Partial substitution of compound concentrate with rice DDGS crude protein: effects on Gir heifer growth

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Journal of Livestock Science (ISSN online 2277-6214) 17: 654-661
Received on 17/10/25; Accepted on 22/8/26; Published on 26/8/26
doi. 10.33259/JLivestSci.2026.654-661

Abstract

The study was designed to evaluate the effect of partially replacing crude protein (CP) from a conventional compound concentrate mixture (concentrates) with protein derived from rice distillers dried grains with solubles (RDDGS) on body weight, feed intake and feed conversion ratio in the diets of Gir heifers. A total of 24 pre-pubertal/pubertal Gir heifers (average body weight 166.29 ±11.21 kg, age 830.62 ±13.67 days) were selected and randomly allocated into three groups, each comprising eight animals. The heifers were randomly assigned to three groups of eight each: Control group (receiving 100% crude protein (CP) from a compounded concentrate mixture), T-1 group (with 25% of CP replaced by RDDGS-CP) and T-2 group (with 50% of CP replaced by RDDGS), all heifers supplemented with a basal diet and mineral mixture. Results showed that replacing concentrates CP by rice DDGS-CP at 25 % level in the diet of pre-pubertal/pubertal Gir heifers for about 6 months (ageing 27 to 33 months) results in significantly higher body weight by 19.51 % (294 vs. 246 kg). Body weight gain increased by 60.05% (+266 g/d) at 25% and 25.29% (+150 g/d) at 50% DDGS-CP replacement over control. Dry matter intake (DMI, kg/day) was significantly lower ($P<0.01$) in the DDGS-supplemented groups (5.88±0.68 and 5.58±0.89 vs. 6.21±0.71 in the control). DMI as a percentage of body weight decreased by 13.83% (2.68 vs. 3.11) in the 25% DDGS-CP group and by 16.07% (2.61 vs. 3.11) in the 50% DDGS-CP group. DMI (g/kg $W^{0.75}$) was also lower in the DDGS groups ($P<0.05$). The feed conversion ratio improved by 40.83% (10.68 vs. 18.05) at the 25% DDGS-CP replacement level ($P<0.01$). However, the 50% replacement level showed only a marginal improvement compared to the 25% level. These findings suggest that Partial replacement of concentrate protein with rice DDGS-CP improved feed efficiency in Gir heifers. The 25% substitution level resulted in better growth performance without adversely affecting intake. Higher replacement levels showed reduced intake and marginal efficiency gains.

Keywords: Gir heifer, rice distillers dried grains with solubles, Body weight, Feed intake, FCR

Introduction

Proper growth of dairy heifers, especially during the pre-pubertal and pubertal phases, is critical for achieving optimal body size and weight at first breeding and calving. Inadequate growth during this stage can lead to delayed puberty, reproductive inefficiencies and reduced lifetime productivity. Since feed expenses account for nearly 50% of the total cost of raising heifers, efficient nutritional management is essential for sustainable and profitable dairy operations (Akins, 2016). In Gujarat, a state with a livestock population of 26.89 million- including 10.54 million buffaloes and 9.63 million cattle (BAHS, 2024)-the development of cost-effective and nutritionally sound feeding strategies is particularly vital.

