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Comparative Assessment of Dairy Cattle Welfare Under Intensive and Semi-Intensive Management Systems in Tamil Nadu, India

RAJADURAI A

rajadurai10093@gmail.com

Tamil Nadu Veterinary and Animal Sciences University https://orcid.org/0000-0001-9168-9154

Rajamanickam K

Tamil Nadu Veterinary and Animal Sciences University

Kumaravelu N

Tamil Nadu Veterinary and Animal Sciences University

Vijayakumar P

Tamil Nadu Veterinary and Animal Sciences University

Elango A

Tamil Nadu Veterinary and Animal Sciences University

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Abstract

The study aimed to assess the welfare of dairy cows kept in semi-intensive and intensive system of farming in Kallakurichi District of Tamil Nadu. For assessing welfare indicators sample size of 20 dairy cows was selected for blood profile in each category. In blood profile like whole blood Haemoglobin, PCV, RBC, WBC, Platelets, Neutrophils, Monocytes, Lymphocytes, Eosinophils and basophils are well within the normal range and no significant differences were observed between intensive and semi-intensive system of dairy farming as well. In serum bio chemical analysis Total protein, Albumin, Globulin, AST, ALP, BUN, Creatinine, Calcium, Phosphorus, Magnesium and Glucose are well within the normal range as well as no significant differences were observed between the systems of farming. T3, T4, TSH and Cortisol level are also well within the normal range but cortisol level exhibited significant difference between systems of farming. Higher cortisol level was recorded in intensive dairy farming compared to semi-intensive dairy farming. In both the systems of dairy farming Temperature humidity index indicated that the values are very well within the ideal value between 65 to 72 which reflects the ideal comfort level. Statistically no difference was found between the study area regarding THI values. Milk samples were collected from 200 animals from both the systems, analysed for fat and SNF, which showed no significant differences between systems of farming. No significant differences were observed about the variables related to health parameters like Mastitis, Milk Fever, Ketosis, Hoof problems and Abortions but Acidosis shows significant difference more in semi-intensive dairy farming compared to intensive farming.

INTRODUCTION

Kallakurichi district, located in the inland region of Tamil Nadu, exemplifies the transition zone where traditional and modern dairy production systems coexist. The district's agricultural economy supports a mix of intensive peri-urban dairies and semi-intensive rural operations, providing an ideal setting for comparative welfare evaluation. Despite the recognized importance of dairy production in the region, systematic assessments of cattle welfare across different management systems remain limited, with few studies having employed validated welfare indicators to characterize the strengths and vulnerabilities of local production practices.

The present study was therefore undertaken to assess and compare the welfare status of dairy cattle maintained under intensive and semi-intensive management systems in Kallakurichi district of Tamil Nadu. Using a modified welfare assessment protocol incorporating both animal-based indicators and resource-based measures, we aimed to: (i) characterize the prevailing welfare conditions across both management systems, (ii) identify specific welfare compromises associated with each production approach, and (iii) generate evidence-based recommendations for welfare improvement tailored to the regional context. The findings are expected to contribute to the growing body of knowledge on dairy cattle welfare in tropical production systems and inform policy interventions aimed at enhancing animal wellbeing while sustaining productivity.

MATERIALS AND METHODS

Study Area

The present investigation was carried out in Kallakurichi District, located in the north-central agro-climatic zone of Tamil Nadu, India. The district is characterized by a tropical climate with distinct summer, monsoon, and winter seasons and supports a substantial population of dairy cattle reared under intensive and semi-intensive management systems.

Study Design and Sampling Procedure

A comparative cross-sectional study design was adopted to assess the welfare status of dairy cows maintained under intensive and semi-intensive farming systems. Dairy farms practicing either of the two systems were identified through field surveys and local veterinary records. From the selected farms, apparently healthy lactating cows of similar age and production status were chosen for the study.

For physiological and biochemical welfare assessment, a total of 40 dairy cows were selected, comprising 20 cows from intensive systems and 20 cows from semi-intensive systems. In addition, milk samples were collected from 200 dairy cows (100 from each system) to evaluate milk quality parameters.

Description of Management Systems

Intensive system

Cows were housed continuously in stalls or sheds with controlled feeding, minimal grazing, and routine management practices including regular milking, concentrate feeding, and limited exercise.

Semi-intensive system

Cows were allowed partial grazing along with stall feeding, providing greater opportunity for movement and natural behaviour compared to the intensive system.

