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Effect of Supplementing Wet Distillers' Grains with Solubles to Maize Silage Based Diet on Performance of Growing Nellore Jodipi Ram Lambs

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ABSTRACT

The objective of the study was to evaluate performance of ram lambs supplemented with distillers grains with solubles (DGS) under intensive system. In a completely randomized design, 24 growing Nellore Jodipi ram lambs were divided into 4 equal groups of six each. Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively.The average daily gain (g) of 105.4, 69.1, 81.6, and 89.5 was recorded recorded in T_1 to T_4 fed lambs respectively, was higher (P<0.05) in T_1 than in T_2. The DMI from silage and total DMI were not significantly different among treatments. The DMI (g/d) from dry DGS was 153.0 in T_1 and 46.6, 74.4 and 99.8, in T_2 to T_4 from wet DGS, respectively and was higher (P<0.05) in T_1 than in T_2. The feed efficiency was inferior (P<0.05) in T_2 as compared to other treatments. The digestibility of nutrients except CP and EE was not significantly different among treatments. The N retained as per cent of intake and the molar proportion of acetate, and acetate to propionate ratio was higher (P<0.05) in T_1 than in other treatments. There was no significant difference among treatments with respect to serum concentration of protein, mineral profile of serum except for a higher (P<0.05) phosphorus in T_1 fed lambs. The carcass traits, chemical composition and mineral profile of longissimus dorsi muscle were also not significantly different among dietary treatments. Returns over feed cost was higher (P<0.01) in T_1 and T_4, than in T_2 and T_3 fed lambs. It was concluded that supplementation of wet DGS to maize silage-based diet at 2.0% of body weight resulted in performance comparable with dry DGS supplementation at 1 % of body weight.

Key words: Maize silage, Ram lambs, Supplementation, Wet Distillers grains with soluble

INTRODUCTION

The cereal processing industries in India are on constant rise producing various beverage-based by-products at higher amounts (Lakshmi *et al.,* 2017). Among these by-products, distillers grains with solubles (DGS) is a by-product of ethanol industry made primarily of unfermented grain residue containing protein, fibre, and fat at higher amounts (Reddy *et al.,* 2017). The DGS is majorly used as a protein source, but can also be used to provide energy due to presence of degradable fibre in large amounts (NDF - 38-40%).

Farmers, especially those in third-world countries, feed sheep with DGS in two forms *i.e.*, wet DGS (WDGS) and dry DGS (DDGS) depending on the availability (Iram *et al.,* 2020). Though wet DGS has four to five days of shelf life, the chemical composition of the dry and wet DGS is similar on dry matter basis. However, poor amino acid digestibility due to Maillard reaction can be observed in dry DGS than in wet DGS due to extreme hot conditions during drying of wet DGS (De Almeida, 2013). Feeding of wet DGS would be economic as the cost incurred in drying the product can be bypassed and loss of protein quality due to heat treatment can be minimized (Schingoethe *et al.,* 2009). Addition of DGS to replace soybean meal to the ration has been beneficial in finishing lamb diets (Kawecka *et al.,* 2018). In view of availability of wet DGS to farmers in the vicinity of distillery plants, this study was taken up to study the effect of supplementing wet DGS to corn silage based on performance of lambs under intensive system of rearing.

MATERIALS AND METHODS

All experimental protocols were approved by the Institutional Committee for Animal Use and Ethics of

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the College of Veterinary Science, Tirupati. Corn silage was purchased from M/S Fertile Green Inc, Nellore, WDGS was procured weekly once from a local vendor and DDGS was purchased from Prorich Agro Foods, Haryana.

In a completely randomized design and under intensive system, 24 Nellore Jodipi ram lambs (3-4 months old, 12.8 ± 2.4 kg BW) were randomly allotted to four treatment groups of six animals each. Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively. Animals were housed in a pucca shed individually in pens of 2.1 x 1.2 x 1 m dimensions having facilities for individual feeding and watering. The ram lambs were fed weighed quantity of DGS at 9:00 AM daily and corn silage *ad libitum* twice daily at 12:00 PM and 4:30 PM. The leftover corn silage if any, was recorded. The body weight of lambs was recorded at weekly intervals. The growth trial lasted for 90 days and was preceded by a 7 days adaptation period during which time the animals were weighed, tagged for identification, treated for ecto- and endoparasites and adapted to corn silage. After completion of growth trial, the lambs were shifted to metabolism cages for metabolism trial with 14 day preliminary and 7 day collection periods that was followed by slaughter by "Halal" method (Gerrard,1964) and whole cuts were taken as per ISI (1963) to study the effect of treatments on carcass traits.

