Research Article

Effects of Dietary Supplementation of Rice Distillers Dried Grains in Grower Phase on Growth Performance and Digestibility of Broiler Chicken

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Abstract | This experiment was conducted to evaluate the effects of dietary supplementation of rice distiller dry grains (rDDG) on growth performance and digestibility of broiler chicken. The 140 day-old broiler chicks were randomly allocated to five groups with four replicates. During starter period (1-21 day), commercial starter diet was fed to the experimental animals. During grower period (21-42 days), the experimental grower diets were isonitrogenously and isocallorically formulated with different levels of rDDG. They were T1 (without rDDG), T2 (5% rDDG), T3 (10% rDDG), T4 (15% rDDG) and T5 (20% rDDG). The cumulative feed intake, weight gain, feed conversion ratio and production efficiency index were measured. As cumulative feed intake, cumulative weight gain and feed conversion ratio (FCR), there were no significantly differences (p>0.05) among the broiler chicken fed dietary treatments (T1, T2, T3, T4 and T5) thorough out grower period (21-28, 21-35 and 21-42 days old age of broiler chicken) although the diet T5 containing 20% level of rDDG gave the tendency of lower in feed intake, greater in weight gain and better FCR as compared to other dietary treatments. The growth performance data throughout the experimental period (1-42 days) showed similar pattern as that of grower period. At the aspect of feed cost, feed cost per kg of feed was decreased as the inclusion levels of rDDG were increased in diets. However, the lowest feed cost per kg (p<0.05) of live weight was observed in broiler chicken fed the diet T5. There were no statistically differences (p>0.05) among the T1, T2, T3 and T5 diets in feed cost per kg of live weight. Regarding data for digestion trial, the dry matter intake, the organic matter intake, dry matter digestibility and OM digestibility of broiler chicken fed all dietary treatments were not significantly different (p>0.05). Thus, inclusion of up to 20% rDDG in grower diet have no detrimental effect on the growth performances of broiler chicken during grower stage (21-42 days of age) and it could be supplemented in grower broiler diets with least cost of feed (MMK per kg of feed and MMK per kg of live weight).

Keywords | Rice distillers dried grains, Broiler, Grower phase, Performance, Digestibility

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INTRODUCTION

Livestock production plays a major role in the life of farmers in developing countries. It enjoys a relative advantage of easy management, higher turnover, quick returns to capital investment and a wide acceptable of its products for human consumption when compared with other commercial livestock industry (Haruna and Hamidu, 2004). Among them, poultry industry provides high quality food for human consumption. Broiler production is becoming an important aspect of poultry production in many developing countries including Myanmar. However, the recent increase in the prices of conventional feed ingredients is a major factor affecting net return from poultry business. Feed accounts for 70-80% of the operating cost of the production in poultry (Bolu and Balogun, 2004; Esonu et al., 2007). This is because of the high cost of conventional feed resources such as maize, soya beans and groundnut, used in producing animal feed (Amaefule and Obioha, 2005).

The increase in high cost of conventional animal feed ingredients in most of the developing countries has necessitated scientists to search for alternative sources of feed ingredients. Use of cheaper and unconventional feed resources to reduce feed cost is an important aspect of commercial poultry production (Bhatt and Sharma, 2001). The distillers dry grains (DDG) and distiller dry grains with solubles (DDGS) are recognized as an acceptable, attractive and potentially valuable feed ingredient for poultry to replace partially with expensive soybean meal which is recognized as the main protein source to produce less expensive diets. The DDGS are a byproduct obtained from ethanol production of cereal grains such as corn, wheat, barley and sorghum cereals (Batal and Dale, 2003; Rausch and Belyea, 2006; Wu-Haan et al., 2010).

Rice as subtract for bioethanol production is increasing due to its relative lower price, higher production and easy availability leads to increased availability of co-product rice distiller dried grain with solubles (rDDGS). It contains all the nutrients from grain in a concentrated form except for the majority of the starch, which has been utilized in the fermentation process. The rDDGS contains 65% distiller's grain and 35% its soluble (Babcock et al., 2008). As nutrients, 20-50% of crude protein (CP), 4323kcal/kg of gross energy, 6-8% of crude fibre (CF) and 0.14% of calcium are included in rDDGS (Dinani *et al.*, 2018). However, the lower amount of available lysine in DDGS occurs due to a drying process (Mir et al., 2017).

