°C (Beckman 6300, Beckman Coulter, Inc., Fullerton, US). After cold performic acid oxidation overnight and subsequent hydrolysis, sulfur-containing amino acids were evaluated. Following that, the excreta samples, as well as the feed samples, were examined in accordance with the AOAC guidelines (2007).

At the end of the trial, 12 broiler chicks were chosen randomly from each treatment (3 broilers per replication cage) and terminated via cervical dislocation. All of the following carcass parameters were manually dissected and recorded: Leg, liver, breast, and abdominal fat, as well as the adipose tissues lining the proventriculus and gizzard. To eliminate variances in cutting techniques, all procedures were carried out by the same, experienced personnel.

Excreta samples were collected and frozen throughout the last three days of the experiment to examine noxious gas emission. Excreta samples were kept in 2.6-L plastic boxes. A small hole in the middle of one of the side walls of each box was sealed with adhesive plaster. The samples were fermented for seven days at 30°C and measured on days one, three, five, and seven. On days 1, 3, 5, and 7, NH3, RSH, and acetic acid were measured using a multi-gas meter (MultiRAE Lite model PGM-6208, RAE, USA). The adhesive plaster was punctured for this measurement, and 100 mL of headspace air was sampled at a height of 2.0 cm above the samples. Each box was wrapped with adhesive plaster again after air sampling. Every 48 hours, headspace measurements were taken again.

Statistical analysis

All data were analyzed using SAS's General Linear Models (GLM) procedure and a one-way ANOVA (SAS Institute, 2008). The GLM approach was used to assess significant differences in mean values among dietary treatments using repeated measurements and Duncan's tests. The significance level was set at $p<0.05$.

RESULTS

Growth performance

The results of broiler growth performance after adding the YS and multi-carbohydrase on broiler growth performance on day 21 and 35 are presented in Table 2. Broilers supplemented with YS and multi-carbohydrase exhibited no significant differences in growth performance during both phases. However, numerically broilers fed the YS 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1% had higher BWG and FI compared to others and T1 showed the lowest value for FCR during the entire experiment.

Table 2 – Effect of reducing dietary crude protein and supplementation of Yucca and multi-carbohydrase on growth performance in broilers.

Item	T1[1]	T2[1]	T3[1]	T4[1]	SE[2]
0-21 days					
BWG, g	588	591	588	594	11
FI, g	910	923	930	934	13
FCR	1.54	1.56	1.58	1.57	0.06
22-35 days					
BWG, g	833	827	835	839	18
FI, g	1509	522	1553	1563	21
FCR	1.81	1.84	1.86	1.86	0.04
Overall					
BWG, g	1421	1418	1423	1433	26
FI, g	2419	2445	2483	2497	37
FCR	1.70	1.72	1.74	1.74	0.03

[1]Abbreviated Phase I: 1) T1 (CP 21%, ME 2969); 2) T2 (CP 19%, ME 2863 + Yucca 0.02%); 3) T3 (CP 17%, ME 2885 + Yucca 0.02%); 4) T4 (CP 17%, ME 2881 + Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%) and Phase II:1) T1 (CP 19%, ME 3086); 2) T2 (CP 17%, ME2977 + Yucca 0.02%); 3) T3 (CP 15%, ME 2978 + Yucca 0.02%); 4) T4 (CP 15%, ME 2978 + Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%)

[2]Pooled standard error.

Nutrient digestibility

Table 3 indicates the effect of supplementing YS and multi-carbohydrase in a reduced CP diets of broilers on nutrient digestibility. T4 broilers had a notably higher nutrient digestibility of DM and Nthan other treatments throughout the trial. Besides, the digestibility of AAwere significantly higher in T1 as compared to other treatments.

Table 3 – Effect of reducing dietary crude protein and supplementation of Yucca and multi-carbohydrase on nutrient digestibility in broilers.