Representative samples of feed offered and feed residues were collected and weighed. Silage samples and WDGS samples were taken at 3 days interval, DM was estimated immediately and dried samples were pooled. During metabolism trial, a 24-hour collection of faeces was recorded everyday morning at 9:00 AM for seven days. Daily faeces was pooled for 24 hours in separate containers and the faeces was weighed, mixed thoroughly and representative sample (2%) was taken separately for each animal and stored in a deep freezer at –20º C. At the end of the trial faecal samples were thawed to room temperature and fresh samples were taken for nitrogen estimation. For further analysis, faeces was dried at 60ºC and ground to pass through 1 mm screen of a Willey mill and were preserved in air tight bottles. A 24-hour collection of urine was recorded everyday morning at 8:00 AM for seven days and representative sample (1/10th of total volume voided) was taken separately for each animal and stored in a deep freezer at –20º C. At the end of the trial urine samples were thawed to room temperature and sampled for nitrogen estimation.

Rumen contents were collected at the time of slaughter and filtered through four layers of muslin cloth and approximately 100 ml of filtrate was collected, a few drops of concentrated sulphuric acid was added and stored at -20º C for further analysis (Spanghero *et al.,* 2019). Blood was collected from each animal under aseptic conditions from jugular vein at the end of growth trial and kept in slant position for 1 h and samples were centrifuged at 3000 rpm for 5 min, serum was collected in Eppendorf tubes and kept at -20ºC for further estimation of serum protein and minerals.About 100g of meat sample (*Longissimus dorsi*) was collected at the time of slaughter and stored at -20º C for further analysis.

Proximate composition (AOAC, 2005) and cell wall constituents (Van Soest *et al.,* 1991) were estimated in the dried and pooled samples of corn silage, leftover silage, WDGS, DDGS and faeces. Urine was analyzed for nitrogen (AOAC, 2005). The per cent moisture, crude protein and crude fat (AOAC, 2005) was estimated. Serum protein was estimated using a commercial kit (Erba Total Protein Estimation) and minerals in serum and meat samples were estimated using atomic absorption spectrophotometer (GBC AAS Avanta PM Model).

Three samples per silage bale were taken, 100 ml of distilled water was added to 10 g of sample and triturated for 3-5 minutes with the help of mortar and pestle and filtered using Whatman filer paper No.1 (Hasanah *et al.,* 2017) for pH estimation.

Samples of WDGS for pH estimation were drawn at weekly intervals, 20 ml of distilled water was added to 5 g of sample, kept for 30 minutes and filtered using Whatman filer paper. No.1, pH of the silage extract, WDGS extract and rumen liquor was estimated using EUTECK 501 pH meter. Silage extract was collected by incubating 10 g of fresh silage with 100 ml of distilled water for 24 hours followed by filtration (Hasanah *et al.,* 2017) and samples were kept at -20^{0}C till estimation of lactic acid.

NH_3-N in rumen liquor was estimated (AOAC, 2005). TVFA and molar proportions of acetic, propionic acid and butyric acids was estimated using ACME 6000 gas chromatography. Samples were prepared for GC analysis (Soren and Rao, 2015) and stock standards were purchased from Sigma. Working standard solutions of acetic, propionic and butyric acid were prepared having concentration of 10 m Mol/ml separately and mixed standard was prepared from individual working standard solutions to contain acetic, propionic and butyric acids in 65:21:14 ratio. The operating conditions followed during analysis included, inlet temperature at 200º C, detector temperature at 220º C and oven program with initial temperature at 100º C for 3 min, ramp rate at 10º C/min till final temperature at 180º C.

Calculation:

Concentration of analyte in sample (mM/ml) =

$$\frac{\text{area of analyte} \times \text{concentration of analyte in standard} \quad \frac{\text{mM}}{\text{ml}} \times \text{dilution factor}}{\text{area of analyte in standard}}$$

10 g of fresh silage sample was triturated (Hasanah *et al.,* 2017) for 3-5 minutes using 100 ml of distilled water and filtered using Whatman filter paper No. 1 and the extract was used for estimation of ammonia nitrogen (AOAC, 2005).

