

Comparative Evaluation of Rice and Maize DDGS on Nutrient Intake, Feed Conversion Ratio and Cost of Feeding in Crossbred Heifers

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ABSTRACT

The present study evaluated the effect of feeding rice- and maize-based Distillers Dried Grains with Solubles (DDGS) on intake, feed conversion ratio (FCR), and feeding economics of crossbred heifers. Eighteen crossbred heifers (75% Holstein Friesian × 25% Kankrej, Av. age 13.78±0.38 months, b.wt. 178.54±6.38 kg) were randomly allotted to three dietary treatments: T1 (control TMR without DDGS), T2 (TMR with 10% rice DDGS), and T3 (TMR with 10% maize DDGS), for a period of 112 days. The total mixed rations were iso-nitrogenous and iso-caloric. Dry matter and nutrient intake on daily basis were statistically similar among treatments, while it was higher in maize-DDGS (T3) group on percent and metabolic body weight basis. Water intake was also statistically similar in all groups and without adverse effects of DDGS inclusion. The requirement of dry matter per unit body weight gain was significantly higher in the maize-fed crossbred heifers' group (T3), while feeding cost per unit weight gain was significantly ($p < 0.05$) reduced in maize-DDGS (T3) group. The results indicate that maize DDGS can be incorporated at a 10% level in the diet of crossbred heifers to improve feed economy with higher nutrients intake.

Key words: Crossbred heifers, Distillers dried grains with solubles, Feed conversion ratio, Feeding economics, Intake.

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INTRODUCTION

Efficient use of feed resources is very important for profitable dairy farming. Feed costs constitute a major proportion of total production expenditure in dairy enterprises; therefore, identification of nutritionally reliable and economically feasible feed ingredients is essential for sustainable dairy production systems (Van Amburgh and Drackley, 2005). In recent years, the increasing availability of co-products from the bioethanol industry has created new opportunities for formulating cost-effective ruminant diets (Shurson, 2017). Distillers dried grains with solubles (DDGS), generated after fermentation and distillation of cereal grains during ethanol production, is one such ingredient receiving considerable attention because of its nutritional value and potential to replace expensive protein supplements in livestock rations (Klopfenstein *et al.*, 2008; Liu, 2011). DDGS contains concentrated fibre, protein, residual oil, and yeast-derived components due to the removal of starch during fermentation, which makes it suitable for inclusion in ruminant total mixed rations (Spiehs *et al.*, 2002). DDGS differ in nutrient composition depending on grain type and processing conditions, with RDDGS often containing higher crude protein and rumen undegradable protein, while MDDGS generally provides higher energy density and total digestible nutrients (Belyea *et al.*, 2010; Liu, 2011). These compositional differences may influence feed intake

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behaviour, nutrient utilization, and overall feeding efficiency in growing cattle.

Heifers in the growing phase require balanced nutrient intake to support skeletal development, optimal growth,

and future reproductive performance (Heinrichs *et al.*, 2022). Feed conversion efficiency and economic viability of ration formulations are key indicators used to evaluate the suitability of alternative feed ingredients in dairy production systems. Several studies have reported that inclusion of DDGS in ruminant diets can maintain or improve feed efficiency and nutrient utilization when used as a partial replacement for conventional protein sources (Klopfenstein *et al.*, 2008; Shurson, 2017). However, comparative assessments of rice- and maize-derived DDGS on intake patterns, feed conversion ratio, and feeding economics under Indian feeding conditions remain limited. Therefore, the present study was undertaken to evaluate the effect of incorporating 10% rice DDGS or 10% maize DDGS in total mixed rations on feed intake, feed conversion ratio, and feeding cost in crossbred heifers.