In recent years, the utilization of agro-industrial by-products in ruminant diets has gained attention as a means to reduce feeding costs and support sustainable livestock production. Starch is primarily utilized for ethanol production, while the remaining nutrients—such as proteins, fibers and oils—are recovered as by-products and commonly used as livestock feed in the form of dried distillers grains with solubles (DDGS) (Patil et al., 2015). One such by-product is rice distillers dried grains with solubles (RDDGS), a residue from rice-based ethanol production, which is valued for its relatively high crude protein (CP) content and favorable digestibility (Kurechiya, et al., 2026; Hanumantha Rao et al., 2026). Although DDGS is primarily incorporated into animal diets as a protein source, it also provides significant energy due to its high content of degradable fiber, with neutral detergent fiber (NDF) levels ranging from 38–40% (Naveena et al., 2020). The rising cost of conventional feed ingredients such as corn and soybean meal has further promoted the inclusion of higher levels of DDGS in animal rations compared to traditional usage. Studies showed that including DDGS in a calf starter at a rate of up to 20% of the starter dry matter allows for normal growth rates (Suarez-Mena et al., 2011). Singh et al. (2018) found that replacing up to 75% of oilseed cakes with RDDGS in the diets of Murrah heifers did not impair growth or nutrient utilization. Similarly, Pandey et al. (2023) reported improved feed efficiency in crossbred heifers when soybean meal was partially substituted with RDDGS. While dried distillers grains with solubles (DDGS) offer numerous benefits, their inclusion must be optimized.

Despite these promising findings, there remains a lack of data on the use of RDDGS in indigenous cattle breeds, such as Gir heifers, which are an important genetic resource in India's dairy sector. Therefore, the present study was undertaken to evaluate the effects of partially replacing crude protein from conventional compound concentrate mixtures with RDDGS-derived protein in the diets of pre-pubertal and pubertal Gir heifers. The study focused on assessing changes in body weight, feed intake and feed conversion ratio to determine the efficacy of RDDGS as a sustainable and effective protein source for indigenous dairy heifer development.

Materials and Methods

Study Area and Experimental Period

The study was carried out after receiving approval from the IAEC (Protocol No. KU-JVC-IAEC-LA-106-23) at the Cattle Breeding Farm, Kamdhenu University, Junagadh, Gujarat, India (21°31′ N latitude and 70°36′ E longitude), from September 2023 to March 2024, covering the post-monsoon, winter and early summer seasons. A total of twenty-four prepubertal/puberal Gir heifers, with an average age of 27 months (830.62 ± 13.67 days), were observed over a six-month period following a 7-day adaptation phase to DDGS supplementation. The heifers were randomly assigned to one of three groups, each consisting of 8 animals (Control, Treatment -1 and Treatment -2).

Care and management of heifers

All experimental Gir heifers were housed separately in clean sheds, fed individually and provided *ad libitum* clean water twice daily. They were tied throughout the day but allowed exercise from 7:00 to 9:30 a.m. each morning. Individual care was given to each animal.

Treatment details

The Control group receives 100% crude protein (CP) from a compound concentrate mixture. Treatment-1 (T-1) is provided with 75% of CP from the compound concentrate and 25% from rice DDGS. Treatment-2 (T-2) receives 50% of CP from the compound concentrate and the remaining 50% from rice DDGS (Table-1). All experimental heifers received a basal diet of 10 kg seasonal green fodder (Sorghum or Napier grass) and dry fodder (Groundnut haulm) *ad libitum* and pelleted compound concentrate mixture (BIS: Type-II, without mineral mixture) and rice DDGS were offered to meet the protein requirements of the heifers as per the ICAR (2013) feeding standard, plus 30 g/day of a mineral mixture to supplement trace and macro minerals. The diets were supplemented daily to meet the animals' nutrient requirements, with ration adjustments carried out every 15 days.

Samples of feed and fodder, including sorghum, napier grass, groundnut haulms, compound concentrate mixture and rice DDGS, were analyzed for their proximate composition using the AOAC (2023) methods at the department of Animal Nutrition, College of Veterinary Science and Animal Husbandry, Junagadh, Gujarat, India.

Estimation of body weight, feed intake and feed conversion ratio:

The body weight (kg) of individual experimental Gir heifers was recorded at fifteen-day interval in the morning before watering and feeding using electronic platform balance (1000 kg capacity with an accuracy of 1 kg) and change in body weight (kg) and average daily gain (gm/d) were calculated. Feed leftovers were collected daily and the average daily feed intake (kg/day, % body weight, g/kg $W^{0.75}$) and feed conversion ratio (kg DMI/kg body weight gain) data of experimental Gir heifers were recorded and analyzed for each animal was calculated by measuring the amount of feed offered and the remaining residues.