Statistical analysis

Data obtained were subjected to one-way analysis of variance (version 23.0; SPSS, 2015) and the treatment means were ranked using Duncan's multiple range test with a significance at P<0.05 (Duncan,1955). All the statistical procedures followed were in accordance with Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

The chemical composition of corn silage, DDGS and WDGS is presented in Table 1. There was a wide variation in the chemical composition of silage and WDGS during the study. Many factors influence the variation in composition of corn silage starting from seed sowing till end of fermentation including type of soil,

Table 1. Chemical composition of feedstuffs (% DM basis) #

CompositTion	Corn silage (n=10)	Dry DGS	Wet DGS (n=9)
Dry matter	31.4±2.07 (27.7-33.8)	90.2	31.1±3.45 (26.7-35.6)
On % DM basis			
Crude protein	7.2±1.92 (4.4-9.5)	37.6	32±11.55 (17.0-44.9)
Ether extract	2.6±1.07 (1.6-5.4)	1.0	4.4±0.47 (3.6-5.2)
Crude fibre	30.0±5.06 (23.0-38.7)	13.2	3.7±0.59 (2.8-4.9)
Total ash	5.4±0.40 (4.7-6.0)	9.4	7.8±2.87 (4.8-13.2)
Nitrogen free extract	54.8±3.90(48.2-60.0)	38.8	53.5±11.56 (36.5-71.3)
Neutral detergent fibre	46.8±2.64(43.4-52.3)	38.8	53.8±2.22(51.3-57.9)
Acid detergent fibre	31.1±3.45(24.9-35.1)	18.3	23.8±2.36(20.5-27.2)
pH	3.4±0.35 (2.3-3.8)	-	3.5±0.53(2.9-4.2)
NH_3 - N (% of total N)	10±5.04 (3.3-18.2)	-	-
Lactic acid	3.1±0.46 (2.5-3.8)	-	-

#Values in parenthesis indicate range

Table 2. Effect of dietary treatments on body weight gain and feed efficiency of ram lambs

Parameter	Dietary treatments*				SEM	P value
	T_1	T_2	T_3	T_4		
Initial weight (kg)	12.92	12.87	12.77	12.8	1.00	0.99
Final weight (kg)	22.19	19.43	19.95	21.3	1.44	0.545
Weight gain (kg)	9.27^{a}	6.57^{b}	7.18^{ab}	8.50^{ab}	0.71	0.018
ADG (g)	105.4^{a}	69.1^{b}	81.6^{ab}	89.5^{ab}	8.24	0.008
DMI silage (g)	478	447	416	472	50.67	0.84
DMI DGS (g)	153.0^{a}	46.6^{b}	74.4^{ab}	99.8^{ab}	17.52	0.00
Total DMI (g)	631.1	493.8	490.9	572.4	60.00	0.296
FCR	5.65	7.07	5.85	6.39	0.59	0.351

ADG, average daily gain, DMI, average daily dry matter intake; DGS, distillers grain with solubles; FCR, feed conversion ratio; *Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively; [a,b]Mean values within a row with unlike superscript letters were significantly different for each dietary treatment

irrigation and harvesting practices (Bal, 2006). The most influencing factor is dry matter content at harvest time because nutrient contents like starch, water soluble carbohydrates (WSC) and NDF depends on dry matter content of fodder (Khan *et al.,* 2009) and the content of WSC decides the quality of silage by maintaining pH of silage. The nutrient composition of WDGS is not constant and it would fluctuate frequently depending on many factors like type and quality of grain and conditions of processing such as milling, fermentation, temperatures adopted during drying and the quantity of solubles that are blended into WDGS (Reddy *et al.,* 2017). The average value (% total N) for NH_3-N (Table 1) of corn silage was indicative of good quality but there was wide variation, 4.16±0.68 at the time of opening the silage bale, 10.09±1.44 when 50% of silage in a bale was used up and 15.8±1.9 at the time of complete usage of silage in a bale. High temperature provokes the microbial activity which results in higher NH_3–N due to proteolysis (Muck and Dickerson, 1988). As the experiment was conducted during summer (March-June), high temperature during storage and time of sampling might be the reasons for obtaining higher values for NH_3 - N.