MATERIALS AND METHODS

The present experiment was conducted at Livestock Research Station, College of Veterinary Science and Animal Husbandry, Kamdhenu University, Anand, Gujarat, India (20°35'N, 72°55'E; 43 m above sea level). The study was carried out for a period of 112 days (sixteen weekly periods) after approval by Institutional Animal Ethics Committee (No. 479/LRS/25 dated 19-7-2025). A total of 18 crossbred heifers (75% Holstein Friesian × 25% Kankrej) of almost uniform age (13.78±0.38 months) and body weight (178.54±0.38 kg) were selected and randomly distributed into three treatment groups, each comprising six animals. The treatment groups were as follows: T1: Basal total mixed ration (TMR) without DDGS (control), T2: TMR containing 10% Rice DDGS (RDDGS), and T3: TMR containing 10% Maize DDGS (MDDGS). The composition of total mixed ration was as per Table 1. All rations were made iso-nitrogenous and iso-caloric by adjusting the proportions of different ingredients and bypass fat. Before initiation of the feeding trial, all heifers were dewormed using Fenbendazole (10 mg/kg body weight) and maintained under identical housing, feeding, and managemental conditions in a well-ventilated shed. Heifers were tied individually in front of separate mangers, fed TMR *ad libitum* to achieve an average growth rate of 800-1000 g/day, and provided clean drinking water three times daily. Exercise was allowed for 2 h every morning under supervision.

The feed offered and refusals were recorded daily to determine dry matter intake (DMI). An intake of nutrient, including Digestible Crude Protein (DCP) and Total Digestible Nutrients (TDN), was calculated from intake and nutrient composition of TMR. Representative samples of TMR and feed refusals were collected weekly, dried in a hot air oven at 80 ± 2°C for 24 h, and stored in airtight paper bags for proximate analysis, which was performed as per AOAC (2005). Water intake was measured weekly by recording the difference between the water offered and refused using calibrated plastic buckets. Feed conversion ratio (FCR) was determined as the amount of dry matter consumed per kilogram of body

weight gain. The cost of feeding for each treatment was computed using actual feed consumption and ingredient prices prevailing during the experiment. Economic analysis included daily feed cost and feed cost per kilogram body weight gain.

Table 1: Ingredient proportion (kg) and cost of total mixed ration fed to crossbred heifers

| Ingredients (kg) | T1 | T2 | T3 |
|--|---------------|---------------|---------------|
| Compound concentrate mixture (CCM) | 39.00 | 24.00 | 28.00 |
| Rice-distillers dry grains with soluble | 0.00 | 10.00 | 0.00 |
| Maize-distillers dry grains with soluble | 0.00 | 0.00 | 10.00 |
| Mineral vitamin premix* | 1.00 | 1.00 | 1.00 |
| Salt | 1.00 | 1.00 | 1.00 |
| Bypass Fat (99.0%) | 0.00 | 0.40 | 0.00 |
| Wheat Straw | 15.00 | 26.00 | 21.00 |
| Ground nut straw | 29.00 | 22.60 | 24.00 |
| Hybrid Napier | 15.00 | 15.00 | 15.00 |
| Total | 100.00 | 100.00 | 100.00 |
| Price (₹/kg DM) | 22.97 | 22.85 | 18.78 |

CCM contains soybean meal. ***Mineral vitamin premix:** contains Calcium: 202 g; Phosphorus: 118 g; Magnesium: 10 g; Sodium: 5.4 g; Sulphur: 9 g; Zinc: 12.76 g; Copper: 1 g; Cobalt: 0.125 g; Manganese: 4 g; Selenium: 0.03 g; Iodine: 0.4 g; Iron: 6 g; Chromium: 0.02 g; Vitamin A: 1100000 IU; Vitamin D3: 220000 IU; Vitamin E: 2200 mg; Vitamin B12: 8.8 mg; Niacin: 2759 mg; 5000 mg Methionine activity and 10000 mg Lysine per kg.

The data on feed intake, FCR and economic parameters were presented as Mean ± SE, and were analysed using SPSS software under the Completely Randomized Design. Treatment means were compared using a one-way ANOVA and were declared significant at $p < 0.05$, according to the procedure described by Snedecor and Cochran (2014).

