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ORIGINAL RESEARCH ARTICLE

Effects of Brewery Spent Grain (BSG) included poultry diet on growth performance and meat quality of New Hampshire chicken

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ABSTRACT

An experiment was conducted to evaluate the inclusion effects of Dried Brewery Spent Grain (DBSG) to know its effect on growth performance and meat quality on poultry. Completely randomized design was used to compare the treatments in five replications. The treatments used were 15% DBSG (T1), 20% DBSG (T2), 25% DBSG (T3), Commercial feed (T4) and (0% DBSG) scavenging bird was used as a control. Each treatment contained 10 birds including 200 chickens in the whole investigation. The major factors body weight, carcasses and organs weight, cholesterol, total protein, albumin, and calcium were evaluated. Results showed that mean body weight of the experimental bird after 60 days was not significantly different ($p>0.05$) among the dietary treatments, i.e., T1 (781.46 g), T2 (738.36 g), T3 (728.91 g) and T4 (753.38 g). Carcass, breast muscle, thigh, wing, shank, liver and spleen were not significantly different ($p>0.05$) in weight between DBSG included diet and commercial feed. However, dressing percentage (59.3%) of T4 and gizzard (43.20 gm.) in T3 was significantly higher than other treatments. The significantly higher ($p<0.05$) amount of cholesterol found in T4 (312.01 mg/dl) followed by control diet (239.46 mg/dl), both of which were above than reference range (129-297 mg/dl). However, in other treatments i.e., T1, T2 and T3, the cholesterol content was in between the reference range. Similarly, same level ($p>0.05$) of total protein, albumin and calcium content in blood serum observed in BSG included diet and commercial diet. Hence, 15% to 20% inclusion of BSG could be the optimum level in diets of New Hampshire chickens.

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INTRODUCTION

New Hampshire chicken is widely prevalent backyard poultry, raising under scavenging and semi-scavenging system in Nepal, however some time they supplemented with small amount of maize grain. Chemical analysis of the ingested crop materials in scavenging poultry indicated that the crop indicated that nutrients, particularly protein, could not meet the requirement of crossbred pullet (Pousga, 2018). Therefore, the scavenging chickens should be supplemented properly to obtain their genetic growth potential (Macharia *et al.*, 2015), although the supplementation with conventional concentrate feed has been costly. Feed cost experienced about 70 % of total cost of production in poultry production (Waller, 2007). The native conventional feed supply in Nepal is not adequate to meet the demand of existing livestock and poultry (Osti, 2020), so poultry feed mostly depends on imported feed ingredients, consequently feed cost has been increasing day by day. The conventional feed source can be replaced by cheaper unconventional feed source that are available locally and may be included in maxi-

mum level without harmful to the chicken which help to formulate low-cost feed with balance nutrients (Thirumalaisamy *et al.*, 2016). Local feed ingredients in feed formulation resulted a good response to the performance of egg production in Super kampong chicken (Hafsah and Sarjuni, 2017). Feed produced from non-conventional feed sources help to decrease the overall cost of feed and significantly increase economy of marginal farmer (Wagh *et al.*, 2021). Therefore, a search for alternative feed ingredients with lower purchase costs that are locally availability and not in conflict with human food is being necessary for sustainable poultry production (Bolu *et al.*, 2012; Ironkwe and Bangbose, 2011). In this regard, agro-industrial by-products are highlighted and can be economically viable alternatives (Abd El-Hack *et al.*, 2019; Swain *et al.*, 2012).

