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Grain to Gain: Rice Distillers Dried Grains with Solubles (RDDGS) and the Economic Edge for Nagavali Ram Lambs

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ABSTRACT

The Experiment was conducted at the Livestock Research Station, Garividi, Vizianagaram District, Andhra Pradesh for 90 days i.e. from July to October, 2023 to assess the impact of incorporating Rice Distillers Dried Grains with Soluble (RDDGS) by substituting soybean meal in the concentrate mixture on the growth, digestibility, and cost economics of Nagavali ram lambs. Twenty-four lambs were randomly assigned into four treatment groups. In the treatment groups, soybean meal was replaced with RDDGS at 0% (T_1), 50% (T_2), 75% (T_3), and 100% (T_4) levels. Our results inferred that replacing of soyabean meal with different concentrations of RDDGS did not significantly (p>0.05) affect dry matter intake (DMI and feed conversion ratio. Further, gross digestibility of different nutrients and cell wall constituents were also unaffected. The cost of feed kg^{-1} of weight gain was significantly (p<0.05) reduced. The cost of feed kg^{-1} gain was significant (p<0.05) because of the replacement of soybean meal with RDDGS. T_2, T_3 and T_4, showing decreases of ₹ 11.23, ₹ 17.59, and, respectively, in comparison to the control (T_1). The study concludes that RDDGS can completely replace soybean meal in sheep diets without affecting nutrient efficiency. This replacement maintains the same growth and digestibility while significantly reducing the cost of production per kilogram of body weight by 12.7%. Consequently, RDDGS emerges as a cost-effective alternative to soybean meal, offering economic benefits while sustaining the nutritional quality of the feed.

KEYWORDS: Cost economics, digestibility, growth, RDDGS, ram lambs

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Data Availability Statement: Legal restrictions are imposed on the public sharing of raw data. However, authors have full right to transfer or share the data in raw form upon request subject to either meeting the conditions of the original consents and the original research study. Further, access of data needs to meet whether the user complies with the ethical and legal obligations as data controllers to allow for secondary use of the data outside of the original study.

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1. INTRODUCTION

Sheep rearing is one of the viable options for sustainable rural livelihoods, particularly in semi-arid and arid regions, playing a crucial role in the Indian economy (Dey et al., 2017, Banerjee, 2018). Besides providing socioeconomic security in rural areas, sheep rearing provides nutritional security in the form of mutton and supports textile industry through supply of wool (Sarita et al., 2018). According to the Anonymous (2019), there are approximately 74.26 million sheep, the country faces challenges in sustainable animal production due to nutrient scarcity and high feed costs. Currently, there is a net deficit of 28.9% in concentrate feed, 23.4% in dry crop residue, and 11.24% in green fodder (Roy et al., 2019). Rising costs of soybean meal drive the need for safe, effective protein alternatives. Rice Distillers Dried Grain with Solubles (RDDGS) is a promising option (Belyea et al., 2004). Distiller's Dried Grains with Solubles (DDGS) are derived from the spirit industry and the production of bioethanol. (Biradar et al., 2024; Gite et al., 2024). The DDGS is a by-product of ethanol industry. The RDDGS contains 65% distiller's grain and 35% its soluble (Babcock et al., 2008). Corn DDGS is widely used in dairy rations, and rice grains are now also used to produce RDDGS (47% CP), a valuable livestock feed. The RDDGs contain 45%, 47% and 40.17% crude protein, as reported by Talsani et al. (2021), Gite et al. (2024) and Kaninde et al. (2023) respectively. If included at more than 15% of the diet, DDG is considered a source of energy, as suggested by Stalker et al. (2005). The increasing emphasis on ethanol blending future (Sahin et al., 2013). This product is characterized by its richness in energy and protein at a lower cost compared to conventional feed ingredients like soybean meal (Dinani et al., 2019). DDGS contains higher levels of phosphorus than corn; thus, adding DDGS to an animal's diet may negate or reduce the need for phosphorus supplements (Abudabos et al., 2021). Also, the RDDGS lacks any anti-nutritional factors, making it an economically suitable alternative source in animal diets, serving either as a protein source or an energy source (Yogi et al., 2017). This flexibility depends on the specific nutrient requirements of the animals, the type of diet being fed, and economic considerations. Prior studies have shown that adding RDDGS to calf diets improves both growth rates and feed conversion ratios (Dey et al., 2020). Further, Singh et al. (2018) demonstrated that RDDGS can replace up to 75% of oil cakes (such as GNC and MOC) in concentrate mixes for Murrah heifers, based on crude protein content. Similarly, Chandrika et al. (2021) found that RDDGS can substitute up to 75% of soybean meal in concentrate mixtures for buffalo calves without compromising palatability, nutritional digestibility, nitrogen balance, or animal health. Sihag et al. (2017) reported that there was net saving of ₹ 8.9 and 9.6 per kg weight gain of goat by replacing soybean meal with DDGS at 50 and 75% levels, respectively. Moreover, Dey et al. (2020) observed that RDDGS can completely replace soybean meal in concentrate mixtures for ruminants, leading to increased net profit without adverse effects.Top of Form Yadav et al. (2023) also reported that use of RDDGS up to the level of 20% can be included in diet without affecting health status in Barbari goats. Limited research on RDDGS as a protein source for small ruminants exists, with most studies focusing on corn and wheat DDGS. This experiment evaluates RDDGS as a replacement for soybean meal in concentrate mixtures, assessing its impact on ram lambs' growth, nutrient digestibility, and cost-effectiveness.