Statistical analysis

Data on body weight, feed intake and feed conversion ratio were analyzed using descriptive statistics, one-way ANOVA (Snedecor and Cochran, 1994) and Duncan's post hoc multiple range test in SPSS 16.0 software (SPSS for windows, version 16.0 Chickago USA, SPSS Inc.).

Results and Discussion

Proximate composition of feed stuff

The percentages of dry matter and organic matter on a dry matter (DM) basis, along with the proximate composition of the various feedstuffs used in the study, are presented in Table 2. Rice DDGS had the highest crude protein, followed by the concentrate mixture, groundnut haulm and green fodder. Crude fiber showed the opposite trend. Rice DDGS also had lower ether extract and ash, indicating higher nutritional value. Compound concentrate mixture and rice DDGS have higher acid insoluble ash, while green forages and groundnut haulm show lower values reflecting better cleanliness.

Change in body weight (kg)

Table 3 shows that on day 135, the mean body weight of Gir heifers varied substantially across treatment groups; T-1 had a higher body weight (268.15 ± 12.11 kg) than the control group (225.80 ± 9.30 kg; $P < 0.05$). At day 180 of the experiment, T-1's body weight (293.95 ± 12.72 kg) was substantially greater than the control group's (246.32 ± 9.99 kg), while T-2's (273.27 ± 13.26 kg) was intermediate ($P = 0.03$). T-1 had a considerably greater net gain in body weight (127.64 ± 2.23 kg; 76.75% of initial body weight), followed by T-2 (107.21 ± 3.36 kg; 64.56%) and control (79.82 ± 5.75 kg; 47.94%; $P < 0.001$). T-1 had an additional body weight gain of 47.82 kg (59.91%) compared to the control group, while T-2 had an additional gain of 27.39 kg (34.31%).

Feeding rice DDGS improved body weight in heifers, mainly due to its high protein, energy, and fat content, which enhanced nutrient utilization and ether extract digestibility. Singh et al. (2022) showed significant ($P<0.05$) effects of DDGS addition on growth performance, while Dey et al. (2020) discovered a numerical rise in body weight ($P>0.05$).

Table 1. Schedule for feeding crude protein (CP) from pelleted compound concentrate mixture (concentrates) and rice DDGS

Group of Animals	No. of Animals	% CP from concentrates and DDGS
Control (C)	08	100% crude protein (CP) from compound concentrate mixture /day/heifer
Treatment- 1 (T-1)	08	75% CP from compound concentrate mixture + 25% CP protein from rice DDGS/day/heifer
Treatment- 2 (T-2)	08	50% CP from compound concentrate mixture + 50% CP from rice DDGS/day/heifer

Table 2: Proximate composition of seasonal green fodder, dry fodder and compound concentrate mixture and rice DDGS (% DM basis)

Particulars (% DM basis)	Green Sorghum	Napier grass	Groundnut haulm	Compound concentrates mix.	Rice DDGS
Dry Mater (DM)	23.20	22.70	90.43	90.52	90.28
Organic Matter (OM)	91.55	89.13	88.39	87.27	95.53
Crude Protein (CP)	06.70	06.90	10.40	20.15	40.12
Crude fiber (CF)	31.25	27.18	29.37	10.24	04.98
Ether Extract (EE)	03.10	03.35	04.25	02.76	06.02
Nitrogen Free Extract (NFE)	50.50	51.70	44.37	54.12	44.41
Total Ash	08.45	10.87	11.61	12.73	04.47
Acid insoluble ash (AIA)	**00.81**	**00.97**	**00.68**	**02.04**	**01.09**

