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Evaluation of cost-effective maintenance rations on nutrient intake and physiological responses of unproductive Tharparkar cattle

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ABSTRACT

Management of unproductive cattle is economically challenging, particularly under resource-constrained conditions where feeding costs dominate the total expenditure. Therefore, development of cost-effective, nutritionally adequate maintenance rations is essential for sustainable livestock management. This study aimed to evaluate the effect of such rations on nutrient intake, physiological responses, and economic efficiency in unproductive Tharparkar cattle. A 60-day feeding trial was conducted using twenty-four non-pregnant, non-lactating Tharparkar cows randomly allocated to four dietary treatments: control (T0; conventional ration), T1 (cost-effective concentrate-based ration), T2 (total mixed ration), and T3 (urea-treated wheat straw supplemented with minimal concentrate). Dry matter intake, body weight, hematological indices, serum biochemical parameters, and stress biomarkers were measured. Dry matter intake and body weight remained statistically similar ($P > 0.05$) across all groups, indicating that the experimental rations met maintenance requirements. Hematological and serum biochemical parameters remained within normal physiological ranges, confirming the metabolic safety. Serum urea concentration was significantly higher ($P < 0.001$) in T3 (19.08 ± 0.36 mg/dL) compared to T0 (12.54 ± 0.32 mg/dL) at day 60, but remained within acceptable limits. Stress indicators, including superoxide dismutase activity and serum cortisol, were unaffected by dietary treatments. These findings demonstrated that urea treated straw and cost-effective rations provide a nutritionally adequate and economically viable strategy for maintaining unproductive cattle under resource-constrained conditions.

Keywords: Cost-effective ration, Tharparkar, TMR, Economic viability, Unproductive cattle, Urea-treated straw

Cattle has historically been central to Indian agriculture, contributing to livelihood, nutrition, and rural economy. India currently possesses the world's largest livestock population (535.78 million), including 192.49 million cattle (DAHD 2019). The country is also the leading global milk producer, contributing approximately 24% of total milk production (DAHD 2025). Despite their importance, a substantial proportion of cattle becomes unproductive due to age, low productivity, or health issues. Unlike many other countries, culled cattle in India are generally not permitted for slaughter, owing to deep-rooted religious sentiments and state-specific legal prohibitions enacted under various cow protection laws, including provisions aligned with the Cow Protection Bill (Lok Sabha, 2019) and related state legislations. This leaves farmers with only two options: releasing these animals as stray cattle or sending them to cow shelters, known as gaushalas. According to DAHD 2019 there are 5.02 million stray cattle in India, with the highest numbers reported in Rajasthan (1.27 million), Uttar Pradesh (1.18 million), and Madhya Pradesh (0.85 million). Currently, more than 5,000 gaushalas across the nation care for these elderly and unproductive animals. However, these institutions face significant management and financial challenges

To address this challenge, there is an urgent need to develop and adopt scientific, balanced, and cost-effective feeding strategies, as feed and fodder constitute the largest recurring expenditure in cattle rearing, accounting for approximately 60–70% of the total production cost (Alqaisi *et al.* 2014). Developing a maintenance ration that uses low-cost materials, such as urea-treated straw and cost-effective concentrate, is a practical way to reduce the daily cost of keeping these animals. By reducing feeding expenditure, gaushalas and similar cattle management setups can achieve more economic self-sufficiency and operational sustainability. Accordingly, the present study was designed to formulate and scientifically evaluate alternative low-cost rations aimed at addressing the

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management and maintenance challenges associated with unproductive cattle in India.

MATERIALS AND METHODS

The experiment was conducted on Tharparkar cattle maintained at the Unproductive Cattle Shed, Livestock Production and Management Section, ICAR–Indian Veterinary Research Institute (IVRI), Izatnagar, Uttar Pradesh, India. The experimental farm is located at 28°22′ N latitude and 79°24′ E longitude, at an altitude of 169.2 m above mean sea level. The region experiences a subtropical climate, with winter temperatures declining to about 5°C, summer temperatures rising up to 45°C, and an average annual rainfall of 90–120 cm, most of which is received during the southwest monsoon period (July–September). The study was carried out from August to October 2024.