2. MATERIALS AND METHODS

The current experiment was designed to assess in RDDGS in ram lambs through digestion trial. It was carried out in the Livestock Research Station in Garividi, Nagavali district, Andhra Pradesh, India from July, 2023 to October, 2023. The latitude of Garividi, Andhra Pradesh, India is 18.285839° N, and the longitude is 83.536339 ° E. A total of twenty-four ram lambs, aged between 3 to 4 months and weighing 9–11 kg, were divided into four groups, with each group consisting of six animals. The completely randomized design (CRD) was followed for experimental design. During the 90-day of growth trial, animals were provided ad libitum Super Napier and the respective concentrate mixture corresponding to each treatment. In the control group (T_1), the concentrate mixture was formulated using traditional feed ingredients and soybean meal. For treatments, T_2, T_3, and T_4, soybean meal (SBM) was substituted with Rice Distillers Dried Grains with Solubles (RDDGS) at 50%, 75%, and 100% levels, respectively, in the concentrate mixture. The ingredient compositions (iso nitrogenous) of concentrate mixtures of all four treatment groups are detailed in Table 1. The animals were individually housed in pens and received Super Napier as source of roughage and concentrate mixture separately at 9:00 AM and 3:00 PM daily. They had unrestricted access to clean water throughout the day. A daily record was maintained for the feed intake and leftovers (orts). The rations were computed as per body weights of the experimental animals following the Anonymous (2013) feeding standards. Rations were revised as per the fortnightly body weight changes. The chemical composition of the concentrate mixture is presented in Table 1. During the midpoint of the 90-day growth trial, a 6-day digestion trial was conducted. Samples of feedstuffs and orts were collected at 24-hour intervals and dried in triplicate at 100°C in a hot air oven. Following the drying process, samples of feed, feces, and orts were analyzed for proximate composition according to Anonymous (2005). Additionally,

Table 1: Ingredient and chemical composition (% DM basis) of experimental diets fed to ram lambs

Nutrient	Super Napier	RDDGS	CM-1	CM-2	CM-3	CM-4
Ingredient composition (% DM basis)						
Maize	-	-	31	34	35	31
DORB	-	-	36	33	32	36
Soybean meal	-	-	30	15	7.5	0
Rice DDGS	-	-	0	15	22.5	30
Mineral mixture	-	-	2	2	2	2
Salt	-	-	1	1	1	1
Chemical composition (% DM basis)						
Dry matter	24.32	91.02	91.34	91.30	91.32	91.33
Organic matter	88.05	94.18	90.67	91.15	90.57	91.28
Crude protein	11.68	47.32	20.05	20.07	20.07	20.08
Ether extract	3.47	6.25	2.96	2.78	3.43	3.84
Crude fibre	37.95	5.70	14.76	15.17	12.84	12.23
Nitrogen free extract	34.95	34.91	52.90	53.13	54.23	55.13
Total ash	11.95	5.82	9.33	8.85	9.43	8.72
Neutral detergent fibre	77.75	41.12	33.92	33.23	32.16	33.09
Acid detergent fibre	42.27	22.78	15.87	14.63	16.08	15.56
Hemi-cellulose	35.48	18.33	18.05	18.6	16.08	17.53
Cellulose	36.54	9.58	13.14	11.55	10.69	15.14
Acid detergent lignin	7.14	9.70	8.63	5.86	6.33	6.78
Silica	3.66	1.34	1.71	1.49	1.57	1.65
Calcium (%)	0.50	0.83	0.61	0.65	0.81	0.70
Phosphorous (%)	0.41	0.89	0.69	0.83	0.79	0.66

the cell wall constituents were determined based on the method outlined by Van Soest et al. (1991). The data were subjected to one-way analysis of variance procedure using Anonymous (2012), using the linear model. The post-hoc comparison of means was done for the significant difference by Duncan multiple range tests. Significant differences of treatments were considered at (p<0.05).