An increase in ethanol production has led to an increased supply of DDGS available as livestock feed (Noll et al., 2007). Rao et al. (2016) reported that rDDGS can safely be incorporated in broiler diet at the inclusion level of 10%. Gupta et al. (2015) reported that rDDGS can safely be incorporated in layer diet up to the inclusion level of 10%. The gut health, immunity and intestinal morphology of birds were improved without affecting egg production and egg quality traits by incorporation of rDDGS. The DDGS could use as alternative feed resources in broiler diet up to 25% without harmful effect on body weight gain and feed conversion ratio (FCR) (Waldroup et al., 1981). A reduction in productive performance was observed as a result of adding DDGS into broiler diet (Dale and Batal, 2003). The DDGS can be safely added at levels of 5%–8% in starter diets for broilers and turkeys and 12%–15% in grower-finisher diets for broilers, turkeys, and laying hens (Swiatkiewicz and Koreleski, 2008).

In Myanmar, there are many industries for biofuel production and cereal grains are used for the production of biofuel. Wet rice distiller grain is a co-product of the ethanol industry in Myanmar and its availability is increasing due to higher demand for ethanol as biofuel. Because of large production of biofuel, million tons of fermentation residues are available to the feed industry for its use in animal and poultry feed. However, still limited scientific information is available on uses of locally produced rDDG in broiler nutrition. If these locally available rice distiller wet grains were further processed and were used as alternative potential protein sources in broiler diet, the feed cost would be reduced in broiler production.

Therefore, this study was carried out to evaluate the supplementary effects of different levels of locally available rDDG in grower phase on growth performance and nutrient digestibility of broiler chicken.

MATERIALS AND METHODS

Collection of rice distillers dried grains and other ingredients

The rice distiller wet grain (rDWG) used in this experiment was not genetically modified byproduct, which was obtained from Grand Royal Group International Co. Ltd., Yangon. They were displayed over the polyethylene sheet and were sun-dried for about 5 days to get rDDG to be used as feed ingredient in broiler diet. Other feed ingredients were purchased from local feed shop.

Location of housing and disinfection

The experiment was conducted from Jan 29th, 2019 to March 12th, 2019 at staff quarter, University of Veterinary Science, Nay Pyi Taw, Myanmar. Poultry house with slatted floor was divided into twenty compartments providing enough space for animal. The whole house including inside and outside surfaces were cleaned, washed and disinfected prior to the arrival of the chicks. All feeders, drinkers and other equipment needed for experiments were also disinfected.

Experimental design and dietary treatments

Samples of the various ingredients including rDDG used in this experiment were subjected to analyses nutrient contents before being used in the formulation of experimental diets. A completely randomized design (CRD) was used in this experiment. A total of 140 day-old broiler chicks were weighed at arrival. From day 1 to day 21 (starter phase), commercial diets were fed to all experimental chicken. After 21 days, the birds were weighed and randomly assigned to five treatment groups with four replicates into 20 pens (replicates) in the slatted floor system. There were 7 chicks in each replicate. The experimental diets (Tables 1 and 2) were isonitrogenously and isocallorically formulated for grower period according to the requirement of NRC (1994). The experimental diets were T1 (Control diet without rDDG), T2 (Diet containing 5% of rDDG), T3 (Diet containing 10% of rDDG), T4 (Diet containing 15% of rDDG) and T5 (Diet containing 20% of rDDG).

Table 1: Ingredient compositions (%) of experimental diets.

