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Effects of feeding distillers dried grains with Solubles (DDGS) with exogenous enzyme supplementation on growth and nutrient utilization of indigenous chicken

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Abstract
Distillers dried grains with Solubles (DDGS), a co-product of ethanol production process, has been identified as a promising feed resource for its use in the rations of poultry as an energy and protein source. The present investigation aimed at assessing the effects of feeding graded levels of DDGS with or without enzymes on the growth performance of indigenous chicken. A total of 180 21 d old indigenous chicks were divided into six groups *viz.* T1, T2, T3, T4, T5 and T6 each with 30 chicks. The birds of T1, T3 and T5 were fed a basal diet containing 0, 10 and 20 per cent DDGS while the birds in T2, T4 and T6 were fed the same basal diet as that of T1, T3 and T5, respectively, but were additionally supplemented with a commercial exogenous multi-enzyme preparation. The feeding trial was conducted for a period of 182 d (13 fortnights) excluding a metabolic trial for a period of 8 days. The average final body weight was recorded highest in T2 group (1643.93±25.22 g) and lowest in T5 group (1580.00±14.50 g) without any significant (P>0.05) difference among the groups. No significant difference (P>0.05) was observed in respect of final body weight, total and mean daily gain in body weight, total feed consumption as well as overall feed conversion efficiency (FCRs) among the treatment groups. Positive Nitrogen, Calcium and Phosphorus balances were observed in all the treatment groups with significant differences (P>0.05) in respect of P retention between T1 and T4 and T6; T3 and T6 and T5 and T6 groups. It is concluded that DDGS can be incorporated at 20% level in the rations of indigenous chicken for the economic gain without any adverse affect on growth and nutrient utilization.

Keywords: Body weight, DDGS, enzymes, FCR, growth, indigenous chicken

Introduction
The maize and soybean meal are the major conventional sources of energy and protein, respectively, in poultry feeds, which are not only becoming scarce but also costly. It seems, maize will not be completely available in the next few years for using as energy source in poultry diets due to its use to produce biofuel ethanol in the most produced countries. The shortage of high quality conventional poultry feed ingredients is considered as one of the major concern facing poultry producers worldwide especially in the developing countries like India in near future. So, in the present status of feed resource availability, utilization of non-conventional feed resources in the poultry feeding is indispensable to keep pace with the deficiency of nutrients, to make ration economic and to have more profit from poultry. The replacement of costlier traditional ingredients with cheaper non-conventional ingredients without adversely affecting the feed quality and bird performance is probably the most viable proposition to address this situation.

Among others, distillers dried grains with solubles (DDGS), a co-product of ethanol production process, has been identified as a promising feed resource for its use in the ration of poultry as an energy and protein source. Recently, a renaissance in the use of DDGS has been observed worldwide due to rapid escalation in DDGS production and improvement in its quality when derived from new generation ethanol plants (Panda *et al.*, 2016) [17]. It is a source of energy, protein, water soluble vitamins and minerals (Jensen *et al.*, 1978; Waldroup *et al.*, 1981; Parsons *et al.*, 2006) [11, 32, 18]. It contains a substantial amount of total phosphorus (0.72%), out of which 54% is available for poultry (NRC, 1994) [16]. It is also a good source of xanthophylls (Runnels, 1957) [22] and linoleic acid (Scott, 1965) [24].

Ward *et al.* (2008) [33] noted that arabinoxylans and cellulose were the predominant non-starch polysaccharides (NSP) in DDGS, which restrict in the extensive use of it in poultry feeds. Exogenous enzymes are able to offer nutritional benefits in a variety of ways by hydrolyzing NSP that could not be used by poultry (Cost *et al*., 2008) [4]. Enzyme supplementation helps in removing the deleterious incriminating factors, improving the digestibility of existing nutrients, increasing the utilization of NPS and supplementing most of the endogenous enzymes (Classen *et al*., 1988 and Friesen *et al*., 1992) [3, 7]. On the other hand, there is an ever-increasing demand for meats and eggs of indigenous chicken all over our country. Both the meats and eggs of indigenous chicken fetch higher prices which are more than double of the prices of broiler meats as well as commercial table eggs. In numbers of markets these are marketed as organic meats and organic eggs, resulting their increased demand among the consumers. So, it may be considered as the need of the hour to rear indigenous chicken for meat as well as egg purpose by feeding balanced poultry feeds like other commercial birds with proper nutrient concentrations. Rearing such chickens with somewhat cheaper feeds by using un-conventional and low-costly ingredients like DDGS to reduce the cost of production may be considered as very remunerative one for the village poors. Therefore, the present study was undertaken to investigate the effect of dietary incorporation of DDGS with or without multi-enzyme supplementation on the growth performance and nutrient utilization of indigenous chicken.