Item, %	T1[1]	T2[1]	T3[1]	T4[1]	SE[2]
DM	79.62[b]	79.79[b]	78.53[c]	80.73[a]	0.21
N	72.47[a]	72.49[a]	69.11[b]	73.38[a]	0.85
Essential amino acid					
Arg	92.19[a]	88.56[b]	88.92[b]	92.01[a]	0.39
His	73.70[a]	51.29[c]	52.77[c]	61.87[b]	1.79
Ile	83.71[a]	79.90[b]	74.20[c]	82.19[ab]	1.04
Leu	88.56[a]	84.58[b]	80.02[c]	86.85[ab]	0.80
Lys	87.66[a]	89.24[a]	83.40[b]	89.86[a]	0.88
Met	90.97[a]	91.80[a]	88.33[b]	92.45[a]	0.52
Phe	89.21[a]	85.12[b]	82.50[c]	88.01[a]	0.72
Thr	80.55[a]	76.78[b]	72.13[c]	81.62[a]	0.95
Val	81.55[a]	77.35[b]	70.49[c]	80.09[ab]	1.24
Nonessential amino acid					
Ala	81.70[a]	74.59[b]	66.34[c]	77.74[ab]	1.44
Asp	83.46[a]	78.40[b]	75.66[b]	82.85[a]	1.06
Cys	82.18[a]	73.67[b]	72.84[b]	81.72[a]	1.19
Glu	88.71[a]	84.65[b]	82.47[b]	88.00[a]	0.76
Gly	62.54[a]	58.52[ab]	55.27[b]	53.96[b]	1.93
Pro	87.43[a]	82.15[b]	78.83[c]	85.44[a]	0.70
Ser	8617[a]	77.63[b]	77.98[b]	84.04[a]	0.75
Tyr	86.30[a]	82.70[b]	80.45[b]	85.63[a]	0.91

[1]Abbreviated phase 1: 1) T1 (CP 21%, ME 2969); 2) T2 (CP 19%, ME 2863 + Yucca 0.02%); 3) T3 (CP 17%, ME 2885 + Yucca 0.02%); 4) T4 (CP 17%, ME 2881 + Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%) and phase 2:1) T1 (CP 19%, ME 3086); 2) T2 (CP 17%, ME2977 + Yucca 0.02%); 3) T3 (CP 15%, ME 2978 + Yucca 0.02%); 4) T4 (CP 15%, ME 2978 + Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%)

[2]Pooled standard error.

[a,b,c]Means in the same row with different superscripts differ ($p<0.05$).

Carcass parameters

The effects of reducing dietary CP and supplementation of YS and multi-carbohydrase on broiler carcass yield are presented in Table 4. In comparison to other treatments in the entire experiment, T4 broilers supplemented with yucca and multi-carbohydrase showed the greatest value of breast yield percentage, indicating the best carcass features. Aside from that, T3 broilers had the highest abdominal percentages.

Table 4 – Effect of reducing dietary crude protein and supplementation of Yucca and multi-carbohydrase on carcass yield of broiler.

Item	T1[1]	T2[1]	T3[1]	T4[1]	SE[2]
Carass, %	66.15	66.77	66.52	67.93	2.57
Leg yield, %	19.71	19.80	19.61	19.98	1.07
Breast yield, %	16.66[b]	17.13[ab]	16.50[b]	17.62[a]	1.34
Abdominal fat yield, %	2.42[b]	2.56[ab]	2.62[a]	2.54[a]	0.28

[1]Abbreviated phase 1: 1) T1 (CP 21%, ME 2969); 2) T2 (CP 19%, ME 2863 + Yucca 0.02%); 3) T3 (CP 17%, ME 2885 + Yucca 0.02%); 4) T4 (CP 17%, ME 2881 + Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%) and phase 2:1) T1 (CP 19%, ME 3086); 2) T2 (CP 17%, ME2977 + Yucca 0.02%); 3) T3 (CP 15%, ME 2978 + Yucca 0.02%); 4) T4 (CP 15%, ME 2978 + Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%)

[2]Pooled standard error.