All experimental procedures involving animals were conducted in accordance with the guidelines of the Institutional Animal Ethics Committee (IAEC) of ICAR–IVRI, Izatnagar, and complied with the regulations of the Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA), GoI.

Experimental animals: A total of twenty-four non-pregnant, non-lactating, unproductive Tharparkar cows were selected based on similar body weight (Average body weight- 339.62 ± 11.99 kg) and apparent health status. The animals were randomly allotted to four dietary treatment groups, with six animals per group. The dietary treatments consisted of four feeding regimes. The control group (T0) received a conventional ration comprising approximately 50% green fodder, 35% wheat straw, and 15% concentrate mixture. The T1 group was maintained on a basal ration consisting of 10% green fodder, 70% wheat straw, and 20% cost-effective concentrate mixture. Animals in the T2 group were offered a total mixed ration (TMR) ad libitum, prepared by homogeneously blending green fodder, wheat straw, and cost-effective concentrate. The T3 group received ad libitum urea-treated wheat straw, supplemented with 10% green fodder, 20 g mineral mixture, 10 g common salt, and 0.5 kg concentrate per animal per day.

The ingredient composition (parts per quintal) and cost analysis of the control and cost-effective concentrate mixtures are presented in Table 1. The inclusion level of urea in the cost-effective concentrate was maintained within safe limits for ruminants, in accordance with ICAR nutritional guidelines.

All animals were housed under a loose housing system and managed according to the Bureau of Indian Standards (BIS) recommendations for space allowance. Routine herd health practices, including vaccination, deworming, and regular clinical monitoring, were followed as per the standard Cattle and Buffalo Farm health schedule of IVRI. Adequate hygiene, proper bedding management, and suitable environmental conditions were maintained throughout the experimental period to ensure animal welfare.

The feeding trial was conducted for a period of 60 days. Animals were offered their respective experimental rations individually, formulated to meet maintenance nutrient requirements as per the ICAR Feeding Standards (2013). All dietary proportions were expressed on a dry matter (DM) basis. Clean and potable drinking water was made available ad libitum and replenished at least twice daily.

Samples from all the feed resources viz. Concentrate (Control and Cost-effective), wheat straw, green fodder (Napier), Urea treated straw were taken for proximate analysis. Proximate analysis of the concentrate and roughage ground sample was done using the AOAC method (2005).

Body weight (BW) was recorded at 15-day intervals (Days 0, 15, 30, 45, and 60) between 08:00–09:00 h, prior to access to feed and water, to minimize variation due to gut fill. Serum metabolites, including total protein (Biuret method), albumin (Bromocresol Green), glucose (GOD-POD), blood urea nitrogen (Modified Berthelot), creatinine (Alkaline Picrate), and cholesterol and triglycerides (enzymatic colorimetric), were quantified using commercial veterinary kits (Coral Clinical Systems, India). Serum globulin was determined by subtracting albumin from total protein. Aminotransferase activities (ALT and AST) were measured according to the Reitman and Frankel method using specific diagnostic kits (Coral Clinical Systems). Systemic oxidative stress and endocrine status were evaluated by measuring superoxide dismutase (SOD) activity (Cayman Chemical, USA) and serum cortisol concentration via a species-specific competitive ELISA kit (ELK Biotechnology, Wuhan, China), following the manufacturers' protocols.

The data obtained were analyzed using IBM SPSS Statistics software (Version 26.0). The effects of dietary treatments and experimental period were assessed using repeated-measures analysis of variance (ANOVA) under a general linear model framework. When significant differences were detected, Duncan's multiple range test was applied for post-hoc comparison at a 5% level of

Table 1. Ingredient composition (parts per quintal) and cost analysis of experimental concentrate rations

Particulars	Rate per unit (₹/kg)	Control Concentrate	Cost-effective Concentrate
Maize	28	37	30.5
Wheat Bran	24	33	60
Mustard Oil Cake	28	0	5
Urea	6	0	1.5
Mineral Mixture	120	2	2
Salt	8	1	1
SBM (De-oiled)	65	27	0
Total		100	100
Cost (₹/kg)		38.31	25.61