Ingredient (%)	T1	T2	T3	T4	T5
Maize	61.23	62.36	63.36	64.37	65.40
Soybean meal	31.20	25.55	20.12	14.50	9.00
rDDG	0.00	5.00	10.00	15.00	20.00
Palm oil	4.08	3.36	2.67	2.05	1.4
Oyster shell	1.30	1.35	1.35	1.40	1.33
DCP	1.4	1.49	1.52	1.60	1.7
Lysine	0.00	0.1	0.2	0.3	0.39
Methionine	0.17	0.17	0.16	0.16	0.16
NaCl	0.3	0.3	0.3	0.3	0.30
Toxinil	0.02	0.02	0.02	0.02	0.02
Premix	0.30	0.30	0.3	0.3	0.30
Total	100	100	100	100	100

rDDG: rice distiller dry grains; DCP: dicalcium phosphate; NaCl: sodium chloride; T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG.

Table 2: Calculated nutrient contents (%) of experimental diets (Grower diet).

Ingredient	T1	T2	T3	T4	T5
CP	19.70	19.68	19.79	19.82	19.90
ME (kcal/kg)	3145	3142	3142	3144	3146
Methionine	0.48	0.48	0.48	0.47	0.47
Lysine	1.08	1.08	1.08	1.08	1.07
Calcium	0.89	0.90	0.89	0.90	0.9
Non phytate phosphorus	0.42	0.42	0.42	0.41	0.42

CP: crude protein; ME: metabolizable energy; T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG.

Bird housing and management

A total of 140 day-old broiler chicks purchased from Myanmar C.P Livestock Production Company Limited were used in seven weeks of study. Chicks were housed in pen and brooded according to the recommended brooding management. At 21 day old age of broiler chicken, they were weighed and randomly allocated to four replicates (pen) per treatment with 7 chicken per replicate. Feeds were offered *ad libitum* and water was free accessed throughout the experiment. On day 21, all broiler chicken were vaccinated with live vaccine against Newcastle disease (Live ND + IB) via intraocular route. Infectious bursal disease (IBD) vaccine was administered to all chicken on day 14 and day 28 via oral route.

Measurement parameters and sample collection

After chick arrival (day 1), the initial body weights of chicks were recorded. Although rDDG were supplemented in grower diet during grower phase, weekly feed intake and body weight of broiler chicken were recorded on a replicate basis throughout experimental period (day 1 to day 42). The cumulative feed consumption, body weight gain and FCR (cumulative feed intake/cumulative weight gain) of broiler chicken were calculated for the whole experimental period (1-42 days) and grower period (21-28, 21-35 and 21-42 days). Mortality of chicken was recorded daily to correct FCR. Production efficiency factor (PEF) was calculated using the following equation.

$$\text{Production efficiency factor (PEF)} = \frac{\text{Final body weight (kg)} \times \text{livability (\%)}}{\text{Age of bird in days} \times \text{FCR}} \times 100$$

Digestion trial was carried out to determine digestibility coefficient by conventional total collection method. At 6th week of experiment, faeces voided by each replicate were collected by putting plastic sheet under the floor of each pen for 3 consecutive days. Feed intakes were recorded to determine nutrient digestibility coefficient (DM and OM). The excreta were weighed, sampled, sun-dried until constant weight was attained and preceded for analysis. Feed consumption of the birds was recorded on a replicate basis for that day and diets were sampled for analysis to determine nutrient digestibility (DM and OM).

$$\text{Apparent nutrient digestibility (\%)} = \frac{\text{Nutrient intake} - \text{Nutrient output}}{\text{Feed intake}} - 100$$

Chemical analysis

The determination of nutrient compositions of feed ingredients used in this experiment was carried out at the laboratory of Physiology and Biochemistry Department, Yezin, Nay Pyi Taw. Feedstuffs were analyzed for DM, OM, CP and EE by the method described by AOAC (1990) and NDF and ADF by Goering and van Soest (1970). Excreta samples were only analysed for DM and OM. Samples were analyzed for nitrogen by using Kjeldahl method (Foss 2020 digester and Foss 2100 Kjeltec distillation unit) and crude protein (CP) was calculated as 6.25 × N (AOAC, 1990).