The weight gain (kg) of ram lambs (Table 2) was 9.27, 6.57, 7.18, and 8.50 in T_1, T_2, T_3 and T_4,

Table 3. Effect of dietary treatments on nutrient digestibility (%) of ram lambs

Parameter	Dietary treatments*				SEM	P value
	T_1	T_2	T_3	T_4		
Dry matter	70.48	70.98	69.7	71.75	2.13	0.937
Organic matter	71.35	72	71.22	73.02	2.05	0.938
Crude protein	59.74^{ab}	56.73^{ab}	54.00^{a}	67.92^{b}	3.67	0.022
Ether extract	71.78^{a}	81.34^{ab}	79.30^{ab}	86.37^{b}	3.74	0.026
Crude fibre	63.43	59.78	61.78	61.25	3.23	0.906
NFE	77.56	79.03	78.43	77.66	1.83	0.948
NDF	73.24	70.75	71.49	72.51	2.55	0.925
ADF	78.69	73.01	70.85	72.2	2.82	0.218

NFE, nitrogen free extract, NDF, neutral detergent fibre; ADF, acid detergent fibre; [a,b]Mean values within a row with unlike superscript letters were significantly different for each dietary treatment; *Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively.

Table 4. Effect of dietary treatments on nitrogen balance of ram lambs

Parameter	Dietary treatments*				SEM	P value
	T_1	T_2	T_3	T_4		
N intake (g/d)	20.52[a]	14.27[b]	13.26[b]	19.68[a]	2.01	0.003
N voide in faeces (g/d)	7.23	5.93	5.54	6.66	0.6	0.198
N voided in urine (g/d)	3.85	3.67	3.05	5.54	0.77	0.11
Total N voided (g/d)	11.08	9.61	8.59	12.2	1.62	0.003
N retained (g/d)	13.29[a]	8.34[b]	7.71[b]	13.02[a]	1.07	0.061
N retained (% intake)	46.27[a]	32.76[b]	34.66[b]	38.04[ab]	3.49	0.012
N retained (% absorbed)	66.43	58.11	67.23	50.92	4.72	0.069

[a,b] Mean values within a row with unlike superscript letters were significantly different for each dietary treatment; *Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively.

respectively; leading to an average daily of gain of 105, 69, 81 and 89 g which was significantly (P<0.05) higher in T_1 than in T_2, and the FCR was inferior in T_2 compared to other treatments but the differences were not significant. The nutrient digestibility due to wet DGS supplementation was not significantly improved except for higher (P<0.05) CP and EE digestibility in T_4 (Table 3).

The nitrogen intake (g/d) and retention (either as g/d or as % of intake) were higher (P<0.05) in T_1 and T_4 compared to other treatments. The higher N retention might be due to the higher (P<0.05) dry matter intake and CP digestibility in T_1 and T_4 groups (Table 4). The higher CP digestibility in group T_4 than other groups might be due to the higher amount of available protein from wet DGS. De Almeida (2013) and Schingoethe *et al.* (2009) stated that Maillard reaction was one of the reasons for lower availability of protein in dried DGS. The DMI from silage and the total DMI were higher in T_1 and T_4 fed lambs The DMI from DGS was also higher (P<0.05) in T_1 and least in T_2. The better growth performance of ram lambs in T_1 and T_4 might also be explained by the higher plane of nutrition (Table 5). In both these treatment groups, the CP and DCP content (% DM) were higher (P<0.05) than in T_2 and T_3. The plane of nutrition of ram lambs in T_1 and T_4 compared favourably with the requirements set by ICAR (2013) feeding standards, which suggested a DMI of 3.8- 4.2% of live weight with a CP and TDN content of 13-14 % and 57-58%, respectively. The DMI (% BW) and TDN (% DM) values were comparable across treatments with the ICAR (2013) feeding standards. There was a deficit of protein intake in T_2, T_3 and T_4 by 24.1, 15.6 and 0.46%, respectively while

Table 5. Effect of dietary treatments on plane of nutrition

Parameter	Dietary treatments*				SEM	P value
	T_1	T_2	T_3	T_4		
Body weight (kg)	18.3	18	16.7	19	1.26	0.186
Total DMI (g)	797	645	554	713	60	0.296
DMI (% BW)	4.41	3.66	3.76	3.76	0.26	0.093
DCP (% DM)	9.46[b]	7.75[c]	7.51[c]	11.85[a]	1.00	0.00
TDN (% DM)	68	70.35	69.01	71.42	2.03	0.693

DMI, average daily dry matter intake; DCP, digestible crude protein, TDN, total digestible nutrients; *Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively.