[a,b,c]Means in the same row with different superscripts differ ($p<0.05$).

Gas emission

The effect of reducing dietary CP and supplementing with yucca and multi-carbohydrase on broiler noxious gas emission characteristics is shown in Table 5. T4 dietary treatment supplemented with Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1% has significantly reduced the NH3 on day 5 and 7. However, there was no difference observed on RSH (mercaptans) and acetic acid throughout the trial.

Table 5 – Effect of reducing dietary crude protein and supplementation of Yucca and multi-carbohydrase on noxious gases emission characteristics of broiler.

Item, ppm	T1[1]	T2[1]	T3[1]	T4[1]	SE[2]
NH_3					
Day 1	19.0	11.0	21.0	10.0	6.1
Day 3	45.0	60.0	30.0	35.0	11.1
Day 5	94.0[a]	70.0[b]	65.0[b]	72.5[b]	7.0
Day 7	96.5[a]	85.0[ab]	67.5[c]	70.0[c]	2.9
RSH					
Day 1	0.4	0.1	0.0	0.0	0.3
Day 3	2.1	1.4	1.2	1.3	0.5
Day 5	4.0	2.5	1.9	2.7	1.2
Day 7	6.0	6.3	8.4	5.6	1.1
Acetic acid					
Day 1	0.0	0.0	0.0	0.0	0.0
Day 3	4.0	3.9	3.3	3.9	0.3
Day 5	3.3	4.6	3.7	2.9	0.6
Day 7	4.0	3.5	3.9	3.6	0.8

[1]Abbreviated phase 1: 1) T1 (CP 21%, ME 2969); 2) T2 (CP 19%, ME 2863 + Yucca 0.02%); 3) T3 (CP 17%, ME 2885 + Yucca 0.02%); 4) T4 (CP 17%, ME 2881 + Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%) and phase 2:1) T1 (CP 19%, ME 3086); 2) T2 (CP 17%, ME2977 + Yucca 0.02%); 3) T3 (CP 15%, ME 2978 + Yucca 0.02%); 4) T4 (CP 15%, ME 2978 + Yucca 0.02% + α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%)

[2]Pooled standard error.

[a,b,c]Means in the same row with different superscripts differ ($p<0.05$).

DISCUSSION

Growth performance

Growth performance is a critical metric for assessing broiler production. According to (Yeo & Kim 1997; Begum *et al.*, 2015), adding yucca extract to broiler diets had no impact on the birds' feed consumption or feed efficiency. Similarly, in the present study, broilers treated with 0.2% YS extract and 0.1% of α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase did not improve the growth performance during the entire trial. The findings were inconsistent with previous researchers who found that supplementing YS in the diet of broiler improved growth performance (Ranjbar *et al.*, 2014; Sahoo *et al.*, 2015). The effect of YS was also evaluated in laying hens, swine and rabbits, and researchers discovered a considerable improvement in growth performance (Al-Bar *et al.*, 1992; Wang & Kim, 2011; Gebhardt *et al.*, 2019). The presence of steroidal saponins in YS, which have a beneficial effect on the digestive tract by activating digestive enzymes and increasing villus height (Cheeke, 2000), could be the reason for increased growth performance in the earlier investigation. Normally, multi-enzymes are hypothesized to increase performance by lowering the anti-nutritive effect of non-starch polysaccharides (NSP), diminishing the cell wall's nutrient encapsulating effect, and alleviating viscosity difficulties associated with certain NSP (O'Neill *et al.*, 2014). Variations between earlier researches and the present work could be due to inconsistencies of pig utilized, the type of diet used, and the amount of supplementation employed in those studies.