Table 3: Mean ± SE for body weights (kg) of experimental Gir heifers

Observation Period	Days	Control (n=8)	T-1 (n=8)	T-2 (n=8)	P-value
Initial	0	166.50 ± 10.93	166.31 ± 11.10	166.06 ± 11.60	NS
1	15	175.75 ± 11.27	179.52 ± 11.25	179.89 ± 11.57	NS
2	30	184.70 ± 10.72	192.62 ± 11.26	193.90 ± 11.13	NS
3	45	194.52 ± 10.69	205.12 ± 11.34	206.38 ± 9.64	NS
4	60	198.15 ± 9.84	217.30 ± 11.37	215.00 ± 10.10	NS
5	75	201.62 ± 9.06	228.52 ± 11.90	221.77 ± 12.38	NS
6	90	206.40 ± 9.20	237.50 ± 12.30	227.81 ± 12.53	NS
7	105	211.75 ± 8.94	246.40 ± 13.22	232.31 ± 12.29	NS
8	120	215.30 ± 8.32	255.38 ± 12.69	237.82 ± 11.94	NS
9	135	225.80^{b*} ±9.30	268.15^{a*}±12.11	249.70^{ab*} ± 12.66	0.05
10	150	234.72 ± 10.02	276.18 ± 12.28	260.42 ± 12.75	NS
11	165	241.08 ± 9.75	282.52 ± 12.31	265.36 ± 13.05	NS
12	180	246.32^{b*} ± 9.99	293.95^{a*} ± 12.72	273.27^{ab*} ± 13.26	0.03
Overall		207.88 ± 9.60	234.58 ± 11.92	225.36 ± 11.80	NS
Net change in BW, kg (% of initial BW)		+ 79.82^{c**} ± 5.75 (47.94 %)	+ 127.64^{a**} ±2.23 (76.75 %)	+ 107.21^{b**} ±3.36 (64.56 %)	0.0001
Difference over control (kg) (%)		-	+ 47.82(59.91 %)	+ 27.39(34.31 %)	

*Means in a row with dissimilar superscript letters differ significantly (P ≤ 0.05); **Means in a row with dissimilar superscript letters differ significantly (P<0.001)

Daily body weight gain (gm/d)

Daily weight gain of Gir heifers was assessed at fifteen-day interval during the experiment. Data for average daily gain (ADG) is illustrated in figure 1. The ADG (gm/d) of Gir heifers was significantly higher (P<0.001) in T-1 (880.83±17.46) and T-2 (880.83±21.87) groups than control (616.67±66.37) at the first observation, with similar trends in later periods. On the fourth observation, T-1 (811.67±32.99) and T-2 (574.58±89.67) also exceeded control (241.67±87.23). Significant differences were noted at the fifth, sixth, seventh and twelfth observations, particularly favoring T-1 (P<0.05). Overall mean ADG was 443.47±97.98 (control), 709.10±69.39 (T-1) and 592.85±90.08 (T-2). T-1 heifers showed the highest gain, significantly (P<0.01) greater than both control and T-2. Partial replacement of rice DDGS improved daily gain by 60.05% (+266 gm/d) at 25% replacement and 29.29% (+150 gm/d) at 50% replacement.

Several studies reported improved average daily gain (ADG) with DDGS supplementation. Dey et al. (2020) reported significant (P<0.01) improvement in Jersey crossbred calves (550 ± 16.7 vs. 688 ± 29.7 g/d) when 25% soybean meal was replaced by rice DDGS. Pandey et al. (2023) also found higher ADG in crossbred heifers (703.9 ± 21 vs. 723.2 ± 22.4 vs. 779.9 ± 23.2 g/d). Griffin et al. (2012) reported significant (P<0.01) increases in steers and heifers with DDGS (0.67–1.03 kg/d across 0–1.03% BW). El-Shinnawy et al. (2015) showed buffalo calves had 16–23% ADG increase with 10–30% DDGS in ration.

Similarly, Murillo et al. (2016) reported higher ADG in steers (200 vs. 366 vs. 355 g/d) with 0–50% corn DDGS and Martinez et al. (2013) found higher gains with 0–0.6% BW DDGS supplementation. Islas et al. (2014) also reported improved ADG in calves fed medium-quality hay plus DDGS.