Table 2. Proximate composition of feed and fodder provided to the experimental animals

Parameters	Concentrate	Green fodder (Napier)	Wheat straw	Urea Treated Straw	Cost Effective Concentrate	TMR
DM (%)	87.63	25.40	91.59	80.10	87.83	82.57
OM (%)	90.60	88.85	90.49	83.76	90.65	90.33
CP (%)	22.42	8.32	3.36	8.85	18.46	6.94
EE (%)	5.08	3.03	1.51	1.20	1.92	1.06
TA (%)	9.40	11.15	9.51	9.49	7.15	9.23
NDF (%)	24.39	52.52	73.36	58.82	29.10	68.42
ADF (%)	10.48	32.75	49.50	46.39	7.52	41.30

significance ($p < 0.05$). The results are presented as mean ± standard error of the mean (SEM).

RESULTS AND DISCUSSION

Proximate composition of feed ingredients: The chemical composition of the experimental diets (Table 2) reflects a strategic approach to low-cost maintenance. The crude protein (CP) content increased from 3.36% to 8.85%, representing a 163% improvement in nitrogen density. This shift effectively converts a poor-quality crop residue into a balanced maintenance forage by providing non-protein nitrogen (NPN) for rumen microbial protein synthesis. The total mixed ration (TMR) provided a homogenized nutrient profile (CP 6.94% and NDF 68.42%), which prevents selective feeding and ensures a steady fermentation rate in the rumen. The higher neutral detergent fibre (NDF) (73.36%) and acid detergent fibre (ADF) (49.50%) in untreated straw were successfully diluted in the TMR and T3 groups, facilitating better voluntary intake. Furthermore, the cost-effective concentrate maintained high organic Matter (90.65%) and adequate CP (18. 46%), proving that expensive traditional ingredients can be replaced with more economical alternatives without compromising the basal nutrient requirements of unproductive Tharparkar cattle.

Body weight and daily dry matter intake: The stability of BW in the T3 (urea-treated straw) and T2 (TMR) groups suggested that non-protein nitrogen (NPN) and homogenized high-fiber diets successfully met the physiological requirements of unproductive Tharparkar cattle without compromising their physical condition. These observations were in agreement with Shelke *et al.* (2018) who reported that urea-treated crop residues significantly improve palatability and nitrogen availability, thereby maintaining body weight even with reduced concentrate supplementation. DMI did not vary significantly ($P > 0.05$) among the treatment groups at any time point during the 60-day experimental period. Wanapat and Pimpa (1999) reported that optimal ruminal ammonia-nitrogen concentrations enhance fiber digestion and intake in buffaloes, supporting the observed intake stability in the present study.

Haematological parameters: All hematological parameters, including erythrocyte (RBC) and leukocyte (WBC) counts, hemoglobin concentration, and PCV, remained within the normal physiological range for the species, with no significant differences ($P>0.05$). Supplementation with 4% urea-treated wheat straw did not affect hemoglobin levels in lactating buffaloes (Dutta

Table 3. Body weight and Dry matter intake

Body weight					
Day	T0	T1	T2	T3	P value
0	340.00 ± 11.76	339.16 ± 12.07	339.33 ± 10.85	340.00 ± 13.16	0.974
15	342.66 ± 11.15	344.16 ± 11.64	340.00 ± 10.72	341.66 ± 11.59	0.865
30	348.50 ± 10.46	345.83 ± 11.64	346.66 ± 10.77	345.00 ± 13.84	0.895
45	347.16 ± 10.75	341.00 ± 11.23	340.33 ± 08.72	343.33 ± 11.94	0.724
60	346.33 ± 11.66	343.50 ± 10.62	348.00 ± 11.76	344.16 ± 13.38	0.747
Dry matter intake (kg/day)					
Day	T0	T1	T2	T3	P-Value
15	8.10 ± 0.30	7.06 ± 0.27	7.59 ± 0.15	7.78 ± 0.29	0.071
30	8.16 ± 0.27	7.10 ± 0.29	7.57 ± 0.20	7.80 ± 0.35	0.104
45	8.17 ± 0.31	7.28 ± 0.23	7.69 ± 0.25	7.89 ± 0.37	0.227
60	8.15 ± 0.28	7.03 ± 0.27	7.64 ± 0.16	7.80 ± 0.35	0.065

Note: Means within a row bearing different superscripts (a, b, c) differ significantly ($P < 0.05$). Rows without superscripts indicate that no significant differences were detected among the treatment groups ($P > 0.05$).

