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Comparative assessment of dairy cattle welfare practices on small and medium-sized commercial dairy farms in Uttar Pradesh

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Abstract

Animal welfare is a key determinant of dairy farm sustainability, productivity, and profitability. The present study was conducted to assess and compare dairy cattle welfare practices on small- and medium-sized commercial dairy farms in Uttar Pradesh and to identify the major factors influencing welfare status. A total of 40 commercial dairy farms rearing crossbred cattle were selected and categorized into small (10–20 adult cattle) and medium (21–50 adult cattle) farms based on herd size. Data were collected using a pre-tested interview schedule, and welfare assessment was carried out using the Dairy Cattle Welfare Scale (DCWS), which comprised three major components covering housing and management practices, resource provision, and animal-based welfare indicators. Principal Component Analysis (PCA) was also performed to identify the key dimensions contributing to welfare variation among farms. The mean welfare scores for Components A, B, and C were 14.65 ± 0.70 , 20.40 ± 0.49 , and 23.85 ± 0.67 , respectively, for small farms, compared with 15.70 ± 0.69 , 21.40 ± 0.71 , and 23.95 ± 0.70 for medium farms. Small farms performed better in terms of housing system and floor space availability, body condition score, cow comfort index, human–animal relationship, and abnormal behaviour indicators. In contrast, medium farms achieved higher scores for roof design, floor type, microclimate protection, feeding and watering space, availability of separate milking areas, average productivity, cow cleanliness, hock injury, lameness, and mastitis incidence. Despite these differences, cow cleanliness and abnormal behaviour were identified as the poorest-performing welfare indicators across both farm categories. The overall welfare scores (out of 100) were 58.67 ± 1.19 for small farms and 61.30 ± 1.62 for medium farms, with an overall mean score of 59.98 ± 1.31 , indicating comparatively better welfare standards on medium-sized farms. Overall, 52.50% of the surveyed farms were classified under the good welfare category, while 47.50% fell under the average welfare category, suggesting that just over half of the farms maintained acceptable welfare standards. PCA identified seven principal components explaining 73.98% of the total variance, highlighting the multifactorial nature of dairy cattle welfare. The findings emphasize the need for targeted improvements in hygiene, behavioural management, and housing practices to enhance animal welfare, particularly on small dairy farms.

Keywords: Dairy cattle welfare, Dairy Cattle Welfare Scale (DCWS), commercial dairy farms, small dairy farms, medium dairy farms, crossbred cattle, animal welfare assessment, housing management, welfare indicators, Principal Component Analysis (PCA), Uttar Pradesh

1. Introduction

The livestock sector plays a significant role in the Indian economy by contributing to agricultural growth, rural employment, and nutritional security. According to the *Basic Animal Husbandry Statistics* (2022), the livestock sector contributed 6.17% to the Gross Value Added (GVA) of the national economy and 30.87% of the total value of agricultural output. India possesses the world's largest cattle population, with 192.49 million cattle, including 50.42 million crossbred cattle, as reported in the 20th Livestock Census (2019) ^[1]. The increasing adoption of crossbred cattle and the commercialization of dairy farming have substantially improved milk production but have also intensified concerns regarding animal welfare. It has become an important component of sustainable dairy farming because it directly influences animal health, productivity, reproduction, and product quality (Fraser, 2008) ^[12]. The World Organisation for Animal Health

(WOAH, formerly OIE) defines good animal welfare as a state in which an animal is healthy, comfortable, well nourished, safe, able to express its natural behaviour, and free from pain, fear, and distress. The concept of the Five Freedoms, proposed by the Farm Animal Welfare Council (FAWC, 1993) ^[10], remains the foundation for welfare assessment in farm animals. These freedoms include freedom from hunger and thirst, discomfort, pain, injury and disease, fear and distress, and the freedom to express normal behaviour.

Poor housing, inadequate feeding, improper flooring, poor hygiene, and limited veterinary care adversely affect dairy cattle welfare, leading to reduced milk yield, impaired reproduction, increased disease incidence, and economic losses (Whay *et al.*, 2003) ^[47]. Conversely, improved welfare practices enhance productivity, longevity, and milk quality while reducing production costs. Consumer awareness regarding the ethical treatment of farm animals

has also increased considerably, making animal welfare an important component of quality assurance in dairy production (Hristov *et al.*, 2012) ^[22].

India's dairy production systems range from traditional smallholder farms to organized commercial enterprises, resulting in considerable variation in housing, management, and welfare standards. Uttar Pradesh is the leading milk-producing state in India and contributes nearly 16% of the country's total milk production. However, information on dairy cattle welfare under commercial farming conditions in the state is limited. Therefore, the present study was undertaken to assess and compare dairy cattle welfare practices between small- and medium-sized commercial dairy farms in Uttar Pradesh and to develop suitable recommendations for improving animal welfare and sustainable dairy production.

Materials and Methods

Location of the study

A total of 40 dairy farms were selected for the study. These 40 dairy farms were grouped into two categories small (10-19 animals), medium (20-49 animals), 20 dairy farms in each group. All of these selected farms were maintaining crossbred dairy cattle only.

Table 1: List of selected district and blocks

District	Block
Firozabad	Shikohabad, Jasarana, Tundla, Eka, Fariha, Sirsaganj
Etah	Etah, Basundhara
Etawah	Etawah, Jasawantnagar
Auraiya	Ajitmal, Achalda, Phaphund

Data Collection

Data for the study were collected from both primary and secondary sources. *Primary data* were collected from 40 commercial dairy farms during April 2023 to December 2023 through personal interviews, farm records, and direct observations using a pre-tested interview schedule. Information on farm characteristics, housing, feeding, watering, milking facilities, and management practices was recorded. Animal-based welfare indicators, including body condition score (BCS), milk yield, cow cleanliness, lameness, hock injuries, cow comfort, human-animal relationship, and abnormal behaviour, were assessed through on-farm observations. Additional visits were made whenever required to verify the collected information.