3. RESULTS AND DISCUSSION

3.1. Dry matter intake

Daily Dry Matter Intake (DMI) remained similar across all treatments, and this is in line with earlier reports (Huls et al., 2006; Abdelrahim et al., 2014) that yielded similar results. Similarly, Mckeown et al. (2010) observed that DDGS from corn, wheat, or triticale could replace a mixture of barley grain and canola meal at 20% of the diet DM without altering DMI. Similarly, Rao (2023) also reported that the inclusion of RDDGS up to 30% level, by replacing SBM and gingelly cake, had no effect (p>0.05) on DMI in Murrah buffalo bull calves. Chandrika et al. (2021) in buffalo calves reported that inclusion of RDDGS up to 75% levels had no effect (p>0.05) on DMI. In contrast, Islas et al. (2014) reported that supplementation of DDGS at 0.5% and 1% body weight had significant (p<0.001) effect on DMI, both in terms of kg d^{-1} and as % BW in calves while, Yang et al. (2012) reported that inclusion of wheat DDGS up to 35% replacing barley grain or barley silage led to linear decrease (p<0.01) in the DMI.

3.2. Nutrient digestibility

The digestibility of DM, OM, CP, EE, CF, and NFE (Table 2) remained unaffected (p>0.05) by the inclusion of DDGS up to 100% levels. The absence of differences in digestibility coefficients could be attributed to equal Dry Matter Intake (DMI) across all groups. Consistent with these findings, Singh et al. (2021) reported that replacing soybean meal in the concentrate mixture upto 20% with RDDGS did not show any significant effect on the digestibility of nutrients (DM, CP, EE, and CF) among the groups in osamabadi goats. Singh et al. (2018) also reported that replacing oil cakes with RDDGS upto

Table 2: Nutrient digestibility in ram lambs fed with different diets

Parameters NS	Nutrient Digestibility (%)			
	T_1	T_2	T_3	T_4
DM	65.42±0.89	65.94±0.42	66.05±0.63	66.71±0.47
OM	68.42±0.83	69.13±0.35	69.00±0.61	69.72±0.45
CP	70.73±0.71	71.63±0.36	71.01±0.23	71.04±0.89
CF	75.25±1.65	76.91±0.99	76.66±1.08	76.19±1.79
EE	56.69±1.42	57.36±0.31	57.08±0.93	57.84±0.66
NFE	76.48±0.40	76.87±0.39	76.51±0.52	76.53±0.36
NDF	61.73±0.98	62.20±0.50	62.17±0.82	62.90±0.63
ADF	55.10±1.22	55.28±0.85	55.56±0.96	55.61±1.08
Cellulose	61.88±1.93	61.68±0.40	61.73±0.84	61.91±0.73
HC	65.42±1.14	65.52±1.35	65.08±0.49	65.96±0.70

NS: Non-significant (p>0.05)

50% levels in murrah heifers did not influence (p>0.05) on DM and CP digestibility. Reddy et al. (2021) observed in Nellore ram lambs that replacing PNC with DDGS up to 75% levels did not result in significant (p>0.05) differences in DM, OM, and CP digestibility. Hatamleh and Obeidat (2019) reported that the inclusion of DDGS did not depress (p>0.05) DM and CP digestibility in all treatments. In contrast, Matheny et al. (2016) noted a linear increase (p<0.05) in the digestibility of DM, OM, and CP with the rising concentration of DDGS in dairy heifers.

The digestibility coefficients of NDF, ADF, hemicellulose, and cellulose (Table 2) remained consistent across different levels of RDDGS in the diet. In line with the present findings, Reddy et al. (2021) reported that replacing PNC with DDGS up to 100% in lamb diets had no significant (p>0.05) effect on the digestibility of NDF and ADF. Hatamleh and Obeidat (2019) similarly found no significant impact (p>0.05) on NDF and ADF digestibility with the inclusion of DDGS in lamb diets. Manthey et al. (2016) observed that increasing DDGS levels had no effect (p>0.01) on the digestibility of NDF and ADF in dairy heifers. Dey et al. (2020) reported that replacing soybean meal with RDDGS at 100% level in the concentrate mixture had no significant effect (p>0.05) on NDF and ADF digestibility in Jersey crossbred calves.