Materials and Methods

A total of one hundred and eighty numbers of 21 d-old indigenous chicks found in Dhemaji district of Assam, reared for both meat and egg purposes, were taken and divided them into six groups *viz*. T1, T2, T3, T4, T5 and T6 containing 30 chicks with 3 replicates of 10 chicks in each group. The chicks were wing banded and reared under deep litter system of management throughout the experimental period following standard and uniform managemental practices. The birds of T1 group (control) were offered the standard chick, grower and layer feeds as per BIS (2007) [2] (Table I). The birds of T2 group were fed with the same standard chick, grower and layer feeds as per BIS (2007) [2] with supplementation of multi-enzyme (Xzyme, Composition: Each kg of Xzyme premix contains: Lactic Acid Bacteria -30,000 million spores, Saccharomyces Cervisiae- 100 billion CFU, Amylase- 29,000 IU, Betaglucanase-4,05,000 IU, Phytase- 44,500 IU, Lipase-31,000 IU, Protease- 7,40,000 IU, Cellulase- 5,500 IU, Pectinase -1,01,000 IU and Hemicellulase- 25,000 IU). Maize DDGS was incorporated at 10% level in all the rations for T3 and T4 groups and the rations for T4 group was supplemented with multi-enzymes. In the same way, the birds of T5 and T6 groups were fed with rations containing 20% DDGS without and with enzymes, respectively. The Composition of chick, grower and layer rations for birds of different treatment groups along with the estimated crude protein (CP) and calculated metabolizable Energy (ME) values were presented in Table 1. The feeding trial was conducted for a period of 182 days (13 fortnights) using chick feeds for first 42 d, grower feeds for next 43-140 d and layer feeds for last 141-182 d. The BW was recorded on day one and thereafter at fortnightly intervals early in the morning before feeding. From the records, average fortnightly and final body weights and the body weight gains of individual birds as well as average feed consumption and feed conversion ratio (FCR) were studied and recorded. A metabolic trial was also conducted after the completion of feeding trial for a period of 8 d by taking 4 birds from each of the groups and keeping them in metabolic cages. Representative samples of each of the concentrate feed, DDGS used in the experiment, residual feed and excreta voided by the birds of different

Table 1: Ingredient and nutrient composition of experimental diets

Ingredients (%)	Ration stages								
	Chick mash			Grower mash			Layer mash		
	T1/T2*	T3/T4*	T5/T6*	T1/T2*	T3/T4*	T5/T6*	T1/T2*	T3/T4*	T5/T6*
Maize	48.00	42.93	39.00	40.40	32.26	29.32	43.18	34.21	32.27
SBM	30.50	25.00	19.00	15.50	10.00	5.00	25.00	19.85	14.30
Rice Polish	5.00	5.00	5.00	5.00	5.00	5.00	5.00	7.00	8.00
DDGS	00	10.00	20.00	00	10.00	20.00	00	10.00	20.00
DCP	1.30	1.20	1.00	1.30	1.20	1.00	1.30	1.20	1.00
LSP	1.70	2.00	2.00	1.70	2.00	2.00	7.00	7.20	7.30
Methionine	0.10	0.07	0.08	0.10	0.07	0.08	0.10	0.07	0.08
Lysine	0.00	0.05	0.18	0.00	0.05	0.18	0.00	0.05	0.18
Salt	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
Mineral-vit. Premix**	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Toxin binder	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Broken Rice	6.00	6.50	6.20	7.05	10.00	10.00	6.00	10.0	6.00
DORB	6.98	6.78	7.12	28.53	29.00	27.00	12.00	10.00	10.45
Enzymes	00	00	00	00	00	00	00	00	0.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Nutrient composition									
C P(%)	19.25	19.33	19.22	15.49	15.54	15.45	17.55	17.51	17.47
EE(%)	2.97	3.74	4.53	2.75	3.44	4.27	2.77	3.73	4.69
CF(%)	4.92	5.13	5.12	6.88	7.01	7.16	5.43	5.58	6.02
NFE(%)	65.82	64.37	62.95	66.47	65.23	64.14	66.61	65.01	63.61
Calcium(%)	1.08	1.14	1.04	1.01	1.08	1.05	2.93	2.98	2.95
T-P(%)	0.88	0.86	0.87	1.01	1.00	0.99	0.83	0.83	0.84
ME*** (Kcal/kg)	2798	2793	2800	2527	2503	2539	2580	2600	2604