Blood Sample Collection and Haematological Analysis

Blood samples were collected aseptically from the jugular vein of each selected animal using sterile vacutainer tubes. Whole blood samples were used for haematological analysis, which included estimation of haemoglobin (Hb), packed cell volume (PCV), red blood cell (RBC) count, white blood cell (WBC) count, platelet count, and differential leukocyte counts (neutrophils, lymphocytes, monocytes, eosinophils, and basophils). Standard laboratory procedures were followed for all estimations (Jain, 2010).

Serum Biochemical Analysis

Blood samples collected without anticoagulant were centrifuged to separate serum. Serum samples were analysed for biochemical parameters including total protein, albumin, globulin, aspartate aminotransferase (AST), alkaline phosphatase (ALP), blood urea nitrogen (BUN), creatinine, calcium, phosphorus, magnesium, and glucose using standard diagnostic kits and procedures as described by Thrall et al. (2012).

Hormonal Assay

Serum hormone levels including triiodothyronine (T3), thyroxine (T4), thyroid-stimulating hormone (TSH), and cortisol were estimated using commercially available enzyme-linked immunosorbent assay (ELISA) kits following the manufacturer's instructions (Kaneko et al., 2008). Cortisol concentration was used as a key indicator of physiological stress and animal welfare (Mormède et al., 2007).

Temperature–Humidity Index (THI)

Ambient temperature and relative humidity were recorded at the time of sampling using a digital thermo-hygrometer. The temperature–humidity index (THI) was calculated using standard equations as described by Thom (1959) to assess environmental comfort and heat stress levels in both management systems.

Milk Sample Collection and Analysis

Milk samples were collected aseptically during routine milking hours from selected cows in both systems. The samples were analyzed for milk fat and solids-not-fat (SNF) content using standard milk testing equipment and methods (BIS, 2001).

RESULTS AND DISCUSSION

Haematological Parameters

The haematological profile of dairy cows maintained under intensive and semi-intensive management systems in Kallakurichi District is presented in Table X. The evaluated parameters, including haemoglobin (Hb), packed cell volume (PCV), red blood cell (RBC) count, white blood cell (WBC) count, platelet count, and differential leukocyte count (neutrophils, lymphocytes, monocytes, eosinophils, and basophils), were found to be within the established physiological reference ranges in both systems (Table 1).

Statistical analysis revealed no significant differences ($p > 0.05$) between intensive and semi-intensive dairy farming systems for any of the haematological parameters. This indicates that both management

systems were adequate in maintaining normal hematopoietic and immune status of dairy cows. The absence of haematological alterations further suggests that neither system imposed severe physiological stress capable of disrupting blood homeostasis.

Table 1
Haematological Parameters

S.No	Haematological Parameters	Semi Intensive	Intensive
1	Haemoglobin (Hb) (g/dL)	8.7 ± 0.17	7.9 ± 0.14
2	Packed cell volume (PCV) %	23.6 ± 1.01	21.9 ± 1.03
3	Red blood cell (RBC) (×10⁶/μL)	4.2 ± 0.08	4.5 ± 0.05
4	White blood cell (WBC) (×10³/μL)	8.2 ± 0.02	7.4 ± 0.01
5	Platelet (10³/μL)	301 ± 1.4	304 ± 1.8
6	Neutrophils (%)	5.93 ± 0.6	5.7 ± 0.6
7	Lymphocytes (%)	92.4 ± 2.28	92.1 ± 1.8
8	Monocytes (%)	0.48 ± 0.16	1.7 ± 0.18
9	Eosinophils (%)	0.16 ± 0.01	0.19 ± 0.02
10	Basophils (%)	0.31 ± 0.01	0.17 ± 0.01

Haematological blood tests are primarily aimed to monitor the health status and to detect possible diseases (Brucka-Jastrzębska et al. 2007). Parameters can be used to evaluate animal stress and welfare levels (Anderson et al. 1999). Most of the mean values of the biochemical parameters fell within the range of reference values (Winnicka 2008). This study no statistically significant differences in blood glucose and total protein contents were found in the cows, which is supported by Brzóska (2005). Kumar *et al.*, (2025) Pasture management has a positive effect on the basic haematological parameters, and thus on the welfare of dairy cows. Where cows cannot use pastures, it is advisable to provide them with access to outdoor runs

Serum Biochemical Parameters

The serum biochemical parameters including total protein, albumin, globulin, aspartate aminotransferase (AST), alkaline phosphatase (ALP), blood urea nitrogen (BUN), creatinine, calcium, phosphorus, magnesium, and glucose are summarized in Table 2. All measured parameters were observed to fall within normal physiological limits, with no statistically significant differences ($p > 0.05$) between intensive and semi-intensive systems (Table 2).