Table 6. Rumen fermentation pattern of the ram lambs fed experimental diets

Parameter	Dietary treatments*				SEM	P value
	T_1	T_2	T_3	T_4		
Rumen Ph	6.58	6.48	6.38	6.38	0.11	0.58
NH_3 - N (mg/100 ml)	5.8	5.92	6.1	6.17	0.21	0.603
TVFA (mMol/dl)	21.83	18.9	20.48	19.54	1.16	0.327
Molar proportion						
Acetic acid	0.42[a]	0.39[ab]	0.33[b]	0.37[ab]	0.02	0.034
Propionic acid	0.34	0.36	0.37	0.37	0.01	0.199
Butyric acid	0.25	0.25	0.29	0.26	0.02	0.317
Acetate :Propionate	1.25[a]	1.1[ab]	0.89[b]	0.99[ab]	0.1	0.033

[a,b]Mean values within a row with unlike superscript letters were significantly different for each dietary treatment; *Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively.

in T_1 fed lambs it was as per recommendations. Lower protein content in T_2 and T_3 diets might be the reason for getting lower body weight gain in those two groups. It was of interest to see if wet DGS supplementation could promote optimum ruminal fermentation and stimulate consumption of basal roughage *i.e.* corn silage. Intake of the silage is related to three measures of quality, namely dry matter and digestible organic matter content, and ammonia nitrogen content as a proportion of total nitrogen content. Other measures of silage quality affecting its intake are nitrogen content, butyric acid content and pH (McDonald *et al.,* 2001). In the present study also, the NH_3-N content as a proportion of total nitrogen increased from the time of opening a silage bale to the end of use probably affecting the voluntary DM intake from silage. Further, CF content of silage ranged from 23.0 to 38.7% with a mean value of 30.0% (Table 1) and the higher CF content might also have failed to stimulate the voluntary intake of silage. The leftover silage contained 34.3% crude fibre.

The rumen fermentation pattern (Table 6) revealed optimum rumen pH across treatments and a slightly higher NH_3-N in T_2 to T_4 diets due to wet DGS

Table 7. Serum protein (g/dl) and mineral profile (mg/dl) of the ram lambs

Parameter	Dietary treatments*				SEM	P value
	T_1	T_2	T_3	T_4		
Protein (g/dl)	6.25	5.94	6.21	6.25	0.23	0.742
Ca	6.48	7.51	7.23	7.34	1.59	0.496
P	7.17[a]	6.60[b]	6.83[ab]	6.76[ab]	0.41	0.041
Na	331.68	317.75	322.12	323.83	18.02	0.081
K	20.21	20.11	19.42	22.23	2.17	0.457
Mg	2.76	2.95	2.76	2.94	1.1	0.299
Fe	0.22	0.26	0.25	0.27	0.18	0.36
Zn	0.12	0.13	0.11	0.12	0.82	0.324
Co	0.12	0.02	0.022	0.021	0.06	0.173

[ab]Mean values within a row with unlike superscript letters were significantly different for each dietary treatment; *Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively.

supplementation. Further, TVFA concentration and molar proportions of propionic acid and butyric acid in rumen liquor was comparable among treatment groups whereas the acetic acid concentration was higher ($P<0.05$) in T_1 than in other treatments. Higher value for acetate was noticed in dry DGS fed group than that of wet DGS fed groups which might be due to lower NDF content in dry DGS (Avila Stango *et al.,* 2013).

The serum protein and mineral profile (Table 7) did not differ significantly among treatments, except for a higher ($P<0.05$) serum phosphorus in ram lambs fed on T_1. The higher phosphorus content of the dry dried distillers grain with solubles (Reddy, 2017) might have led to a higher serum phosphorus concentration in ram lambs fed on T_1 since the DMI from dry DDGS was higher than the DMI from wet WDGS in other treatments.