RESULTS AND DISCUSSION

Daily Dry Matter and Nutrient Intake

The daily dry matter intake (DMI) and nutrient intake of crossbred heifers fed different DDGS sources are presented in Table 2. The average daily DMI (kg/day) was statistically not influenced by feeding of DDGS (T2, T3) as compared to control feeding (T1). However, DMI expressed as % body weight showed a significant difference ($p < 0.05$), with the highest intake in the maize-DDGS T3 group compared to control T1 and rice DDGS fed T2 group. The dry matter intake during various period indicated progressive improvement with age advancement in all crossbred heifer groups (Fig. 1).

The increased relative DMI in T3 may be attributed to the higher fat content and better palatability of maize-DDGS compared to rice-DDGS, which possibly improved voluntary feed intake. Similar observations were reported by Klopfenstein *et al.* (2008) and Sahin *et al.* (2013), who found that maize-DDGS diets improved feed intake in cattle.



Despite the difference in intake percentage, the overall DMI in all groups remained within the recommended range for growing heifers, indicating that DDGS inclusion up to 10% did not negatively influence feed consumption.

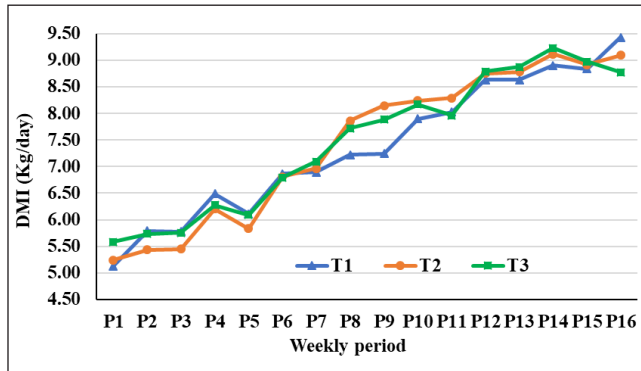


Fig. 1: Daily dry matter intake of crossbred heifers

The daily CP intake did not differ significantly among treatments, but when expressed as % body weight and g/kg $W^{0.75}$, T2 and T3 recorded significantly higher values ($p < 0.05$) than T1. This improvement may be due to the higher protein concentration in DDGS, especially in maize-DDGS, which contains 26-31% CP with 47-53% rumen-undegradable protein (Li *et al.*, 2011). Similarly, replacement of soybean meal with rice DDGS in diet of Jersey crossbred calves (Dey *et al.*, 2019), cottonseed meal with DDGS up to 100% in Nellore cattle (Fonseca *et al.*, 2021), soybean meal and rapeseed meal with DDGS in Holstein bulls (Meyer *et al.* (2010), and feeding of DDGS in dairy cows (Ranathunga *et al.*, 2018) did not influence the CP intake. Our findings aligned with these results and confirm that moderate DDGS inclusion maintains protein consumption. Some studies have reported higher protein intake with diets containing DDGS. Walter *et al.* (2012) and He *et al.* (2015) reported higher CP intake in feedlot heifers

and in Angus heifers, respectively, on feeding wheat or corn DDGS. These differences likely arise from variation in inclusion level, DDGS type and dietary CP balance.

An intake of DCP (kg/day and % BW) showed significant variation ($p < 0.05$) among groups, with T3 recorded the highest values. Similarly, DCP intake per kg $W^{0.75}$ was also significantly higher in T3 compared to T1 and T2. The higher DCP intake in T3 might be attributed to improved nutrient digestibility and enhanced microbial protein synthesis due to the presence of readily fermentable carbohydrates and bypass protein in DDGS (Youssef *et al.*, 2013). The higher DCP intake observed in DDGS-fed groups in the present trial is consistent with several earlier findings. Pandey (2021) reported improved DCP intake in crossbred heifers on feeding RDDGS incorporated diet. Whereas Dey *et al.* (2019) reported only numerical improvement in DCP intake per metabolic body weight on feeding DDGS containing diet to Jersey crossbred calves.