Table 4. Haematological parameter across different ration

Platelet Count					
Days	T0	T1	T2	T3	P value
0	367.33 ± 13.13	326.50 ± 11.68	381.16 ± 13.26	391.66 ± 27.68	0.979
30	328.33 ± 12.82	313.33 ± 13.18	384.16 ± 13.74	349.16 ± 16.60	0.881
60	353.33 ± 03.57	359.16 ± 11.93	365.16 ± 11.43	374.66 ± 02.52	0.596
PCV (%)					
Days	T0	T1	T2	T3	P value
0	34.56 ± 1.48	34.43 ± 1.55	32.45 ± 1.2	36.21 ± 1.04	0.304
30	35.63 ± 1.08	34.33 ± 1.45	31.81 ± 1.21	32.08 ± 1.51	0.161
60	33.56 ± 0.21	34.20 ± 1.48	34.18 ± 1.43	33.91 ± 0.17	0.969
RBC ($10^6/\mu L$)					
Days	T0	T1	T2	T3	P value
0	8.14 ± 0.23	7.73 ± 0.21	8.49 ± 0.22	8.57 ± 0.31	0.098
30	8.06 ± 0.36	8.24 ± 0.26	8.32 ± 0.34	8.31 ± 0.21	0.928
60	7.78 ± 0.30	8.03 ± 0.27	7.88 ± 0.23	7.31 ± 0.06	0.209
WBC ($10^3/\mu L$)					
Days	T0	T1	T2	T3	P value
0	10.45 ± 0.46	10.76 ± 0.63	10.93 ± 0.60	10.23 ± 0.50	0.813
30	11.55 ± 0.24	11.30 ± 0.45	10.50 ± 0.36	10.51 ± 0.21	0.103
60	09.91 ± 0.40	10.33 ± 0.54	10.48 ± 0.46	09.93 ± 0.08	0.704
Haemoglobin (g/dL)					
Days	T0	T1	T2	T3	P value
0	11.60 ± 0.40	11.58 ± 0.36	11.13 ± 0.49	11.41 ± 0.55	0.879
30	10.25 ± 0.53	10.65 ± 0.27	9.90 ± 0.37	09.88 ± 0.50	0.341
60	11.91 ± 0.45	12.09 ± 0.41	12.40 ± 0.27	11.82 ± 0.20	0.665

Note: Means within a row bearing different superscripts (a, b, c) differ significantly ($P < 0.05$). Rows without superscripts indicate that no significant differences were detected among the treatment groups ($P > 0.05$).

et al. 2004). Saeed *et al.* (2019) further noted no significant variations in RBC count, hemoglobin, mean corpuscular volume (MCV), or mean corpuscular hemoglobin concentration (MCHC) among treatment groups fed urea-treated palm kernel cake straw.

Serum parameters: Serum biochemical parameters such as total protein, albumin, globulin and total cholesterol did not vary significantly among four groups (Table 5). In the present study, serum total protein, albumin, and globulin levels remained within the physiological normal range for all treatment groups ($P > 0.05$), suggesting the absence of systemic inflammation or hepatic dysfunction. The albumin-to-globulin (A:G) ratio, a vital synthetic index for identifying dysproteinemias (Eckersall, 2008), remained comparable to expected values across all groups. Total protein and A:G ratio, did not vary significantly in crossbred cows fed urea-treated paddy straw, corroborating the metabolic safety of the dietary interventions used in this study (Wanapat *et al.* 2009).

Serum Urea Nitrogen: Serum urea concentrations were significantly higher in the T3 group receiving urea-treated straw, reflecting increased ruminal ammonia absorption and subsequent hepatic urea synthesis. However, these values remained within physiologically safe thresholds, as described by Alekish and Ismail, 2019.