The brewery industry produces a considerable amount of brewer's grain, it is estimated that 2288.9 tons of brewery produce per year in Nepal (Chaudhary and Bhattarai, 2017). The brewer's grain is extracted residue which is of variable composition due to a variety of grains. The most commonly used are barley, wheat, corn, rice and oats (Abd El-Hack *et al.*, 2019). The residue is remaining insoluble material that contains raw fibre fractions, crude protein, amino acids, ether extract, starch, minerals and vitamins (Ashour *et al.*, 2019; Alabi *et al.*, 2014), predominantly fibre and protein (Mussatto *et al.*, 2006). Use of the wet bakery waste is in practice for swine feeding in eastern part of Nepal (Gairhe and Paudel, 2019). The wet brewery grains could be effective in milking cattle as a concentrate during hot and humid weather without decreasing milk yield and DM intake when fed at 30% DM (West *et al.*, 1994). It can also replace the concentrate feed up to 30 % in goat feeding (Shah *et al.*, 2023). The energy value of spent grain can be enhanced by reducing the moisture level (Chaudhary and Bhattarai, 2017) and can be used as non-conventional feed. Very limited research has been done in feeding brewery dried grain (BDG to chicken, although Parpinelli *et al.* (2020) reported that there were no changes in carcass yield, relative organ weight intestinal morphology and meat quality of chicken fed BDG. In Nepalese context local brewery industry are dominant in rural to peri-urban areas, mostly uses finger millets for alcohol (*Raksi or Madira*) production and residues, *i.e.*, brewery spent grain (BSG) remains unused. The BSG left on the ground outside the brewery spoil quickly and could become an environmental nuisance, including water pollution. The environmental impact of the brewing process could alleviates by using brewers grains as animal feed alleviates impact of the brewing process (Lazarevich *et al.*, 2010; Crawshaw, 2004). Thus, the study intended to know the possible inclusion level of dried BSG in poultry diet, and its effect on growth performance and meat quality of New Hampshire chicken.

MATERIALS AND METHODS

Experimental site

The research was conducted at a "home stay" village of Rainaskot Municipality, Lamjung District of Gandaki province which belongs to middle hills of Nepal. It lies between 28°03'21.49"N and 28°10'15.51"N latitudes and 84°26''04.71"E and 84° 33''15"E longitude, 600 meter above mean sea level. Gurung was predominant cast in the site. Raising back yard poultry, making local "*raksi*" (Nepali alcohol) from finger millet and conducting home stay business were basic occupation of the people.

Farmer selection

In the home stay village farmers who produce local "*raksi*" from millet and hold back yard poultry in scavenging system were gathered and asked them, if they were interested to use BSG in poultry diet. Among them five interested farmers were selected for conducting this experiment.

Feed formulation and treatments

For the five treatments, scavenging poultry raising without any supplementation of concentrate feed was considered as control diet and supplements of commercial started ration and grower ration was a treatment four which has been symbol as T4. Similarly diet for other three treatments, *i.e.*, T1, T2, T3 were formulated by using dried BSG in different level inclusion, 15 %, 20 %, and 25 %, respectively. Diet composition of experimental animals is given in Table 1.

Experimental design

A total 50 chicks of New Hampshire breed were provided to each farmer. The chicks were homogenous of two weeks aged. The 50 chicks were equally divided in to five group in Completely Randomized Design (CRD) so that 5 type of diet could provide each 10 chicks of experimental unit. The 5-diet type were used as treatments and five farmers were used for replication of the treatments.

Brewery spent grain (BSG)

The BSG of millet was collected from the local "*Bhatti*" (a place for producing local *raksi* or *madira*) in a wet form. The BSG was sun dried for 3 days to reduce moisture content, so that it could be used in poultry feed. The nutrient composition of the DBSG was analyzed in a laboratory of National Animal Nutrition Research Centre, Khumaltar. The nutrient composition of the DBSG has presented in Table 2.

Feeding management and data recording

The experiment birds were maintained in the semi-intense condition, they were allowed to graze for 4-5 hours daily. Concentrate feed was provided based on the chick's age. The concentrate @ 30 gm. per chicks was supplemented for 3 to 4 weeks aged chicks and 10 gm. per chicks feed was increased by every two-week interval, hence concentrate feed was supplemented @ 80 gm. at the age of 13th to14th week. The supplement feed was offered in each experimental unit that consist of 10 birds at morning and evening time. Weight was measured in every 15 days interval up to 90 days. Similarly, medication and mortality were also recorded during the experiment period. At the end of

Table 1. Ingredients used in feed formulation for different types of diet feed to New Hampshire chicken feeding in Rainuskot, Lamjung.