The TDN intake (kg/day) did not vary significantly among treatments; however, when expressed as % BW and g/kg $W^{0.75}$, T3 had significantly higher ($p < 0.05$) values compared to T2, indicating efficient utilization of nutrients and improved energy availability. Similar findings were reported by Harborth *et al.* (2006) and Pandey (2021), who observed better nutrient utilization in DDGS-supplemented heifers. The non-significant effects on TDN intake per day were reported by Dey *et al.* (2019) in Jersey crossbred calves that included DDGS in their diet, while Pandey (2021) reported higher ($p < 0.05$) TDN intake per day of crossbred heifers supplemented with RDDGS in their diets as compared to the control group. Similarly, per cent TDN intake improvement ($p < 0.05$) was reported in buffalo calves by Chandrika *et al.* (2021) on feeding DDGS containing diet. The higher percent TDN intake in MDDGS-fed heifers suggests improved energy

Table 2: Dry matter, other nutrients and water intake of crossbred heifers fed various DDGS

| Parameters | T1 | T2 | T3 |
|--|----------------------------|---------------------------|---------------------------|
| Dry matter (kg/day) | 7.37 ± 0.17 | 7.44 ± 0.16 | 7.48 ± 0.14 |
| Dry matter (kg/100kg BW) | 3.13 ^a ± 0.03 | 3.18 ^a ± 0.03 | 3.26 ^b ± 0.03 |
| Dry matter (g/kg $W^{0.75}$) | 122.05 ± 1.29 | 123.93 ± 1.42 | 126.47 ± 1.20 |
| Crude protein (kg/day) | 1.02 ± 0.02 | 1.07 ± 0.02 | 1.06 ± 0.02 |
| Crude protein (kg/100 kg BW) | 0.43 ^a ± 0.00 | 0.46 ^b ± 0.00 | 0.46 ^b ± 0.00 |
| Crude protein (g/kg $W^{0.75}$) | 16.92 ^a ± 0.18 | 17.78 ^b ± 0.20 | 17.97 ^b ± 0.17 |
| Digestible crude protein (kg/day) | 0.73 ^b ± 0.02 | 0.75 ^a ± 0.02 | 0.78 ^a ± 0.01 |
| Digestible crude protein (kg/100kg BW) | 0.31 ^a ± 0.00 | 0.32 ^a ± 0.00 | 0.34 ^b ± 0.00 |
| Digestible crude protein (g/kg $W^{0.75}$) | 12.17 ^a ± 0.13 | 12.45 ^a ± 0.14 | 13.18 ^b ± 0.12 |
| Total digestible nutrient (kg/day) | 4.23 ± 0.10 | 4.13 ± 0.09 | 4.20 ± 0.08 |
| Total digestible nutrient (kg/100kg BW) | 1.79 ^{ab} ± 0.02 | 1.76 ^a ± 0.02 | 1.83 ^b ± 0.02 |
| Total digestible nutrient (g/kg $W^{0.75}$) | 70.05 ^{ab} ± 0.74 | 68.69 ^a ± 0.79 | 70.94 ^b ± 0.67 |
| Water intake (kg/day) | 30.69 ± 1.11 | 30.48 ± 1.00 | 31.54 ± 1.12 |
| Water intake (kg/100kg BW) | 13.00 ± 0.37 | 13.00 ± 0.33 | 13.57 ± 0.36 |
| Water intake (kg/kg DMI) | 4.16 ± 0.11 | 4.10 ± 0.10 | 4.15 ± 0.10 |

Means with different superscripts (a, b) within a row differ significantly ($p < 0.05$).

Table 3: Feed conversion ratio and feeding economics in crossbred heifers fed various DDGS

| Parameter | Attribute | T1 | T2 | T3 |
|-----------------------|-----------------------------|----------------------------|----------------------------|----------------------------|
| Feed conversion ratio | FCR (kg DM/kg gain) | 7.43 ^a ± 0.13 | 7.59 ^{ab} ± 0.10 | 7.86 ^b ± 0.09 |
| | Daily feed cost ₹/head/day) | 176.21 ^b ± 3.98 | 176.43 ^b ± 3.81 | 146.85 ^a ± 2.73 |
| Feeding economics | Feed cost (₹/kg BW gain) | 177.63 ^b ± 3.21 | 179.89 ^b ± 2.38 | 154.22 ^a ± 1.67 |