SBM- Soybean meal, DDGS- Distillers dried grains with soluble, DCP- Di-calcium phosphate, LSP-Limestone powder, DORB- De-oiled rice bran, CP-Crude protein, EE-Ether extract, CF-Crude fibre, NFE-Nitrogen free extract, T-P-Total phosphorus, ME-Metabolizable energy.
*Diets of T2, T4 and T6 groups were additionally supplemented with multi-enzyme preparations (Xzyme) at 0.05 per cent level

**** Mineral-vitamin premix contained (per 1.2 kg)**
Calcium- 255 g, Phosphorous- 127.5 g, Magnesium- 6 g, Manganese- 1.5 g, Iron- 1.5 g, Iodine- 325 mg, Copper- 4.2 g, zinc-9.6 g, Cobalt- 150 mg, Sulphur- 7.2 g, Potassium- 100 mg, Sodium- 6mg, Selenium- 10 mg, Vitamin A- 700000 IU, Vitamin D3- 70000 IU, Vitamin E- 250 mg, Nicotinamide-1000 mg and Chromium- 78 mg.

***** Calculated value**
treatment groups were analyzed in the laboratory for proximate principles as per the method described by AOAC (2007) [1]. Calcium and phosphorus content of feeds, residues and excreta were estimated as per the modified method of Talapatra *et al.* (1940) [29]. The experiment was conducted in a completely randomized design (CRD). The statistical analyses of the experimental data were carried out according to the method described by Snedecor and Cochran (1994) [25] following One way ANOVA and the means were compared for Duncan's Multiple Range Test (DMRT) for significance.

Results and Discussion
The BW changes of the birds of different treatment groups (T1, T2, T3, T4, T5 and T6) were presented in Table 2. No significant difference (P>0.05) was observed among the groups in respect to initial, final, total gain and rate of mean daily gain in BW. The average final body weight (Table 2) of experimental birds was found to be highest in T2 group (1643.93±27.49 g) receiving no DDGS but with enzyme supplementation and lowest in T5 group (1580.00±19.56 g), where the birds were fed with diets containing 20% DDGS without any enzymes. The maximum and minimum mean final body weight gains and daily body weight gains among the experimental birds were recorded in T2 (1592±25.18 g and 8.75±0.14 g) and T5 group (1529±14.57 g and 8.10±0.08 g), respectively.

Table 2: Mean daily and total body weight gain (g/bird) in experimental birds of different groups

Dietary groups	Particulars			
	Initial BW	Final BW	Net gain in BW	ADG (g)
T1	51.57±0.32	1607.86±16.29	1556±16.36	8.55±0.09
T2	51.43±0.25	1643.93±25.22	1592±25.18	8.75±0.14
T3	51.63±0.32	1589.26±13.83	1537±13.89	8.15±0.08
T4	51.53±0.33	1603.21±13.88	1552±13.96	8.53±0.08
T5	51.53±0.33	1580.00±14.50	1529±14.57	8.10±0.08
T6	51.53±0.33	1596.07±11.78	1545±11.83	8.49±0.06
SEM	0.13	8.41	7.91	0.04