These findings suggest that nutrient intake, metabolic activity, liver and kidney functions, and mineral balance were adequately maintained under both management systems. The similarity in biochemical

profiles reflects comparable feeding practices and overall metabolic health of dairy cows in the two systems.

Table 2
Serum Biochemical Parameters

S.No	Serum Biochemical Parameters	Semi Intensive	Intensive
1	Total Protein (g/dL)	7.4 ± 0.32	7.06 ± 0.36
2	Albumin (g/dL)	3.4 ± 0.08	3.4 ± 0.21
3	Globulin (g/dL)	3.9 ± 0.21	3.7 ± 0.15
4	AST (U/L)	89.9 ± 0.12	86.1 ± 0.19
5	ALP (U/L)	64.2 ± 0.32	68.1 ± 0.21
6	BUN (mg/dL)	11.81 ± 0.16	10.33 ± 0.12
7	Creatinine (mg/dL)	0.95 ± 0.01	0.84 ± 0.01
8	Calcium (mg/dL)	14.23 ± 1.15	14.27 ± 1.02
9	Phosphorus (mg/dL)	6.4 ± 0.23	6.07 ± 0.21
10	Magnesium (mg/dL)	5.65 ± 1.37	5.72 ± 1.33
11	Glucose (mg/dL)	31.52 ± 0.37	32.52 ± 0.35

Kumar *et al.*, (2025) said biochemical tests showed slightly higher serum concentrations of urea and AST and ALT enzymes in the pastured compared to the other cows. The pastured group was characterized by the lowest plasma cholesterol concentration. Satyendra KM *et al.*, (2016) The blood biochemical profiles along with traditional methods like body weights and BCS can be used for assessment of nutritional status

Hormonal Profile and Stress Indicators

The hormonal analysis revealed that serum concentrations of triiodothyronine (T3), thyroxine (T4), and thyroid-stimulating hormone (TSH) did not differ significantly ($p > 0.05$) between intensive and semi-intensive systems, indicating normal thyroid function and metabolic regulation across both systems. However, serum cortisol levels showed a statistically significant difference ($p < 0.05$) between the two management systems (Table 3). Dairy cows reared under the intensive system exhibited higher cortisol concentrations compared to those maintained under the semi-intensive system. Cortisol is a well-recognized biomarker of physiological stress, and its elevated level in intensively managed cows may be attributed to restricted movement, limited expression of natural behaviour, and higher management-related stressors.

Table 3
Dairy Cattle stress hormone profile

S.No	Hormonal Profile	Semi Intensive	Intensive
1	T3 (ng/ml)	1.19 ± 0.02	1.45 ± 0.02
2	T4 (ug/dl)	5.75 ± 0.08	5.57 ± 0.06
3	TSH (µIU/ml)	< 0.005	< 0.005
4	**Cortisol (ug/dl)**	**0.29 ± 0.01**	**0.56 ± 0.01**

These finding highlights that, although general health parameters remained normal, intensive dairy farming may impose comparatively higher stress on animals than semi-intensive systems.

Studies have consistently reported that serum T3, T4, and TSH concentrations are relatively insensitive to changes in housing systems when nutritional adequacy and thermal comfort are maintained. For instance, Sejian et al. (2013) observed no significant differences in thyroid hormone profiles of dairy cattle maintained under different management and environmental conditions, concluding that thyroid hormones primarily reflect metabolic adaptation rather than short-term management stress. serum cortisol has been widely used as a sensitive indicator of management-related stress in dairy cattle. Rushen et al. (2001) and Broom (2011) demonstrated that intensively managed cows often exhibit elevated cortisol levels due to factors such as restricted locomotion, higher stocking density, increased human–animal interactions, and limited opportunity for natural behaviours. Von Keyserlingk et al. (2009) further emphasized that confinement systems can increase hypothalamic–pituitary–adrenal (HPA) axis activity, resulting in higher circulating cortisol concentrations.

Temperature–Humidity Index (THI)

The Temperature–Humidity Index (THI) values recorded in the present study ranged from 65 to 72 under both intensive and semi-intensive dairy cattle management systems. Statistical analysis revealed no significant difference ($p > 0.05$) in THI values between the two systems, indicating uniform microclimatic conditions across the study area. The observed THI range falls within the thermoneutral or comfort zone for dairy cattle, suggesting that animals were not exposed to heat stress during the experimental period.

Armstrong (1994), THI values below 72 are considered non-stressful for dairy cattle, whereas values exceeding this threshold may adversely affect physiological functions, feed intake, milk yield, and reproductive efficiency. The THI values recorded in the present study being consistently below this critical limit clearly indicate that thermal stress was minimal or absent in both management systems.