Changes in dry matter intake (kg/d)

The changes in average dry matter intake (kg/d) of Gir heifers at fifteen-day interval during the experimental period are detailed in graphical representation figure 2.

Throughout the experiment, the average daily dry matter intake (DMI) of Gir heifers in the control, T-1 and T-2 groups were 6.21±0.71, 5.88±0.68 and 5.58±0.89 kg/d, respectively, with the DDGS-supplemented group showing significantly lower DMI (P<0.01). DDGS, rich in protein (rumen undegradable protein or RUP), fiber and fat, boosts feed nutrient density. This allows heifers to meet nutritional needs with less feed, reducing DMI but still meeting energy requirements for growth.

Klein et al. (2014) reported reduced hay and total DMI when DDGS was fed three days per week (P<0.05). Garnsworthy et al. (2021), who observed a linear decrease in dry matter intake (DMI) in dairy cows fed diets containing wheat DDGS, with values of 23.1, 23.1, 22.9 and 22.3 kg/day as the inclusion level increased and a significant reduction noted at 240 g/kg. Pandey et al. (2023) found a significant difference in DMI when crossbred diets contained soya deoiled cake (40 %) and wheat straw/groundnut mixture (50 %) without rice DDGS (4.96±0.08 vs. 4.45±0.10 kg/d; P<0.05). The reduction in dry matter intake when feeding DDGS may be attributed to its higher energy density, primarily due to increased lipid content and a greater proportion of undegradable protein.

Dry matter intake expressed as percent of body weight of experimental Gir heifers

Overall average dry matter intake in terms of kg per 100 kg BW of experimental Gir heifers during the experimental period were 3.11±1.11, 2.68±1.11 and 2.61±0.90 in the control, T-1 and T-2 group, respectively. The overall DMI expressed as % of body weight (% kg BW) significantly reduces by 13.83 % (2.68 vs. 3.11) in heifers fed DDGS at 25 % level and 16.07 % (2.61 vs. 3.11) at 50 % replacement level. The details are presented graphically in figure 2. Similar findings were reported by Pandey et al. (2023) found that in crossbred heifers DMI (2.66±0.04 vs. 2.59±0.03 vs. 2.58±0.03 kg/100 kg BW) reduced significantly when soya deoiled cake was replaced with rice DDGS ($P<0.01$). Dey et al. (2020) observed a slight numerical decrease in dry matter intake (DMI) (kg/100 kg BW) in cows fed concentrate containing 25 % DDGS (3.26 vs. 3.38).

Dry matter intake in terms of g/kg $W^{0.75}$ of experimental Gir heifers

The overall dry matter intake (g/kg $W^{0.75}$) were found to be 113.72±2.76, 98.83±2.79 and 96.18±2.39 in the control, T-1 and T-2 groups, respectively, being significantly lower in the DDGS-treated groups of heifers as compared to the control group heifers ($P<0.01$). The average dry matter intake expressed as g/kg $W^{0.75}$ of experimental Gir heifers is presented in graphical representation in the figure 4. Present finding is in accordance with results of Sihag et al. (2018) also found similar results in lactating cattle (115.29±2.04 vs. 118.48±1.68 vs. 118.31±1.59 vs. 116.63±4.16 g/kg $W^{0.75}$) when concentrate mixture was replaced with DDGS.