Statistical analysis

The data were subjected to the analysis of variance (ANOVA) using SPSS Software (SPSS, 2007) for windows version 16.0 (Chicago, SPSS Inc.) and the significant differences between treatment means were compared by Duncan' Multiple Range Test (DMRT) at $p<0.05$.

RESULTS AND DISCUSSION

Chemical compositions of rice distillers dried grains

Chemical compositions of rDDG are shown in Table 3. The CP, ME value, NDF and ADF values were 50.19%, 3005.05 kcal/kg, 22.28% and 18.40%, respectively.

Table 3: Chemical compositions (%) and ME (kcal/kg) of rDDG.

Description	DM	OM	Ash	CP	NDF	ADF	EE	ME
rDDG	94.18	96.86	3.14	50.19	22.28	18.40	2.85	3005.05

DM: dry matter; OM: organic matter; CP: crude protein; NDF: neutral detergent fibre; ADF: acid detergent fibre; EE: ether extract; ME: metabolizable energy; T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG.

Growth performance of broiler chicken

The growth performance data consisted of cumulative feed intake, cumulative weight gain, cumulative FCR and PEF. The effects of diets containing different levels of rDDG on cumulative feed intake of broiler chicken during grower period are shown in Tables 4, 5 and 6. The results revealed that the cumulative feed intake, body weight gain and FCR of the birds fed all dietary treatments during 21-28 days, 21-35 days and 21-42 days period were not significantly different ($p>0.05$) from each other. However, the birds fed T5 (rDDG 20%) showed tendency in lower feed intake, higher weight gain and better FCR in comparison with other treatments.

Table 4: Effects of diets containing different levels of rDDG on cumulative feed intake (g/bird) of broiler chicken during grower period.

Diets	21-28 days[1)]	21-35 days[1)]	21-42 days[1)]
T1	866.92	2053.18	3277.95
T2	983.45	2103.32	3307.60
T3	986.46	2110.87	3364.94
T4	941.90	2106.78	3316.86
T5	895.52	1915.58	3043.33
SEM	16.41	37.67	54.03
p value	0.409	0.456	0.384

T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG; SEM: standard error mean. [1)] Means in each column are not significantly different ($p>0.05$).

Table 5: Effects of diets containing different levels of rDDG on cumulative weight gain (g/bird) of broiler chicken during grower period.

Diets	21-28 days[1)]	21-35 days[1)]	21-42 days[1)]
T1	474.53	1054.37	1595.80
T2	459.11	995.35	1557.81
T3	456.39	1005.71	1530.36
T4	463.04	1012.56	1534.37
T5	483.12	1057.48	1677.30
SEM	6.29	10.74	20.42
p value	0.678	0.218	0.110

T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG; SEM: standard error mean. [1)] Mean in each column are not significantly different ($p>0.05$).

Table 6: Effects of diets containing different levels of rDDG on feed conversion ratio (FCR) of broiler chicken during grower period.

Diets	21-28 days[1)]	21-35 days[1)]	21-42 days[1)]
T1	2.04	1.95	2.05
T2	2.10	2.08	2.12
T3	2.16	2.10	2.20
T4	2.05	2.09	2.19
T5	1.85	1.82	1.81
SEM	0.04	0.05	0.06
p value	0.205	0.207	0.118

T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG; SEM: standard error mean. [1)] Means in each column are not significantly different ($p>0.05$).

Table 7: Effects of diets containing different levels of rDDG on growth performance of broiler chicken from day 1 to day 42.

Diets	Cumulative feed intake[1)]	Cumulative weight gain[1)]	FCR[1)]	PEF[1)]
T1	4628.95	2634.96	1.76	363.71
T2	4658.60	2555.68	1.80	343.92
T3	4715.94	2526.57	1.87	368.82
T4	4667.86	2578.45	1.82	347.85
T5	4394.33	2686.69	1.64	400.32
SEM	54.04	25.79	0.03	8.13
p value	0.384	0.306	0.150	0.087

FCR: feed converstion ratio; PEF: production efficiency factor; T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG; SEM: standard error mean. [1)] Means in each column are not significantly different ($p>0.05$).