The absence of significant variation in THI between intensive and semi-intensive systems implies that environmental factors were well managed, possibly through adequate housing design, ventilation, and farm location. Similar findings were reported by West (2003), who emphasized that when THI remains within the comfort range, dairy cows are able to maintain normal physiological and metabolic functions irrespective of housing systems.

The favourable THI conditions likely contributed to the normal haematological, biochemical, hormonal, and productive parameters observed in the present study. Environmental comfort reduces the activation of thermoregulatory and stress-related mechanisms, thereby preventing alterations in blood metabolites and endocrine responses. This supports the findings of von Keyserlingk et al. (2009), who reported that well-regulated environmental conditions help sustain animal welfare and productivity even under intensive management systems.

Overall, the results suggest that THI did not act as a confounding stressor in the present investigation. Consequently, the observed differences in cortisol levels between intensive and semi-intensive systems can be attributed primarily to management-related factors rather than climatic stress. These findings highlight the importance of maintaining optimal microclimatic conditions to safeguard dairy cattle welfare under different farming systems.

Milk Quality Parameters

Milk quality analysis revealed that fat and solids-not-fat (SNF) percentages did not differ significantly ($p > 0.05$) between dairy cows reared under intensive and semi-intensive management systems. The absence of statistical variation indicates that the type of management system alone did not exert a measurable influence on milk composition in the present study. Both systems were capable of maintaining milk fat and SNF levels within acceptable and normal ranges (Table 4).

The observed uniformity in milk composition can be attributed to adequate and balanced feeding practices, effective health management, and consistent milking routines adopted across both systems. Milk fat and SNF are primarily influenced by nutritional status, energy balance, rumen function, and genetic potential, rather than housing system per se. When these factors are well regulated, differences in management intensity may not translate into measurable changes in milk constituents.

Similar findings have been reported by Walstra et al. (2006), who emphasized that milk composition remains relatively stable across production systems when cows receive nutritionally balanced rations. Likewise, Sutton (1989) demonstrated that milk fat and SNF are more responsive to dietary composition and rumen fermentation patterns than to housing or management systems.

Studies comparing confined and semi-grazing dairy systems have also shown non-significant differences in fat and SNF content, provided that energy and protein requirements are adequately met. Palmquist and Jenkins (1980) reported that dietary lipid and fibre balance play a dominant role in regulating milk fat synthesis, overshadowing the influence of management systems.

The present findings further suggest that both intensive and semi-intensive systems are equally capable of producing milk of acceptable quality, reinforcing the view that good nutritional and health management practices are more critical determinants of milk quality than the production system itself. These results are consistent with earlier reports indicating that improvements in feeding strategies and herd health can effectively offset potential management-related differences in milk composition.

Overall, the lack of significant variation in milk fat and SNF between systems highlights the importance of focusing on ration formulation, feeding consistency, and disease control to sustain milk quality, irrespective of the dairy farming system adopted.

Table 4
Milk Quality Parameters

S.No	Parameters	Semi Intensive	Intensive
1	Fat (%)	5.03 ± 0.12	4.98 ± 0.24
2	SNF(%)	7.93 ± 0.06	7.88 ± 0.06

Health and Disease Incidence

The incidence of major health disorders, namely mastitis, milk fever, ketosis, hoof problems, and abortions, did not differ significantly ($p > 0.05$) between intensive and semi-intensive dairy farming systems. This finding indicates that disease prevention, veterinary care, and general health management practices were comparably effective in both systems (Table 5). The absence of significant variation suggests that when routine health monitoring, timely treatment, and adequate nutrition are ensured, the overall burden of common production-related diseases remains similar across management systems.

Mastitis, which is strongly influenced by milking hygiene, housing sanitation, and udder health management, showed no significant difference between systems, implying that milking practices and hygiene standards were adequately maintained in both intensive and semi-intensive farms. Comparable findings were reported by Bradley (2002), who emphasized that mastitis prevalence is more closely related to hygiene and management protocols than housing type alone. Likewise, the non-significant variation in metabolic disorders such as milk fever and ketosis suggests effective mineral supplementation and energy balance across both systems, in agreement with earlier reports by Goff (2008).

In contrast, acidosis showed a significantly higher incidence ($p < 0.05$) in the semi-intensive dairy farming system compared to the intensive system. This finding highlight acidosis as a key management-sensitive disorder in semi-intensive production systems. The increased prevalence of acidosis may be attributed to irregular feeding schedules, abrupt dietary transitions between grazing and stall-feeding, and imbalanced concentrate-to-roughage ratios, which can disrupt rumen fermentation dynamics. Sudden increases in fermentable carbohydrates without adequate effective fibre are well known to predispose dairy cows to subacute ruminal acidosis (SARA).