Nutrient digestibility

Throughout the experiment, T4 broilers had significantly higher nutrient digestibility of DM and N, and T1 broilers had the highest AA digestibility. Similarly, previous research has shown that broiler chicks supplemented with yucca schidigera had significantly higher protein digestibility (Sahoo *et al.*, 2015). Additionally, Chen *et al.* (2021), found that introducing yucca extracts to the diets of late gestating and lactating sows greatly increased DM digestibility. Contrary to our findings, Alghirani *et al.* (2021)

documented that the inclusion of yucca schidigera in broiler diets significantly lowered the digestibility of DM. According to Htoo *et al.* (2007), a reduction in CP can lead to a decrease in AA digestibility, therefore adding YS and multi-carbohydrase might be the answer. Meng *et al.* (2004) previously described the beneficial effect of carbohydrase addition on nutrient digestibility, which is in agreement to the present study, in which an increase in digestibility was observed as the result of multi-carbohydrase treatment. In general, phytogenic feed additives containing steroidal saponins, such as yucca schidigera, have been proven to enhance intestinal health and reduce microbial pressure while preventing intestinal disease, perhaps leading to improved nutrient digestibility and absorption (Begum *et al.*, 2015).

Carcass parameters

Body weight, as well as carcass weight, and dressing percentage, have a significant correlation (Chung *et al.*, 2021). In the present experiment, combining YS and multi-carbohydrase improved carcass yield. Sahoo *et al.* (2015) found that the *yucca schidigera* treatment broiler group had higher breast meat yield which is in line with the present findings. Nevertheless, Azadegan *et al.* (2014) have found no significant differences in the carcass characteristics of broilers fed saponin-containing diets. The variations between earlier research and the current work could be due to differences in the bird strains utilized, the type of diet used, the saponin source used, and the amount of supplementation placed in those studies.

Gas emission

The poultry production is accompanied by considerable environmental pollution with NH3. The higher concentrations of gaseous NH3 are the most common contaminant in the poultry farming, affecting performance, bird welfare, and consequently, human health (Costa *et al.*, 2012). The usage of natural products such as a *yucca schidigera* extract product, which can assist the moderation of ammonia supply, is the key to dealing with the ammonia problem in the poultry sector. Saponin, the major steroidal chemical element of YS extract, does this by physically binding ammonia and lowering its amount (Ayoub *et al.*, 2019). In the current study, supplementation of YS and multi-carbohydrase on the broiler diets significantly affected the reduction of NH3. When 100 ppm of yucca extract was introduced to layer diets, there was a substantial decrease in ammonia generation and emission in laying-hen barns (Chepete *et al.*, 2012). Additionally, YS in broiler diets lowered ammonia concentrations considerably without affecting broiler performance (Cabuk *et al.*, 2004). However, other authors have demonstrated no effects of Yucca extract on ammonia N concentrations in ruminants (Hristov *et al.*, 1999). A supplementation of multi-carbohydrase could decrease the excretion of ammonia. Sun & Kim (2019) have reached an agreement on this where they found that adding multi-enzyme to corn-soybean meal-DDGS-based diets reduced excreta ammonia emissions while having no negative influence on production performance. The higher digestibility of N could account for the lower NH_3 emissions seen in this study.

CONCLUSION

Except for growth performance, which has not been impacted, broilers treated with *yucca schidigera* extract 0.02% and α-1,6-galactosidase and β-1,4-mannanase multi-carbohydrase 0.1%, outperformed the other treatment broilers in terms of nutrient digestibility, carcass metrics, and gas emissions. Based on the results obtained, there is an interactive effect on overall performance of broilers when the diets with low CP are supplemented with the yucca extract and multi-carbohydrase. Therefore, the full benefit potential of supplemental yucca extract and multi-carbohydrase can be realized by using feed lower in CP, thereby improving the production performance of broilers.

ACKNOWLEDGEMENTS

The Department of Animal Resource & Science was supported through the Research-Focused Department Promotion & Interdisciplinary Convergence Research Projects as a part of the University Innovation Support Program for Dankook University in 2022.