The growth performance in terms of cumulative feed intake, cumulative body weight gain, FCR and PEF of broiler chicken from day 1 to day 42 are presented in Table 7. No significant differences (p>0.05) among the birds fed all dietary treatments were observed in cumulative feed intake, cumulative body weight gain, FCR and PEF. However, the birds fed diet containing T5 (20% inclusion level of rDDG) gave the better growth performance in comparison with those fed other dietary treatments (T1, T2, T3 and T4).

Table 8: Feed cost (MMK) per kg of feed and feed cost (MMK) per kg of live weight.

Diets	Feed cost (MMK) per kg of feed	Feed cost (MMK) per kg of live weight (21-42 days)	Feed cost (MMK) per kg of live weight (1-42 days)
T1	582.53	1196.20[a]	1083.32[a]
T2	550.48	1170.90[a]	1077.26[a]
T3	522.58	1149.72[a]	1050.94[a]
T4	493.32	1080.47[a]	1023.63[a]
T5	464.27	860.23[b]	914.21[b]
SEM	-	39.47	19.08
p value	-	0.009	0.005

MMK: Myanmar kyat (Myanmar currency); T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG; SEM: standard error mean. [a,b)] Means in each column with different superscripts are not significantly different at p<0.05.

Feed cost

Feed costs as affected by different levels of rDDG are shown in Table 8. Feed cost per kg of feed was reduced as the levels of rDDG were increased in the grower diet. In terms of feed cost per kg of live weight, the birds fed T5 diet gave the significantly lowest (p<0.05) feed cost in comparison with those fed other dietary treatments. There were no significantly differences (p>0.05) in feed cost per kg of live weight among the birds fed T1, T2, T3 and T4 diets.

Nutrients intake and nutrient digestibility

The effects of diet containing different levels of rDDG on intake and digestibility of broiler chicken are shown in Table 9. There were no significant differences (p>0.05) among the birds fed all dietary treatments in dry matter intake, organic matter intake, dry matter digestibility and organic matter digestibility.

In this study, the chemical compositions (CP, ME value, NDF and ADF values) of rDDG were 50.19%, 3005.05kcal/kg, 22.28% and 18.40%, respectively. The CP (50.19%) and ADF (18.4%) content of rDDG in the current experiment were relatively higher than the CP (44.68%) and ADF (12.70%) contents of rDDGS reported by Dinani et al. (2018) while the NDF content was relatively lower than their reported value. The differences in chemical composition of rDDG in the current experiment with the chemical composition observed by other researchers might be due to different method of drying process. Dinani et al. (2018) mentioned that the drying process might crucial influence not only on variability of nutrients but also on concentration and availability of nutrients in different samples of rDDGS.

Table 9: Effects of diets containing different levels of rDDG on intake (DM and OM) and digestibility (DM and OM) of broiler chicken.

Diets	Intake (g/day)[1)]		Digestibility (%)[1)]	
	DM	OM	DM	OM
T1	166.81	142.18	83.40	84.61
T2	151.06	131.19	81.15	81.81
T3	160.34	138.56	82.06	83.02
T4	158.68	139.51	80.99	82.06
T5	163.43	144.47	81.74	82.59
SEM	2.51	2.20	0.72	0.71
p value	0.375	0.411	0.877	0.792

DM: dry matter; OM: organic matter; T1: diet witout rDDG; T2: diet containing 5% level of rDDG; T3: diet containing 10% level of rDDG; T4: diet containing 15% level of rDDG; T5: diet containing 20% level of rDDG, SEM: standard error mean. [1)] Means in each column are not significantly different (p>0.05).