These observations are consistent with the findings of Plaizier et al. (2008), who reported that inconsistent feeding management and dietary variability significantly increase the risk of ruminal acidosis, particularly in systems combining grazing with concentrate supplementation. Similarly, Kleen et al. (2003) emphasized that cows exposed to frequent diet changes are more susceptible to ruminal pH fluctuations, leading to higher acidosis incidence.

The comparatively lower occurrence of acidosis in intensive systems may be due to better-controlled feeding regimes, consistent total mixed ration (TMR) feeding, and reduced dietary variability, which help maintain stable rumen pH. These findings underline the importance of nutritional consistency and ration balancing, particularly in semi-intensive systems where grazing patterns and concentrate supplementation may vary daily.

Overall, the results suggest that while general health status and disease control are comparable across intensive and semi-intensive dairy systems, nutritional management plays a decisive role in the occurrence of acidosis. Targeted interventions such as gradual diet transitions, adequate effective fibre inclusion, and improved feeding regularity are essential to minimize acidosis risk and enhance overall dairy cow welfare in semi-intensive farming systems.

Table 5
Health measures

S.No	Disease	Semi Intensive	Intensive	p-value
1	Mastitis	29/200 (14.5%)	38/200(19%)	ns
2	Milk Fever	15/200 (7.5%)	23/200(11.5%)	ns
3	Ketosis	9/200(4.5%)	14/200(7.0%)	ns
4	Hoof problems	18/200(9.0%)	27/200(13.5%)	ns
5	Acidosis	13/200(6.5%)	29/200(14.5%)	0.009
6	Abortions	11/200(5.5%)	14/200(7.0%)	ns

Abbreviation: Ns, not significant (p ≥.05).

Kumar *et al.*, (2025) Mastitis Incidence and abnormal behaviours were more pronounced in medium farms, suggesting challenges in hygiene management and potential behavioural stress due to stocking density or handling practices.

Overall Welfare Implications

The overall findings of the study suggest that both intensive and semi-intensive dairy cattle management systems in the study area are capable of maintaining acceptable welfare standards in terms of physiological health, metabolic stability, environmental comfort, and milk quality. Nevertheless, the elevated cortisol levels in intensively managed cows point toward higher stress exposure, while the increased incidence of acidosis in semi-intensive systems indicates the need for improved nutritional management.

CONCLUSION

The present study provides a comprehensive assessment of dairy cattle welfare under intensive and semi-intensive management systems in the Kallakurichi district of Tamil Nadu. Overall, the findings

indicate that both systems were largely comparable with respect to key physiological, biochemical, environmental, productive, and health-related welfare indicators.

Hematological parameters, including hemoglobin concentration, packed cell volume, erythrocyte and leukocyte indices, and differential leukocyte counts, remained within normal physiological limits in both management systems, with no statistically significant differences. Similarly, serum biochemical parameters and thyroid hormone profiles reflected a stable metabolic and endocrine status of the animals, suggesting that nutritional and general management practices in both systems were adequate to maintain normal homeostasis.

Cortisol levels, however, differed significantly between systems, with higher concentrations observed in intensively managed cows, indicating a relatively higher physiological stress load under intensive dairy farming conditions. Despite this, the temperature–humidity index values recorded in both systems fell within the optimal comfort range, demonstrating that climatic stress was minimal and well managed across the study area.

Milk quality parameters, namely fat and solids-not-fat content, did not differ significantly between systems, indicating that management intensity did not adversely influence milk composition. Likewise, the incidence of major production-limiting health disorders such as mastitis, milk fever, ketosis, hoof problems, and abortions showed no significant variation between intensive and semi-intensive systems. An exception was acidosis, which was significantly more prevalent in the semi-intensive system, highlighting the need for improved feeding management and ration balancing in this system.

In conclusion, both intensive and semi-intensive dairy farming systems in Kallakurichi district were generally effective in maintaining acceptable levels of dairy cattle welfare. Nevertheless, the elevated cortisol levels in intensive systems and the higher incidence of acidosis in semi-intensive systems underscore the importance of system-specific management interventions. Adoption of stress-reducing practices in intensive farms and improved nutritional strategies in semi-intensive farms would further enhance animal welfare, productivity, and sustainability of dairy farming in the region.

Declarations

Competing Interest declaration: No

Data Availability declaration: Not applicable

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