There was no significant difference among treatments with respect to carcass characteristics (Table 8), chemical composition and mineral profile of *Longissimus dorsi* muscle and were comparable with those available in literature. Kasap *et al.* (2018) reported values of 75.61% moisture, 2.13% EE and 20.91% CP in the longissimus thoracis et lumborum muscle of lambs

Table 8. Carcass characteristics, chemical composition and mineral profile of longissiumus dorsi muscle

Parameter	Dietary treatments*				SEM	P value
	T_1	T_2	T_3	T_4		
Pre-slaughter weight (kg)	22.43	19.33	17.90	21.23	1.79	0.30
Dressed weight (kg)	9.97	8.27	7.90	9.47	0.87	0.297
Dressing %	44.43	42.30	44.05	44.62	1.25	57.0
Neck & Shoulder	10.26	11.18	9.99	10.11	0.62	0.541
Brisket & Fore shank	31.98	26.79	31.71	28.27	1.66	0.053
Loin	13.09	12.44	13.56	13.28	0.68	0.721
Rack	10.94	14.38	11.96	14.95	1.35	0.101
Leg	33.73	35.21	32.79	33.40	0.72	0.10
Meat (kg)	6.35	5.03	4.91	6.16	0.62	0.23
Bone (kg)	3.54	2.95	2.99	3.35	0.3	0.456
M:B ratio	1.58	1.69	1.62	1.54	0.05	0.197
***L. dorsi* muscle composition**						
Dry matter (%)	27.51	28.30	25.76	28.59	1.06	0.24
Crude protein (%, DM)	23.92	25.01	24.04	25.56	0.97	0.603
Ether extract (%, DM)	1.83	2.02	2.06	2.19	0.21	0.125
Mineral profile of L. *do*rsi muscle (mg/100 g)						
Na	69.84	71.72	72.61	69.18	95.27	0.852
K	335.77	331.25	336.31	330.99	81.83	0.997
Ca	7.51	8.30	7.81	7.03	2.73	0.761
Mg	21.78	23.96	21.93	22.83	3.36	0.264
Fe	1.42	1.54	1.43	1.41	2.34	0.412
Cu	0.32	0.45	0.52	0.53	0.56	0.227
Zn	8.64	9.48	9.59	9.69	1.26	0.23
Mn	0.24	0.22	0.23	0.22	0.31	0.483
Co	0.21	0.20	21	0.22	0.05	0.591

*Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively.

Table 9. Cost economics of ram lamb production per animal

Parameter	Dietary treatments*				SEM	P value
	T_1	T_2	T_3	T_4		
Animal cost (₹)	3247.92	3016.67	3091.67	3200	42.68	0.193
Silage cost (₹)	1025.62	999.08	990.63	1037.26	59.89	0.295
DGS cost (₹)	340.37[a]	144.00[b]	190.02[b]	309.78[a]	38.93	0.000
Total feed cost (₹)	1365.99[a]	1088.05[b]	1009.26[b]	1347.04[a]	152.21	0.051
Feed cost (₹)/kg gain	146.25	163.08	169.27	158.21	13.22	0.159
Returns (by sale of meat & offal ₹)	5481.21	4549.42	4643.17	5200.25	350.9	0.299
Net Profit/Loss (₹) (e-(a+d))	772.88[a]	578.58[b]	651.50[b]	775.25[a]	138.16	0.052

[a,b] Mean values within a row with unlike superscript letters were significantly different for each dietary treatment.
Cost of silage: ₹ 6.8/kg, Cost of dry DGS: ₹ 23/kg, Cost of wet DGS: ₹ 10/kg; *Corn silage was fed *ad libitum* to all the rams, basal diet was supplemented with DDGS at 1.0% BW in control group (T_1), whereas WDGS was supplemented at 1.0, 1.5 and 2.0 % BW in groups T_2, T_3 and T_4, respectively.

reared in outdoor conditions. Kawecka *et al.* (2018) reported values of 22.94, 2.87 and 19.57 of DM, EE and CP, respectively with diets containing 45% dry DGS. Radzik-Rant *et al.* (2018) reported 26.09 % DM and 4.62 % EE content in the muscle of lambs fed with wet brewers grains. Higher intake of dry DGS in T_1 and wet DGS in T_4 fed lambs resulted in higher ($P<0.01$) cost of DGS supplementation in these treatments leading to higher ($P<0.05$) total feed cost compared to T_2 and T_3 fed lambs. However, no significant differences were found in total returns. Net profit was higher ($P<0.05$) in T_1 and T_4 than in T_2 and T_3 fed lambs (Table 9).

CONCLUSIONS

It was concluded that supplementation of wet DGS at 2.0 % of body weight resulted in ram lamb performance comparable with dry DGS supplementation at 1.0% of body weight.

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