Energy status and lipid metabolism: Serum glucose, cholesterol, and triglyceride concentrations remained stable across treatments, indicating that energy balance and lipid metabolism were not adversely affected.

Hepatic and Renal Function**:** Liver enzyme activities (ALT and AST) and serum creatinine levels showed no significant differences among groups and remained within normal ranges, confirming that hepatic and renal functions were uncompromised. ALT and AST are sensitive indicators of hepatocellular integrity (Mordak *et al.* 2020), while creatinine reflects renal filtration efficiency.

Stress Biomarkers: Balanced diets are essential to prevent oxidative damage (Celi and Gabai 2015). SOD activity and serum cortisol values presented in Table no. 6 remained within the normal physiological range

Table 5. Serum biochemical parameters across different ration

Serum total protein (g/dL)					
Days	T0	T1	T2	T3	P value
0	7.05 ± 0.39	6.91 ± 1.29	6.65 ± 0.60	7.25 ± 0.96	0.12
30	6.64 ± 0.44	6.74 ± 0.55	6.41 ± 0.42	7.04 ± 0.72	0.17
60	6.79 ± 0.44	6.74 ± 0.55	7.41 ± 0.42	7.04 ± 0.72	0.17
Serum globulin (g/dL)					
Days	T0	T1	T2	T3	P value
0	4.45 ± 0.34	4.21 ± 1.51	3.88 ± 0.41	4.39 ± 0.87	0.23
30	4.25 ± 0.56	4.08 ± 0.87	3.33 ± 0.48	3.90 ± 0.78	0.55
60	4.19 ± 0.52	3.94 ± 0.95	3.93 ± 0.61	4.02 ± 0.69	0.13
Serum albumin (g/dL)					
Days	T0	T1	T2	T3	P value
0	2.60 ± 0.19	2.70 ± 0.35	2.77 ± 0.40	2.86 ± 0.39	0.26
30	2.39 ± 0.51	2.66 ± 0.43	3.08 ± 0.44	3.14 ± 0.55	0.17
60	2.60 ± 0.22	2.80 ± 0.52	3.48 ± 0.33	3.02 ± 0.40	0.09
Serum urea (mg/dL)					
Days	T0	T1	T2	T3	P value
0	$12.70^{x} \pm 0.34$	$11.90^{x} \pm 0.30$	$12.14^{x} \pm 0.20$	$12.93^{x} \pm 0.40$	0.14
30	$12.21^{a} \pm 0.39$	$15.16^{by} \pm 0.28$	$14.96^{by} \pm 0.39$	$17.82^{cy} \pm 0.47$	<0.001
60	$12.54^{a} \pm 0.32$	$14.93^{by} \pm 0.38$	$15.06^{by} \pm 0.45$	$19.08^{cz} \pm 0.36$	<0.001
Serum cholesterol (mg/dL)					
Days	T0	T1	T2	T3	P value
0	129.44 ± 3.39	126.76 ± 3.76	127.66 ± 3.41	125.13 ± 4.92	0.88
30	121.34 ± 4.98	126.52 ± 3.93	129.94 ± 4.15	123.24 ± 5.12	0.57
60	120.35 ± 5.03	126.27 ± 3.24	125.28 ± 4.77	126.18 ± 3.64	0.72
Serum Glucose (mg/dL)					
Days	T0	T1	T2	T3	P value
0	60.60 ± 3.85	60.60 ± 4.00	58.04 ± 3.61	64.37 ± 4.75	0.661
30	59.3 ± 4.28	60.19 ± 4.47	60.57 ± 4.04	59.78 ± 4.64	0.998
60	63.04 ± 3.88	65.24 ± 3.46	61.06 ± 5.49	58.26 ± 5.14	0.74
Serum Triglycerides (mg/dL)					
Days	T0	T1	T2	T3	P value
0	34.25 ± 0.63	35.21 ± 0.56	34.44 ± 0.70	34.36 ± 0.89	0.767
30	36.9 ± 0.35	36.57 ± 0.64	36.78 ± 0.66	36.44 ± 0.74	0.061
60	34.86 ± 0.72	33.55 ± 0.38	35.80 ± 0.30	35.37 ± 0.82	0.077
ALT (IU/L)					
Days	T0	T1	T2	T3	P value
0	11.25 ± 0.72	11.94 ± 0.93	11.8 ± 0.75	12.23 ± 0.91	0.79
30	11.75 ± 0.76	12.47 ± 0.71	12.45 ± 0.69	12.20 ± 0.81	0.89
60	11.16 ± 0.87	11.83 ± 0.94	12.25 ± 0.77	12.02 ± 0.75	0.85
AST (IU/L)					
Days	T0	T1	T2	T3	P value
0	81.11 ± 1.72	84.27 ± 1.80	88.13 ± 2.23	83.02 ± 1.36	0.34