Ingredients	T1	T2	T3
Maize	48	47	46
Soyabean	20	19	18
Mustard cake	3	2	1
Rice bran	10	8	6
Dried Brewer Spent Grain (DBSG) of Millet	15	20	25
Limestone	1	1	1
Toxin Binder	1	1	1
Trace Minerals	1.5	1.5	1.5
Salt	0.5	0.5	0.5
Phytate (2000FTU)	0.1	0.1	0.1
Methionine	0.06	0.06	0.06
Lysine	0.03	0.03	0.03

Note: T1 is 15 % DBSG included diet, T2 is 20 % DBSG included diet, T3 is 25 % DBSG included diet T4 is commercial feed.

Table 2. Nutrient composition (% of DM) of Dried Brewery spent Grain.

Nutrients	DBSG (millet)
Dry Matter	90.63
Crude Protein	12.27
Crude Fibre	19.37
Total Ash	3.83

Note: DBSG denoted Dried Brewery Spent Grain.

the experiment, one birds from each replicate i.e., 5 birds per treatment were slaughtered after 4 hours of feed withdrawal. Eviscerated weight including carcass weight, carcass dressing percentage, breast muscle, thigh, wings, shank and internal organ *viz*. liver, gizzard, heart, spleen were measured and recorded according to Swain *et al.* (2012). Similarly, blood sample was collected in 5 ml syringe from wing vein of the experimental bird and allowed to sediment for serum separation. The separated serum was analyzed in the laboratory of National Animal Health Research Centre, Khumaltar, and Lalitpur for cholesterol, total protein, albumin and calcium content.

Statistical analysis

All the collected data were then entered in MS Excel and converted into text files. Effect of treatment were analyzed using one-way and two-way ANOVA procedure in accordance with the Completely Randomized Design (CRD). Data were analyzed for descriptive statistics and possible associations between the variables were analyzed using SPSS ver 22.0 programming. The statistically significant means were then compared using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

The mean body weight (gram) of bird fed with different level of DBSG, Commercial diet and control diet (conventional scavenging system) has been presented in Table 3. In first 45 days, the dried BSG included dietary treatments *i. e*., T1, T2, T3 and commercial feed (T4) had significant effect ($p<0.05$) on mean body weight of the Chickens. The higher body weight was observed in the experimental birds supplemented with commercial feeds as compare to DBSG included diet and control diet (Table 3). Supporting the result Campus and State (2012) reported that final mean body weight, daily weight gain was significantly ($p<0.05$) higher than control diet BDG. Furthermore, Kuleile *et al.* (2020) reported dietary treatment with BDG to a day-old broiler had significant ($p<0.05$) influence on daily weight gain and final weight gain to 42 days. The lower production parameter at young age could be as a result of high fiber content associated with feeding of BDG. Fibrous ingredients resulted in dilution of metabolizable energy (M.E.) of the basal diet (Longe, 1984). Moreover, the observed average body weight might be due to low feed intake of formulated feed during a period of adoption (Campus and State, 2012).

However, after 45 days, there was no significant difference ($p>0.05$) observed among all the formulated DBSG included diet, and commercial diet. This might be due to higher fiber digestion capacity built up with the increased age of the experimental bird. Only significant difference ($p<0.05$) was observed with control diet. The changes in weight gain of the birds fed with DBSG included diet in later stage of growth may be reported due to removal of sugars. Because starches during the malting and mashing process, proteins and some minerals are higher in BDG (Westendorf and Wohlt, 2002). The less growth of experimental birds reared only in scavenging indicates the local chickens were deprived of adequate nutrition to achieve growth. At the end of the experiment there was no significant difference ($p>0.05$) on average weight between BSG included treatments (T1, T2, T3) and commercial feed (T4) but significant difference ($p<0.05$) was observed with control diet.

Table 3. Mean body weight (gram) of New Hampshire chicken fed with different level of Dried Brewery Spent Grain (DBSD), Commercial diet and rearing under conventional scavenging system of Rainuskot, Lamjung, during 2022.