3.3. Nutrient intake and FCR

The digestible CP and TDN intake values (Table 3) remained comparable across all treatments, without any significant differences among different treatment groups. In alignment with the results of current study, Hatamleh and Obeidat (2019) noted that the inclusion of DDGS did not yield a significant (p>0.05) effect on CP intake. Similarly, Chandrika et al. (2021) observed in buffalo calves

Table 3: Nutrient intake cost economics

Parameters	T_1	T_2	T_3	T_4
Nutrient intake (g/d)				
DCP	71.2	71.5	71.0	71.5
TDN	430	430	440	440
Cost of green fodder @ ₹ 2.0 kg^{-1}	2.0	2.0	2.0	2.0
Cost of concentrate mixture (₹ kg^{-1})	31.16	29.00	27.88	26.36
FCR	11.36	11.32	11.36	11.19
Total cost of feed (₹) day^{-1}	12.79^{a}	12.15^{b}	11.86^{bc}	11.40^{c}
Cost of feed kg^{-1} gain (₹ kg^{-1} gain)	209.62^{a}	198.39^{b}	192.03^{bc}	182.98^{c}

Means with different superscripts in a row differ significantly *(p<0.05); 1US$=INR 83.23

that the inclusion of RDDGS up to 75% levels had no significant (p>0.05) impact on CP and TDN intake. The Feed Conversion Ratio (FCR) values (Table 3) ranged from 11.19 to 11.36. Feed conversion ratio (kg DMI kg^{-1} gain) remained unaffected at 100% replacement of soybean meal with DDGS in the concentrate mixture for growing ram lambs. However, a more favorable FCR was reported at 100% replacement of RDDGS. These findings align with studies conducted by Schauer et al. (2008) and Huls et al. (2006), both of which found no significant difference in the feed-to-gain ratio when DDGS substituted part of the maize and soybean meal.

3.4. Cost economics

The cost analysis of live weight gain in ram lambs, fed

diets incorporating RDDGS is presented in figure 1. The average daily feed cost (₹ head^{-1} d^{-1}) was decreased with inclusion of RDDGS (Table 3). A noteworthy (p<0.05) reduction in daily feeding cost ram^{-1} lamb was observed when substituting SBM with RDDGS up to 100% levels. The cost of feed kg^{-1} gain (₹ kg^{-1} gain) was significantly (p<0.05), reduced by 5.4%, 8.4% and 12.7% in T_2, T_3, and T_4 groups, respectively in comparison with control group. It reveals that there was a substantial reduction (p<0.05) in the cost kilogram^{-1} of gain in treatments T_2, T_3, and T_4, showing decreases of ₹ 11.23, ₹ 17.59, and ₹ 26.64, respectively, in comparison to the control (T_1). Consistent with these findings, Chandrika et al. (2021) demonstrated a significant (p≤0.05) reduction of 15.67% in feed cost kilogram^{-1} of body weight gain in T_1 (50% RDDGS) and a 19.36% reduction in T_2 (75% RDDGS) compared to the control group. Omer et al. (2015) also noted a decrease in feed cost kg^{-1} gain by 24.89% and 29.83% at 25% and 50% replacement of cottonseed cake with corn DDGS in crossbred calves. Singh et al. (2018) reported a decrease in feed cost kg^{-1} gain animal^{-1} by ₹ 14.90 and ₹ 13.27 at 50% and 75% levels of replacement of oil cake with RDDGS in Murrah heifers. Furthermore, Pandey et al. (2023) observed a net saving of ₹ 11.91 and ₹ 23.83 kg^{-1} BW gain when replacing half and full soya DOC with RDDGS in growing crossbred heifers.

4. CONCLUSION

The RDDGS replaced soybean meal completely without affecting the palatability of the ration, growth performance, nutrient utilization, nutritive value of the ration, and feed conversion ratio in Nagavali ram lambs, resulting in a net saving of ₹ 26.64 in the cost per kilogram of live weight gain. The RDDGS can be chosen as a cost-reducing ingredient in ram lamb rations.

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