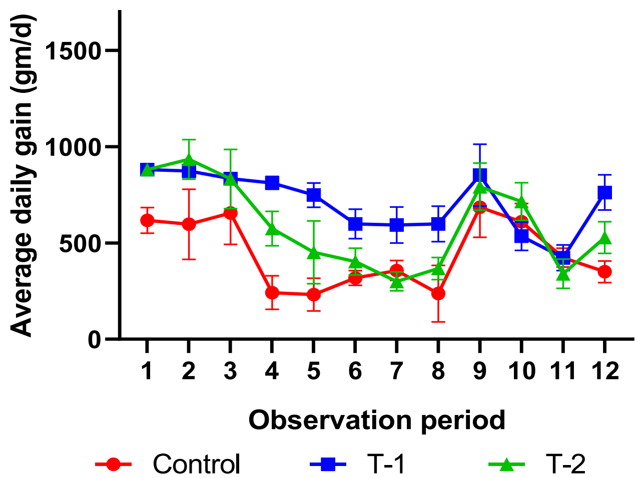

Figure 1: Change in ADG (gm/d) of experimental Gir heifers

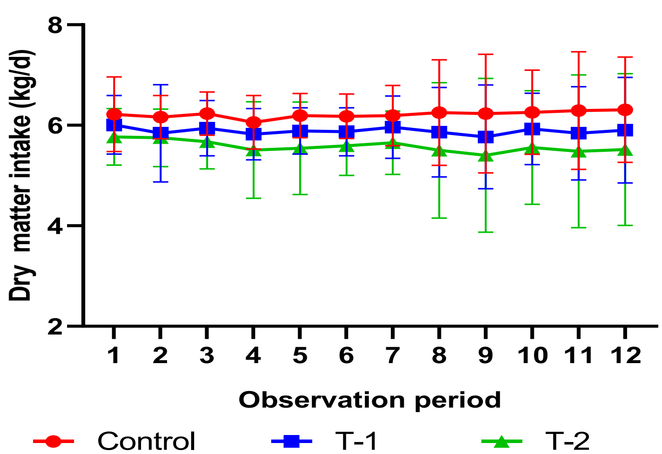

Figure 2: Change in DMI (kg/d) of experimental Gir heifers

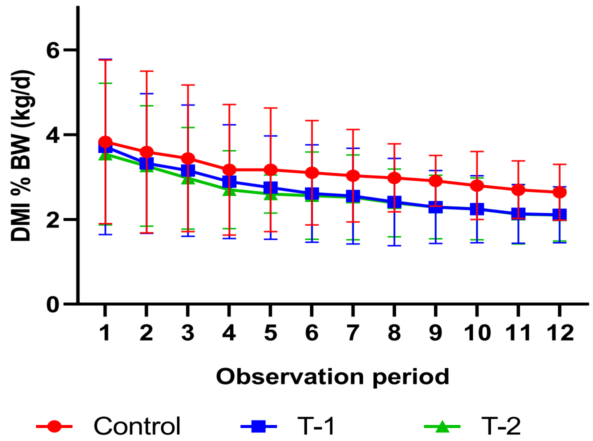

Figure 3: Change in DMI expressed as % of BW of experimental Gir heifers

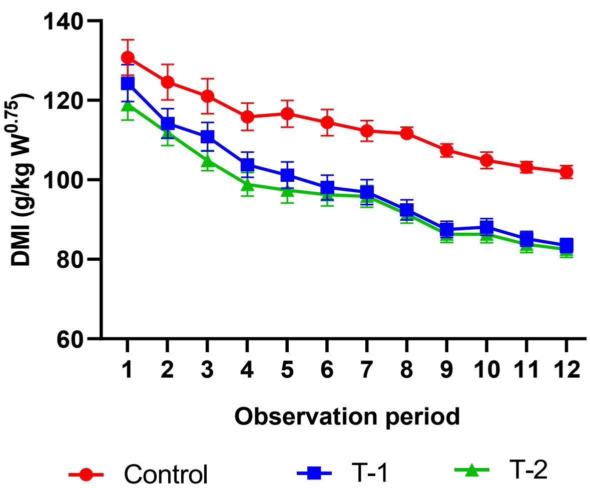

Figure 4: Change in DMI in terms of g/kg $W^{0.75}$ of experimental Gir heifers

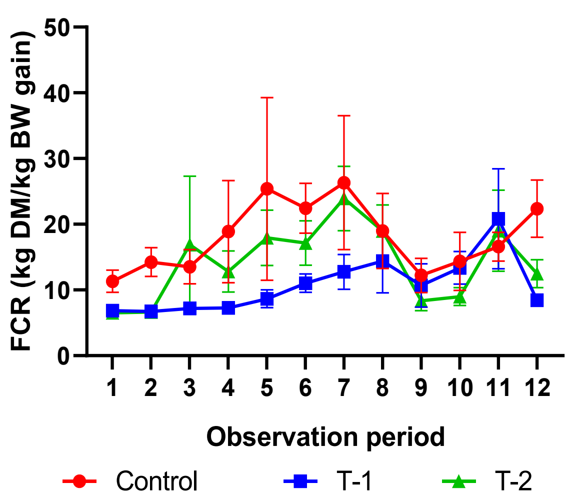

Figure 5: Change in FCR (kg DMI/kg body weight gain) of Gir heifers

Feed conversion ratio (kg DMI/kg body weight gain) of experimental Gir heifers

Overall mean feed conversion ratio (kg DMI/kg body weight gain) of Gir heifers were 18.05±2.47, 10.68±0.69 and 14.14±1.27 in the control, T-1 and T-2 group, respectively. The overall mean feed conversion ratio of experimental Gir heifers was significantly affected by DDGS feeding/replacement in the T-1 group heifers than that in the control group heifers (P<0.01). The feed conversion ratio of Gir heifers in terms of kg DMI/kg body weight gain significantly improved by 40.83 % (10.68 vs. 18.05) at 25 % replacement rate. Albeit, the same (14.14, difference of only -3.91) at 50 % replacement level remained at par with that at 25 % inclusion level. Figure 5 presents a graphical presentation of the variations in mean feed conversion ratio of Gir heifers over the course of the experimental period.

In recent finding, higher feed conversion efficiency (kg DMI/kg body weight gain) observed when DDGS partially replaced compound concentrate mixture. It indicated that the heifers are more efficient in converting the feed they consume into body weight gain. In other words, DDGS treated Gir heifers require less feed (in terms of DMI) to gain each kilogram