Means with different super script within the same column differed significantly (P>0.05)

The decreased BW in DDGS incorporated groups might be due to change of amino acid pattern of the diets as soybean is known to have more favorable amino acid pattern than corn or corn DDGS for poultry. In DDGS added rations percentage protein from soybean meal was decreased and at lower inclusion rates of DDGS, there appeared to be sufficient amino acids from soybean protein leading to no adverse effect on the growth of the birds. Again, in the layer rations, fed to the birds from 11th fortnight onward, soybean meal percentage was increased to fulfill the higher protein requirement leading to somewhat favorable amino acid pattern in the ration, which might led to comparable body weights of birds in 12th and 13th fortnights. The higher body weights of the birds in enzyme supplemented groups- T2, T4 and T6 compared to un-supplemented groups-T1, T2 and T5 groups, respectively, might be due to better nutrient utilization caused by exogenous multi-enzymes in the ration.

The results of this study were in agreement with Lukaszewicz and Kowalczyk (2014) [14] who reported that incorporation of DDGS up to 15% and without enzyme addition in the diets decreased final BW of the broiler chicken. Similarly, Widyaratne and Zijlstra (2007) [34] also found that, diets with 20% wheat DDGS had a decreasing trend on performance. The results of the research works conducted by Dale and Batal (2003) [5]; Lukaszewicz and Kowalczyk (2014) [14]; Lumpkins *et al*. (2004) [15] and Loar *et al.* (2010) [13] were in the same line with the present study, wherein DDGS incorporated diets in broiler ration at various levels resulted in a decrease in performance with increasing the levels of DDGS in the diets. Similarly, Swiatkiewicz *et al.* (2014) [27] reported from an experiment in broiler chicken that adding 0, 12 and 18% corn-DDGS with or without enzymes (xylanase+phytase) supplementation had no influence on BW when compared with the control diet.

The average total feed consumption per bird was 11665, 1664, 11669, 11739 and 11748 g in T1, T2, T3, T4, T5 and T6 groups, respectively. Similar trend of findings with respect to feed consumption was observed by Pineda *et al.* (2008) [21]. Tang *et al*. (2011) [30] conducted an experiment in broiler birds with 0, 5, 10, 15 and 20% corn DDGS in different groups and reported no significant (P>0.05) differences in overall feed intake among the treatment groups. Other workers such as Swiatkiewicz and Koreleski (2006) [26], Thacker and Widyaratne (2007) [31], Ibrahim *et al.* (2008) [10] and Hassan and Aquil (2015) [9] also found no significant (P>0.05) difference in feed consumption among different treatment groups by adding DDGS levels up to 10-15%. In the same line with the findings of present study, Ghazalah *et al.* (2011) [8] opined that there was no significant effect of DDGS, Avizyme or their interaction on feed intake in Bovans Brown layers. Likewise, Swiatkiewicz *et al.* (2013) [28] also reported that DDGS at the level of 200 g/kg with enzyme (xylanase and phytase) in the diets of laying hens had no effect on feed intake.

In the present study the higher feed intake data in the experimental groups fed with increased levels of DDGS in comparison to control and lower- DDGS supplemented groups might be due to dilution of nutrients and increased fibre level in those diets which was in good agreement with earlier researchers.

Table 3: Mean fortnightly and total feed consumption (g) and mean FCR per bird under different treatment groups

Fortnights	Dietary groups											
	T1		T2		T3		T4		T5		T6	
	Feed consumption (FC)	FCR	FC	FCR	FC	FCR	FC	FCR	FC	FCR	FC	FCR
1st	255	4.98	253	4.83	262	5.19	256	5.03	264	5.30	263	5.13
2nd	393	3.64	401	3.63	396	3.78	398	3.70	403	3.81	408	3.87
3rd	525	3.17	524	3.09	527	3.28	529	3.17	530	3.86	533	3.31
4th	595	2.89	598	2.88	604	3.07	606	2.88	597	2.86	601	2.87
5th	737	3.29	743	3.27	741	3.37	736	3.30	740	3.33	739	3.32