According to the results obtained in this experiment, the growth performance parameters (cumulative feed intake, cumulative body weight gain and cumulative FCR) of broiler chicken throughout grower period and the whole experimental period (day 1 to day 42) were not significantly influenced (p>0.05) by supplementing different dietary levels (0, 5, 10, 15 and 20%) of rDDG in diets during grower phase. However, the inclusion level of rDDG at 20% in broiler diet showed numerically lower value in feed intake, higher value in weight gain and lower value in FCR. The reason might be possible that all birds fed different dietary levels of rDDG may get the sufficient nutrients as all diets were formulated at not only isocaloric and isonitrogenous level but also the similar levels of Ca, P, methionine and lysine. Moreover, the similar nutrient intake and digestibility (Table 8) of the broiler chicken fed dietary treatment containing different levels of rDDGS might favour the similar growth performance in all treatment groups. Dinani et al. (2018) mentioned that 15% rDDGS of known nutritional quality can be utilized in diets for growing broiler with no negative effect on growth performance and meat yield if the diets are formulated on digestible amino acid basis to meet the nutritional requirements of broiler chicken.

The current results indicated that up to 20% of rDDG could safely supplement in broiler grower diet as protein sources. There were many contrasted reports with the current experiment. Zhang et al. (2013) reported that diet containing 20% DDGs decreased average daily feed intake in broiler chicken. The broiler diet containing 15% of rDDGS decreased body weight gain (Campasino et al., 2015). Loar et al. (2010) observed decrease in performance parameters with inclusion of 8% rDDGS in starter and grower diet. Rao et al. (2016) reported that body weight gain and feed efficiency of broiler chicken at 35 days of age were depressed significantly at 15% level of rDDGS. Mir et al. (2017) stated that feeding of 10% DDGs in broiler diet depressed the broiler performance.

The different findings in growth performance of this experiment and other researches might be due to many reasons; the variation in the source and processing method of rDDG, quality of rDDG and the differences in age feeding stage (starter or grower stage) of broiler chicken. In the current experiment, the rDDG was prepared by sun drying of wet distillers grains without separation of distillers grains and liquid containing soluble. However, most of distillers grains used in other researches are distillers dried grain with soluble (DDGs). The rDDGS contained generally 65% distillers grain and 35% distillers solubles on dry matter basis. AAFCO (2005) reported that dry milling process leads to millard reaction and further reduced the lysine availability as compared to parent grains used for ethanol production. Therefore, the different drying method might change the quality of rDDG that used for feed ingredients in animals' diets. Mir et al. (2017) pointed that lower amount of available lysine due to drying processing method during rDDGS production can hamper the growth and efficiency.

Regarding to age at feeding stage, the experimental diets containing different levels (0, 5, 10, 15 and 20%) of rDDGs were fed to broiler chicken during grower period (21 days of age to 42 days of age) in the current experiment. In this period, the digestive system was already functionally developed for enzyme production to facilitate nutrient digestion and absorption. In the other researches, the rDDGS were fed to broiler chicken during both of starter and grower period (day 1- day 42 of experiment). This difference in feeding stage can influence growth performance of broiler chicken. Jacob et al. (2008) mentioned that the DDGS is very low in starch but higher in nonstarch polysaccharide as compared to their parent grain used in ethanol production. Therefore, supplementation of higher DDGS level in starter diet gave negative effect on growth performance because the digestive system of young broiler (7-10 days post hatch) was not fully developed to secrete sufficient levels of enzyme to digest the diet containing such non starch polysaccharide which hamper the digestion of other nutrients. This explanation was supported by Nir et al. (1993) who reported that age associated pattern of enzyme activity was observed through the first 15 days post hatch although amylase activity was peak at 10 days. Krogdahl and Sell (1989) also pointed out that there is a lag phase through 5 to 8 day post hatch in trypsin, lipase and chymotrypsin activity. Level of DDGS in poultry diet depends upon species and age of poultry birds, type of cereal involved in its production, method of drying after fermentation, level of fiber etc. In general, DDGS can be incorporated at the inclusion level of 7.5 to 10% for economic poultry production (AAFCO, 2005). Patil (2008) studied the effects of using distillery dried grains with solubles (DDGS) in the diets with certain feed additives on performance of broilers. The use of DDGS along with enzyme and acidifier, either singly or in combination showed better growth performance with respect to live weight, weight gain, better FCR and higher net profits at the end of fifth week.