CONFLICT OF INTERESTS

No potential conflict of interest relevant to this article was reported.

REFERENCES

Al-Bar A, Cheeke PR, Nakaue HS. Effect of yucca extract (deodorase) on environmental ammonia levels and growth performance of rabbits. Journal of Applied Rabbit Research 1992;15:1105

Alghirani MM, Chung EL, Sabri DS, Tahir MN, Kassim NA, Kamalludin MH, *et al.* Can yucca schidigera be used to enhance the growth performance, nutrient digestibility, gut histomorphology, cecal microflora, carcass characteristic, and meat quality of commercial broilers raised under tropical conditions?. Animals 2021;11(8):2276.

Annison G, Choct M. Anti-nutritive activities of cereal non-starch polysaccharides in broiler diets and strategies minimizing their effects. World's Poultry Science Journal 1991;47(3):232-42.

Ayoub MM, Ahmed HA, Sadek KM, Alagawany M, El-Hack A, Mohamed E, *et al.* Effects of liquid yucca supplementation on nitrogen excretion, intestinal bacteria, biochemical and performance parameters in broilers. Animals 2019;9(12):1097.

Azadegan MM, Hassanabadi A, NASIRI MH, Kermanshahi H. Supplementation of clove essential oils and probiotic to the broiler's diet on performance, carcass traits and blood components. Iranian Journal of Applied Animal Science 2014;4(1):117-22.

Begum M, Hossain MM, Kim IH. Effects of caprylic acid and Yucca schidigera extract on growth performance, relative organ weight, breast meat quality, haematological characteristics and caecal microbial shedding in mixed sex Ross 308 broiler chickens. Veterinarni Medicina 2015;60(11):635-43.

Belloir P, Méda B, Lambert W, Corrent E, Juin H, Lessire M, *et al.* Reducing the CP content in broiler feeds: impact on animal performance, meat quality and nitrogen utilization. Animal 2017;11(11):1881-9.

Cabuk M, Alcicek A, Bozkurt M, Akkan S. Effect of Yucca schidigera and natural zeolite on broiler performance. International Journal of Poultry Science 2004;3(10):651-4.

Cheeke PR, Otero R. Yucca, quillaja may have role in animal nutrition. Feedstuffs 2005; 77(3):11-4

Chen F, Lv Y, Zhu P, Cui C, Wu C, Chen J, *et al.* Dietary yucca schidigera extract supplementation during late gestating and lactating sows improves animal performance, nutrient digestibility, and manure ammonia emission. Frontiers in Veterinary Science 2021;8:676324.

Chepete HJ, Xin H, Mendes LB, Li H, Bailey TB. Ammonia emission and performance of laying hens as affected by different dosages of Yucca schidigera in the diet. Journal of Applied Poultry Research 2012;21(3):522-30.

Chung EL, Alghirani MM, Kamalludin MH, Nayan N, Jesse FF, Wei OT, *et al.* Do different vaccination regimes affect the growth performance, immune status, carcase characteristics and meat quality of broilers?. British Poultry Science 2021;62(1):32-7.

Costa A, Ferrari S, Guarino M. Yearly emission factors of ammonia and particulate matter from three laying-hen housing systems. Animal Production Science 2012;52(12):1089-98.

Farag MR, Alagawany M, Abd El-Hack ME, El-Sayed SA, Ahmed SY, Samak DH. Yucca schidigera extract modulates the lead-induced oxidative damage, nephropathy and altered inflammatory response and glucose homeostasis in Japanese quails. Ecotoxicology and Environmental Safety 2018;156:311-21.

Gebhardt JT, Woodworth JC, Tokach MD, De Rouchey JM, Goodband RD, Loughmiller JA, *et al.* Determining the influence of chromium propionate and Yucca schidigera on growth performance and carcass composition of pigs housed in a commercial environment. Translational Animal Science 2019;3(4):1275-85.