Days	Control	Treatment 1 (T2)	Treatment 2 (T3)	Treatment 3 (T3)	Treatment 4 (T4)
IBW	64.20±4.37	69.60±1.56	68.18±2.17	69.40±3.08	70.30±.85
15	197.20±8.27^{ab}	178.63±7.71^{ab}	174.30±6.04^{b}	178.45±11.87^{ab}	209.45±8.34^{a}
30	343.00±13.54^{b}	328.24±13.48^{b}	310.68±23.12^{b}	336.28±13.73^{b}	446.86±14.73^{a}
45	494.70±29.51^{b}	550.65±16.95^{ab}	502.52±30.28^{b}	528.12±26.05^{ab}	600.38±26.18^{a}
60	579.10±32.47^{b}	781.46±27.97^{a}	738.36±59.05^{a}	728.91±49.24^{a}	753.38±55.38^{a}
75	715.28±29.84^{b}	1011.95±57.92^{a}	1021.28±48.58^{a}	940.22±43.18^{a}	1050.92±53.23^{a}
90	742.08±31.94^{b}	1222.33±90.33^{a}	1237.01±63.85^{a}	1167.43±72.89^{a}	1317.09±74.77^{a}

Note: Superscript with different letter denotes significance ($p<0.05$) in row, Number behind the ± shows the standard error of the mean, IBD denotes Initial Body Weight, T1 is 15 % DBSG included diet, T2 is 20 % DBSG included diet, T3 is 25 % DBSG included diet T4 is commercial feed.

Table 4. Carcass and organ mean weight of New Hampshire Chickens fed with different level of Dried Brewery Spent Grain (DBSD), commercial diet and rearing under conventional scavenging system of Rainuskot, Lamjung, during 2022.

	Control	Treatment 2 (T2)	Treatment 2 (T3)	Treatment 3 (T3)	Treatment 4 (T4)
Dressing %	54.46±.48^{ab}	56.97±.93^{ab}	57.01±.57^{ab}	53.34±2.34^{b}	59.30±1.62^{a}
Carcass weight	425.00±25.00^{b}	805.20±118.56^{a}	727.60±66.34^{ab}	616.80±61.17^{ab}	722.00±117.42^{ab}
Breast muscle	114.50±.50^{b}	162.00±15.74^{ab}	172.60±11.10^{a}	107.20±20.38^{b}	163.00±15.94^{ab}
Thigh	172.00±14.00^{b}	309.20±43.47^{a}	271.40±27.47^{ab}	255.20±20.99^{ab}	256.40±42.23^{ab}
Wings	71.00±7.00^{b}	122.80±12.56^{a}	108.00±7.16^{ab}	102.40±5.49^{ab}	108.80±15.30^{ab}
Shank	45.00±1.00^{b}	77.20±7.20^{a}	64.60±5.98^{ab}	60.40±6.49^{ab}	59.60±9.50^{ab}
Liver	28.00±.00	35.20±2.80	34.40±1.72	27.20±1.02	29.00±3.90
Spleen	5.00±.00	7.80±1.39	6.80±.49	4.60±.68	6.00±1.0
Gizzard	32.00±2.00^{b}	36.00±1.41^{ab}	36.60±.40^{ab}	43.20±1.62^{a}	34.00±3.45^{ab}

Note: Superscript with different letter denotes significance ($p<0.05$) in row, Number behind the ± shows the standard error of the mean, T1 is 15 % DBSG included diet, T2 is 20 % DBSG included diet, T3 is 25 % DBSG included diet T4 is commercial feed.

Similar result was also observed by Anjola *et al.* (2016) who reported no significant difference on average body weight gain on a broiler fed on different level of Brewer Dried Grain as replacement for soybean meal at finisher phase.