6^{th}	771	4.11	775	4.21	777	4.13	778	4.08	781	4.24	782	4.20
7^{th}	875	5.59	873	5.56	880	5.65	875	5.62	878	5.56	881	5.51
8^{th}	1015	9.09	1014	8.95	1007	8.61	1010	8.74	1020	8.71	1022	8.50
9^{th}	1121	12.57	1119	13.10	1129	12.52	1132	12.41	1148	13.57	1123	16.48
10^{th}	1220	17.10	1226	19.31	1218	17.65	1222	15.95	1237	15.99	1241	15.94
11^{th}	1299	25.46	1298	25.63	1285	25.98	1290	23.00	1308	24.98	1311	23.69
12^{th}	1404	31.25	1406	32.51	1398	31.96	1404	31.24	1412	28.78	1419	30.13
13^{th}	1438	40.40	1432	41.34	1444	38.29	1434	44.23	1422	47.56	1428	43.69
Overall	11653	7.51	11665	7.37	11664	7.62	11669	7.51	11739	7.69	11748	7.64

The overall FCR of the birds for entire period of study was least in T2 group (7.37), followed by T1 (7.51), T4 (7.51), T3 (7.62), T6 (7.64) and T5 (7.69) groups, which were comparable among the groups as well as with the control group. The results of this study with respect to FCRs were in agreement with the reports of Swiatkiewicz and Koreleski (2006) [26], who carried out a study on laying hen performance in Lohman Brown hens by feeding DDGS at five inclusion rates of 0, 5, 10, 15, or 20% in the diets and came out with the conclusion that there was no significant (P>0.05) effect on feed conversion when DDGS was fed up to 20%. The FCR data of the present study were also in corroboration with the findings of Hassan and Aqil (2015) [9] who studied the productive performance of Hisex laying hens by adding different levels DDGS at 0, 5, 10 or 20% in their rations and concluded that there were no significant effect of adding DDGS on FCR per egg mass.

Pescatore *et al.* (2012) [19] also observed from an experiment in Hy-Line Brown hens by feeding diets containing 15 or 23% DDGS with or without enzyme complex that neither the dietary treatments affect feed conversion. The findings of this study were in corroboration with the results of Schedle *et al.* (2016) [23] who carried out an experiment in broiler chicken by feeding them diets containing 8%, 16% and 24% DDGS, with or without NSP-hydrolyzing enzymes and observed no effect of increasing DDGS content on FCR in growing stage.

Percent retention of intake nitrogen, calcium and phosphorus (Table 4) ranged between 51.75+2.43 to 53.81+2.14, 39.17+3.60 to 40.26+3.55 and 47.98+0.51 and 50.10+0.54, respectively, in different groups. Positive balances were observed in N, Ca and P utilization and no significant difference (P>0.05) was observed in percent retention of nitrogen and calcium among the groups and significant difference (*P*< 0.05) was recorded between T1 and T4 and T6 groups, between T3 and T6 and between T5 and T6 groups in percent P retention. Nitrogen and Ca balances were found to be on the lower side in all the treatment groups, which might be due to greater release of these nutrients in the eggs, produced by the hens during the days of metabolism trial.

Table 4: Average intake, balance and percent retention of nitrogen, calcium and phosphorus