Gupta S. Inhibitory potential of Yucca gloriosa L. extract and isolated gloriosaol isomeric mixture on ovalbumin induced airway hyperresponsiveness in Balb/C mice. Clinical Pharmacology & Biopharmaceutics 2014;S2(e001).

Hristov AN, McAllister TA, Van Herk FH, Cheng KJ, Newbold CJ, Cheeke PR. Effect of Yucca schidigera on ruminal fermentation and nutrient digestion in heifers. Journal of Animal Science 1999;77(9):2554-63.

Htoo JK, Araiza BA, Sauer WC, Rademacher M, Zhang Y, Cervantes M, *et al.* Effect of dietary protein content on ileal amino acid digestibility, growth performance, and formation of microbial metabolites in ileal and cecal digesta of early-weaned pigs. Journal of Animal Science 2007;85(12):3303-12.

Masey O. 'Neill HV, Smith JA, Bedford MR. Multicarbohydrase enzymes for non-ruminants. Asian-Australasian Journal Animal Science 2014;27(2):290-301.

Meng X, Slominski BA, Guenter W. The effect of fat type, carbohydrase, and lipase addition on growth performance and nutrient utilization of young broilers fed wheat-based diets. Poultry Science 2004;83(10):1718-27.

Munezero O, Kim, IH. Effect of condensed molasses fermentation solubles (CMS) to replace molasses on the growth performance, nutrient digestibility, and backfat thickness in growing pigs. Korean Journal of Agricultural Science 2022;49:185-92.

Ranjbar Z, Shariatmadari F, Torshizi MK. Effect of different levels of yucca extract and antibiotic on growth performance, immune response and blood factors of broiler chickens. Iranian Journal of Medicinal and Aromatic Plants 2014;30(5):675-81.

Sahoo SP, Kaur D, Sethi AP, Sharma A, Chandra M. Evaluation of Yucca schidigera extract as feed additive on performance of broiler chicks in winter season. Veterinary World 2015;8(4):556.

Samuel Olugbenga O, Olusegun Abayomi O, AdebimpeOluseye A, Akinbowale Taiwo T. Optimized nutrients diet formulation of broiler poultry rations in nigeria using linear programming. Journal of Nutrition & Food Sciences 2015;14(2).

Sharifi SD, Golestani G, Yaghobfar A, Khadem A, Pashazanussi H. Effects of supplementing a multienzyme to broiler diets containing a high level of wheat or canola meal on intestinal morphology and performance of chicks. Journal of Applied Poultry Research 2013;22(4):671-9.

Sun HY, Kim IH. Effects of multi-enzyme on production performance, egg quality, nutrient digestibility, and excreta noxious gas emission of early phase Hy-line brown hens. Poultry Science 2019;98(10):4889-95.

Swennen QG, Janssens GP, Decuypere E, Buyse J. Effects of substitution between fat and protein on feed intake and its regulatory mechanisms in broiler chickens: energy and protein metabolism and diet-induced thermogenesis. Poultry Science 2004;83(12):1997-2004.

Vlčková R, Sopková D, Andrejčáková Z, Valocký I, Kádasi A, Harrath AH, *et al.* Dietary supplementation of yucca (Yucca schidigera) affects ovine ovarian functions. Theriogenology 2017;88:158-65.

Wang JP, Kim IH. Effect of caprylic acid and Yucca schidigera extract on production performance, egg quality, blood characteristics, and excreta microflora in laying hens. British Poultry Science 2011;52(6):711-7.

Yadav AS, Kolluri G, Gopi M, Karthik K, Singh Y. Exploring alternatives to antibiotics as health promoting agents in poultry-a review. Journal of Experimental Biology and Agricultural Sciences 2016;4(3S):368-83

Yeo J, Kim KI. Effect of feeding diets containing an antibiotic, a probiotic, or yucca extract on growth and intestinal urease activity in broiler chicks. Poultry Science 1997;76:381–385.