The similar findings with current experiment were observed by several researchers. Noll et al. (2004) reported that the birds fed with DDGS up to 12% did not show any significant change in FCR as compared to control corn-soybean meat-meal diets. Wang et al. (2008) reported that the birds fed with 15% DDGS did not show significant change in FCR than control diet. Youssef et al. (2013) and Min et al. (2015) demonstrated that 15% rDDGS of known nutritional quality can be utilized in diets for growing broiler with no negative effect on growth performance and meal yield. The result of current experiment was also agreed with Kim et al. (2016) who reported that finishing broiler (28 to 56 days) can tolerate up to 24% rDDG in the later phase of production without any detrimental effects on growth performance.

Regarding feed cost in this experiment, as the levels of rDDG in broiler diet were increased, the lesser feed costs per kg of feed were observed. The similar finding was observed by Choi et al. (2008) who pointed that the use of DDGS in broiler diets up to 15% could decrease the feed cost by replacing part of corn and soybean meal, without any negative effect on growth performance and meat qualities. Gupta et al. (2016) also mentioned that the feed cost was tended to reduce when the levels of rDDGS was increased from 0 to 10%. Moreover, the current results revealed that broiler chicken fed diet containing the highest level (20%) of rDDG exhibited lowest feed cost per kg of live weight. This finding was agreed with Dattatraya (2015) and Dinani et al. (2018) who reported that feed cost per kg of live weight was highest in control without rDDGS while the lowest feed cost was observed in the birds fed the diet containing higher levels of rDDGS (12.5 and 15%). Therefore, in their research, the profit per sale of birds was observed in the birds fed diet containing 15% level of rDDGS due to reduction in feed price of this diet.

According the results regarding nutrient intake and nutrient digestibility, the birds fed all dietary treatments showed similar nutrient intake (DM and OM) and nutrient digestibility (DM and OMD). The similar nutrient intake and digestibility of the birds fed different levels of rDDG might contribute to similar growth performance. The current result was not agreed with Dinani et al. (2018) who stated that the dry matter digestibility and gross energy metabolizability were significantly decreased in the birds fed diet containing 15% of rDDGS. Campansino et al. (2015) reported that inclusion of dried distillers' grains with solubles reduced ($p<0.05$) ileal digestible energy at 10 and 15% inclusion, however, inclusion of non-starch polysaccharide degrading enzyme increased ($p<0.05$) ileal digestible energy. The differences in digestibility of current experiment with their experiment might be due to different age phase feeding (starter vs grower) of broiler chicken. In the current experiment, the rDDG including diets were fed through the period of grower phase (21-42 days). As the digestive system of broiler chicken in grower period was functionally developed as mentioned in discussion of growth performance, the digestibility of nutrient was not interfered with the increasing levels of rDDG in broiler diet. As a consequence, no negative effects on growth performance of broiler chicken were observed by inclusion of up to 20% rDDG in grower diet.

CONCLUSIONS

According to the findings, different inclusion levels (5%, 10%, 15% and 20%) of rice distillers dried grains in broiler grower diet gave similar growth performance with control diet without detrimental effects on dry matter and organic matter digestibility. In term feed cost, the higher levels of rice distillers dried grain in diet showed the lower feed cost per kg of feed. In term of feed cost per kg of live weight, the lowest price was observed in birds fed the diet containing 20% of rice distillers dry grains. Therefore, up to 20% of rice distillers dried grains could be incorporated in broiler grower diet with the least cost of feed.

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AUTHOR'S CONTRIBUTION

SMT, TMT, KLT, WWWT, CT, MT, MKT, KZT, MT, ZMT, ZT, KSDM, YYK, MA and KSM designed this experiment and, SMT, TMT, KLT, WWWT, CT, MT, MKT, KZT, MT, ZMT, ZT, KSM and MA mainly carried out sample collection and analyzed the chemical compositions. SMT, KSM and MA performed data analysis and interpretation. SMT, TMT, KLT, WWWT, CT, MT, MKT, KZT, MT, ZMT and ZT drafted the manuscript and KSDM, YYK, KSM and MA completed the critical revision of the article. All authors read and approved the final version of manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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