Table 4 shows the carcass and organ mean weight of experimental bird fed with different level of Dried Brewery Spent Grain (DBSD), commercial diet and rearing under conventional scavenging system. There was no effect ($p>0.05$) on carcasses dressing % among 15 % and 20% dried BSG included diets and control diet, but significantly higher ($p< 0.05$) dressing % observed in commercial diet. Similar result observed by Swain *et al.* (2012) in chicks fed with 10% and 20% BDG included diet and non-supplemented control diet, eviscerated yield percentage increased significantly ($p< 0.05$). In contrast, Kuleile *et al.* (2020) observed no difference in carcass dressing percentage between commercial feed and 25% BDG in Broiler chicken. In case of carcass weight, there was no difference observed, significantly ($p>0.05$), among BSG included diets and commercial diet, but significant difference ($p< 0.05$) observed with control diet. Similar result reported by Kuleile *et al.* (2020) he observed similar weight of carcass in broilers fed with commercial diet and formulated diet containing 25% BDG. Moreover, Parpinelli *et al.* (2020) also found no significant changes in carcass weight in Broiler chickens fed with BDG in different inclusion rate. Regarding, the breast muscle, highest value observed in 20% BDG included diet which was at pars with commercial diet ($p>0.05$), 15% BDG included diet and control, but significant difference ($p< 0.05$) was observed in 25% BDG included diet. Swain *et al.* (2012) reported no significant difference between feed containing 10% BDG, 20% BDG and control diet without BDG. Similar case observed in thigh and wing weight. In both cases 10% dried BSG fed diet gave significantly higher ($p< 0.05$) weight as compare to control. There was no significant difference ($p>0.05$) in the weight of liver and spleen but there was significant ($p<0.05$) difference on weight of gizzard. The highest gizzard weight was found in the formulated diet containing 25% dried BSG, however, similar weight was observed in remaining diets. Due to more work to blend the fiber ingested, gizzard weight is expected to increase (Deaton *et al.*, 1977) which could explain why birds on formulated diet containing 25% BDG had the biggest weight of gizzard.

The effects of different dietary treatments on the cholesterol, total protein, albumin and calcium content in blood serum of experimental birds has been shown in Table 5. The cholesterol level found significantly higher in commercial died fallowed by Control diet, both seemed above the reference level (129—297 mg/dl). Similar result was observed by Anjola *et al.* (2016), the decrease in cholesterol as Brewery Spent Grain in diet was increased. Soluble fiber has been found to reduce the total and LDL cholesterol in blood by related quantity (Ikemoto, 2000) which could explain why birds on 25 % DBSG included diet (T3) had the lowest cholesterol level. There was no significant difference ($p>0.005$) in serum proteins and calcium which falls under normal reference range. Highest value of albumin was observed in formulated feed containing 25% BSG which falls under normal reference range and was at pars with formulated feed containing 15% BSG, 20% BSG.

Table 5. Effect of different dietary treatments on the cholesterol, total protein, albumin and calcium content in blood serum of experimental birds, during 2022.

Nutrients	Control	Treatment 2 (T2)	Treatment 2 (T3)	Treatment 3 (T3)	Treatment 4 (T4)	Reference value
Cholesterol	239.46±27.35^{ab}	213.73±40.42^{ab}	152.80±4.04^{a}	202.70±48.30^{a}	312.01±27.49^{b}	129 - 297
Total protein	3.81±.08	3.82±.18	4.21±.18	3.76±.14	3.90±.11	3.0 - 4.9
Albumin	1.48±.04^{a}	1.75±.11^{ab}	1.80±.05^{b}	2.00±.14^{b}	1.82±.06^{b}	1.17-2.74
Calcium	9.97±.14	9.82±.12	10.34±.37	9.96±.21	10.26±.20	8.1 - 12

Note: Superscript with different letter denotes significance ($p<0.05$) in row, Number behind the ± shows the standard error of the mean, T1 is 15 % DBSG included diet, T2 is 20 % DBSG included diet, T3 is 25 % DBSG included diet T4 is commercial feed.

Conclusion

Initially, formulated feed containing different levels of DBDG had no significant difference on body weight of New Hampshire chickens but after 45 days better performance was observed as commercial diet, indicating best period for supplementing diets could be during grower phase. Similarly, low value in control diet indicates the local practice of poultry rearing to semi scavenging chicken is poor as diet was unable to promote an average weight gain as that of commercial and DBSG included diets. Carcass weight had indicated no significant difference of formulated DBSG included diets with commercial feed as the performance was found to be similar. Similarly, blood serum analysis indicated no significant difference of formulated feed with commercial feed, where the serum analysis of experimental birds was at normal level. Therefor, 15 to 20 % inclusion of dried brewery Spent Grain in growing bird could be recommended for low cost and sustainable backyard poultry production.

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Conflict of interest declaration

The authors declare there is no conflict of interest.

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