of body weight than control diet. The findings of the present study are confirmed with the results of Etman et al. (2011) in buffalo calves (13.607 vs. 13.252 vs. 12.157 vs. 11.360 vs. 11.147 kg DM/kg gain) found significant difference (P<0.05) when DDGS partially replaced with concentrate feed mixture, Omer et al. (2015) in crossbred calves (9.897 vs. 7.504 vs. 7.079 kg DM/kg gain) observed significant (P<0.05) increase feed efficiency while partial replacing of cotton seed meal with DDGS and El-Shinnawy et al. (2015) in buffalo calves (9.166 vs. 8.028 vs. 7.770 vs. 7.710 kg DM/kg gain) reported higher feed efficiency when diet contains 30 and 20 % DDGS.

He et al. (2015) reported significant effect (P<0.01) in crossbred steers when diet containing 30% wheat DDGS in place of barley grain.

Conclusion

The current study showed that feed efficiency and growth in Gir heifers were enhanced when rice DDGS (RDDGS) was partially substituted for normal dietary CP. Despite lower dry matter intake, replacing 25% of CP with RDDGS enhanced feed conversion by 40.83% and raised body weight by 19.51%. Though not as much, the 50% replacement level also shown improvement. For Gir heifers, it is therefore advised to replace 25% of CP with RDDGS as a cost-effective and efficient feeding method, especially in areas where rice DDGS is easily accessible.

Acknowledgement

The Department of Livestock Production Management, Department of Animal nutrition, College of Veterinary Science and Animal Husbandry and Cattle Breeding Farm, Kamdhenu University, Junagadh are acknowledged for providing the facilities required for the timely and successful completion of the work.

Conflict of Interest: All authors declare no conflict of interest.

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