Means with different superscripts (a, b) within a row differ significantly ($p < 0.05$).

consumption relative to body weight, likely due to its higher digestible energy and residual fat content compared to RDDGS (Spiehs *et al.*, 2002). In the present study, maize-DDGS (T3) fed heifers showed significantly ($p < 0.05$) higher percent DMI and nutrient intake (DCP & TDN), along with nutrient intake (DCP and TDN) per metabolic body weight, which may be attributed to its relatively higher fat and bypass protein fractions that enhanced palatability and voluntary feed intake (Spiehs *et al.*, 2002; Depenbusch *et al.*, 2009). However, this higher intake did not correspond to a proportional increase in body weight (data not shown), as values were numerically lower in MDDGS (T3) group than T2 and T1. This could be due to the amino acid profile of maize-DDGS, which is dominated by zein proteins and is deficient in lysine, thereby limiting the efficient utilization of protein and energy intake for tissue growth (Xue *et al.*, 2012; Lobos *et al.*, 2021) and may be due to reduced fibre digestibility and altered rumen fermentation caused by the residual oil content (Stein, 2009; Benchaar *et al.*, 2013).

Water Intake

An average daily water intake values are presented in Table 2. A non-significant difference was observed among treatments for water intake on daily, percent and metabolic body weight basis in crossbred heifers. The similar water intake trends across treatments indicate that DDGS inclusion at 10% did not influence water metabolism or drinking behaviour of heifers. The observed water-to-DMI ratio remained similar across all the treatment groups. The results thus confirm that both rice and maize DDGS can be safely incorporated in heifer diets without affecting water balance. Similar non-significant findings in water intake on feeding DDGS containing diet were reported in crossbred cows (Madhavatar, 2023), in crossbred heifers (Pandey, 2021), and in crossbred calves (Omer *et al.*, 2015). The comparable intakes in our trial can be attributed to iso-nitrogenous and isocaloric diets, which prevented excess nitrogen excretion and maintained stable water requirements.

Feed Conversion Ratio and Feeding Economics

The FCR of crossbred heifers fed different DDGS sources is shown in Table 3. The FCR differed significantly ($p < 0.05$) among treatments, being lowest (better) in T1 (7.43 ± 0.13) and highest (poorer) in T3 (7.86 ± 0.09). This reduction in feed efficiency in DDGS-fed groups could be attributed to higher DMI relative to body weight gain. Similar to our findings, an increase in FCR on feeding diet containing DDGS was

reported in heifers (Depenbusch *et al.*, 2009), in cattle (Gibb *et al.*, 2008), and in Jersey crossbred calves (Dey *et al.*, 2019). While in contrast, Chandrika *et al.* (2021) observed lower ($p < 0.05$) FCR in buffalo calves fed diet containing DDGS. In our study, higher FCR in maize-DDGS-fed heifers (T3) indicates that more dry matter was required per unit weight gain compared to the control.

The average daily feed cost per heifer (Table 3) was significantly lower ($p < 0.05$) in the maize-DDGS group (T3) compared to both the control and rice-DDGS groups (T1 and T2). Similarly, the feed cost per kilogram of body weight gain was lowest ($p < 0.05$) in T3 compared to T1 and T2. The lower feeding cost in maize-DDGS-fed heifers was primarily due to the reduced price of maize-DDGS relative to conventional protein sources, without compromising performance. These findings corroborated with the observations of Dey *et al.* (2019) and Pandey (2021), who reported that DDGS inclusion in livestock rations substantially reduced feed costs while maintaining similar productivity levels.

CONCLUSION

The inclusion of rice- and maize-based DDGS at 10% level in the total mixed ration of crossbred heifers did not affect dry matter and nutrient intake on daily basis, while it was higher in both DDGS (rice and maize) fed groups on percent and metabolic body weight. The water intake was also not influenced by inclusion of DDGS in the diet. The higher requirement of dry matter and lower feeding cost per unit body weight gain was out come on feeding maize DDGS. Thus, the 10 % maize DDGS can be utilized to economise the feeding of crossbred heifers.

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