Table 5 contd...

Table 5 concluded

AST (IU/L)					
Days	T0	T1	T2	T3	P value
30	85.98 ± 1.38	87.45 ± 1.58	85.62 ± 2.10	86.21 ± 1.65	0.53
60	83.21 ± 1.65	86.27 ± 1.35	89.11 ± 2.11	82.15 ± 1.61	0.87
Serum Creatinine (mg/dL)					
Days	T0	T1	T2	T3	P value
0	1.04 ± 0.09	1.02 ± 0.09	1.01 ± 0.09	1.03 ± 0.05	0.99
30	1.03 ± 0.06	1.03 ± 0.10	0.96 ± 0.09	0.96 ± 0.09	0.89
60	1.03 ± 0.05	0.99 ± 0.07	1.04 ± 0.07	1.05 ± 0.09	0.95

Note: Column wise means with x, y, z superscripts represent significant differences(P < 0.05) within a group across various days, while row wise a, b, c superscripts denote significant differences(P < 0.05) among the group. Rows without superscripts indicate that no significant differences were detected among the treatment groups (P > 0.05).

Table 6. Antioxidant (SOD) activity and serum cortisol levels

SOD Activity (U/mL)					
Days	T0	T1	T2	T3	P value
0	0.63 ± 0.06	0.66 ± 0.05	0.63 ± 0.05	0.62 ± 0.07	0.96
30	0.66 ± 0.02	0.59 ± 0.05	0.62 ± 0.06	0.74 ± 0.05	0.21
60	0.64 ± 0.06	0.62 ± 0.05	0.62 ± 0.06	0.68 ± 0.05	0.88
Serum Cortisol (ng/mL)					
Days	T0	T1	T2	T3	P value
0	2.28 ± 0.16	2.31 ± 0.18	2.34 ± 0.14	2.65 ± 0.10	0.28
30	2.35 ± 0.21	2.25 ± 0.18	2.23 ± 0.18	2.32 ± 0.16	0.96
60	2.23 ± 0.16	2.21 ± 0.19	2.25 ± 0.13	2.51 ± 0.21	0.57

Note: Means within a row bearing different superscripts (a,b,c) differ significantly (P < 0.05). Rows without superscripts indicate that no significant differences were detected among the treatment groups (P > 0.05).

for all groups throughout the study, with no statistically significant differences (P > 0.05) observed between the groups at any time point. Similarly, Beauchemin *et al.* (2008) reported that dietary fiber and urea supplementation do not elevate cortisol levels when rations are nutritionally balanced, supporting the absence of physiological stress in the present study.

The study demonstrates that urea-treated wheat straw (T3) and cost-effective TMR (T2) are viable alternatives for the sustainable maintenance of unproductive Tharparkar cattle. Urea enrichment successfully enhanced straw nitrogen density by 163%, converting a poor-quality residue into balanced maintenance forage. Furthermore, the cost-effective concentrate successfully maintained nutritional adequacy at a significantly lower price point compared to the conventional control concentrate. Physiological stability was confirmed by the maintenance of body weight, dry matter intake, and the haemato-biochemical profile, with all systemic health markers remaining within normal physiological ranges. The lack of significant variation in serum total protein, albumin, and cholesterol (P>0.05) validated the metabolic safety of these non-conventional rations. These findings provided a scientifically sound and economically impactful framework for gaushala sustainability, offering a scalable solution for managing unproductive livestock under resource-constrained conditions.

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