Nutrients	Particulars	Dietary groups						SEM
		T1	T2	T3	T4	T5	T6	
Nitrogen	Intake (g)	2.66+0.02	2.70+0.02	2.66+0.01	2.77+0.11	2.68+0.02	2.79+0.02	0.0070
	Excreted in excreta (g)	1.05+0.01	1.05+0.01	1.05+0.01	1.07+0.01	1.10+0.01	1.09+0.01	0.0047
	Excreted in eggs (g)	0.205+0.205	0.205+0.205	0.205+0.205	0.207+0.207	0.200+0.200	0.202+0.202	0.0737
	Balanced (g)	1.41+0.11	1.50+0.02	1.40+0.02	1.43+0.03	1.39+0.02	1.41+0.02	0.0238
	% Retention of N	52.96+2.51	53.81+2.14	52.77+2.55	52.81+2.16	51.75+2.43	52.10+2.50	0.8734
Calcium	Intake (g)	2.78+0.03	2.80+0.01	2.83+0.01	2.87+0.02	2.83+0.02	2.85+0.02	0.009
	Excreted in excreta (g)	1.36+0.01	1.36+0.01	1.38+0.01	1.41+0.01	1.41+0.01	1.40+0.01	.006
	Excreted in eggs (g)	0.317+0.317	0.319+0.319	0.317+0.317	0.316+0.316	0.313+0.313	0.315+0.315	0.114
	Balanced (g)	1.12+0.02	1.11+0.02	1.14+0.01	1.14+0.09	1.11+0.16	1.13+0.11	0.036
	% Retention of N	40.26+3.55	39.79+3.33	40.05+3.52	39.68+3.34	39.17+3.60	39.77+3.71	1.268
Phosphorus	Intake (g)	0.79+0.01	0.80+0.01	0.79+0.01	0.82+0.01	0.81+0.02	0.83+0.01	0.0039
	Excreted in excreta (g)	0.40+0.01	0.40+0.01	0.40+0.01	0.40+0.01	0.41+0.01	0.40+0.01	0.0015
	Excreted in eggs (g)	0.0103+0.0103	0.0104+0.0104	0.0102+0.0102	0.0104+0.0104	0.0102+0.0102	0.0102+0.0102	0.0173
	Balanced (g)	0.38+0.01	0.40+0.01	0.38+0.01	0.40+0.01	0.39+0.01	0.42+0.02	0.0037
	% Retention of N	47.98^{a}+0.51	49.42^{ad}+0.61	48.20^{ab}+0.62	49.59^{bdf}+0.14	48.12^{aef}+0.68	50.10^{cd}+0.54	0.2622

^{abcdef}Means bearing the different superscripts within the row differ significantly (*P*< 0.05)

The results of the present study with respect to N retention was in agreement with the findings of Thacker and Widyaratne (2007) [31], who carried out an experiment on nutritional value of diets containing graded levels of wheat distillers grains with soluble at the levels of 0, 5, 10, 15 or 20% fed to broiler chicks and reported that percent nitrogen retention under different dietary treatments varied non-significantly (P>0.05). Ibrahim *et al.* (2008) [10] conducted a trial in male broiler chicks by feeding diets containing 0, 5, 10 or 15% DDGS and reported that there was no significant effect of increased DDGS levels on excreta quality.

The results of the study conducted by Leytem *et al.* (2008) [12] was also in the same line to the present experiment, who observed that the apparent retention of nitrogen decreased linearly with increasing DDGS inclusion (0-20%) in the diets of broiler birds. Deniz *et al.* (2013) [6] conducted experiments in laying chicken using different levels of DDGS at 0, 5, 10, 15 and 20% with or without enzyme cocktails in their diets and found that the levels in manure N were not affected by dietary DDGS inclusion. In the present study the non-significant (P>0.05) difference in respect of nitrogen retention with linearly decreased retention with increasing levels of DDGS in the diets among the treatment groups might be due to dilution of nutrient density in the ration due to increasing fibre levels in the diets.

The significant (*P*< 0.05) difference in respect of P retention between T1 and T4 and T6 groups might be due to the effects of higher content of DDGS in T4 and T6 groups, which is high in available P content and also due to the action of phytase enzyme which was supplemented in both the groups.

Likewise, significant (P< 0.05) difference in P retention between T3 and T6 and T5 and T6 groups might be due to the effects of phytase. In the present study the significant (P< 0.05) difference in percent of P retention among the treatment groups might be due to presence of higher amount of available phosphorus in DDGS and supplementation of phytase in the diet.

As there is no significant differences among the groups in respect of body weights, BWG, FCR as well as the nutrients utilization except P retention, by observing the economic benefits (not shown in this paper) due to addition of DDGS in the rations, it is concluded that DDGS can safely be incorporated at 20% level as alternate feed ingredient in the rations of indigenous chicken with multi-enzymes for economical and profitable poultry production.

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