Secondary Data

Secondary data were obtained from the Department of Animal Husbandry and Dairying, Uttar Pradesh Dairy Development Board, State Animal Husbandry Department, Basic Animal Husbandry Statistics, 20th Livestock Census, and other government publications. These sources provided information on livestock population, milk production, dairy development, and the geographical and agro-climatic profile of Uttar Pradesh.

Assessment of Dairy Cattle Welfare

The level of dairy cattle welfare was assessed using the Dairy Cattle Welfare Scale (DCWS) developed by Kumar and Kamboj (2016) ^[30], which was adapted from the Integrated Diagnostic System Welfare (IDSW) proposed by Calamari and Bertoni (2009) ^[5].

Dairy Cattle Welfare Scale (DCWS)

The DCWS comprises 20 welfare indicators selected based on the Four Principles of animal welfare to ensure compliance with the Five Freedoms. Of these, 10 indicators are resource- and environment-based (Components A and B), while 10 indicators are animal-based (Component C). Each indicator consists of predefined welfare patterns assigned scores according to scientific recommendations and prevailing farm conditions. The cumulative score of all indicators provides the overall welfare score of a farm. The indicators are grouped into three components:

- **Component A:** Animal housing and other facilities (Weightage: 30)
- **Component B:** Feed and feeding practices (Weightage: 30)
- **Component C:** Animal health, performance, and behaviour (Weightage: 40)

Statistical Analysis

The collected data were compiled, classified, and analyzed using descriptive and multivariate statistical methods. Percentages, means, standard deviation, standard error, scores, and rankings were calculated using Microsoft Excel (2018).

Principal Component Analysis (PCA) was performed using IBM SPSS Statistics Version 21.0. Monte Carlo Parallel Analysis was used to determine the number of components, and biplots were generated using R software (R Core Team, 2021) ^[34].

Principal Component Analysis (PCA) was applied to identify the major factors influencing dairy cattle welfare and to study the relationships among the 20 welfare indicators of the Dairy Cattle Welfare Scale (DCWS). Factors with eigenvalues greater than one were retained using Kaiser's criterion ^[26-27] and Varimax rotation was applied for better interpretation. The adequacy of data for PCA was evaluated using the Kaiser-Meyer-Olkin (KMO) ^[26] test and Bartlett's ^[3] test of sphericity.

Results and Discussion

Component A: Animal housing and other facilities

Component A of the Dairy Cattle Welfare Score (DCWS) evaluated housing and management conditions using six indicators: housing system and floor space, roof type and height, floor type, microclimate protection, feeding and watering facilities, and milking and hygiene infrastructure. The overall mean welfare score was 15.17 ± 0.52 out of 30, with medium dairy farms (15.70 ± 0.69) scoring slightly higher than small farms (14.65 ± 0.70), although the difference was not statistically significant.

The mean score for housing system and floor space was 5.50 ± 0.20 out of 10. Lower scores in medium farms were mainly associated with tie-stall housing, overcrowding, limited floor space, and restricted animal movement. Zero-grazing was practiced on all farms despite the recognized welfare benefits of pasture access (Winckler, 2014) ^[48]. Inadequate floor space restricts normal behavioural expression and compromises animal comfort (Hristov *et al.*, 2012) ^[22].

The mean score for roof type and height was 2.20 ± 0.10 , with medium farms performing better because of improved roof design and ventilation. The floor type indicator recorded a mean score of 1.12 ± 0.07 , reflecting the

widespread use of concrete and brick flooring with poor drainage. Such flooring increases the risk of lameness and reduces cow comfort (Webster, 2011) ^[45]. Similarly, wet or poorly bedded resting areas decrease lying time and increase stress (Fregonesi *et al.*, 2007) ^[15], whereas rubber flooring improves locomotion and reduces lameness (Flower *et al.*, 2007) ^[11].

The mean welfare score for microclimate protection was 2.15 ± 0.25 , with medium farms providing better cooling facilities such as fans and sprinklers. Effective thermal management is essential for maintaining productivity and animal welfare under heat stress (Silanikove, 2000) ^[41]. Feeding and watering facilities scored 2.80 ± 0.10 , although many mangers did not meet Bureau of Indian Standards recommendations. Adequate feeding space and proper feed

barrier design reduce competition and improve feeding behaviour (Abeni & Bertoni, 2009) ^[2], while balanced diets are fundamental for maintaining health and welfare (Webster, 2011) ^[45].

Milking and hygiene infrastructure recorded the lowest mean score (1.40 ± 0.20), particularly in small dairy farms due to the absence of separate milking parlours, inadequate lighting, and poor sanitation. Medium farms showed comparatively better hygiene management, in agreement with Kamboj and Kumar (2016) ^[28]. Overall, the findings highlight the need to improve housing design, flooring, environmental modification, feeding infrastructure, and hygienic milking practices to enhance dairy cattle welfare, health, and productivity under field conditions.

Table 2: Mean welfare scores of 'housing and other facilities' component in small, medium dairy farms

Indicator	Max. score	Mean $\pm$ SE of welfare scores		Overall
		Small farms	Medium farms	
System of housing & availability of floor space	10	5.70 $\pm$ 0.30	5.30 $\pm$ 0.26	5.50 $\pm$ 0.20
Type and height of roof	3	2.10 $\pm$ 0.12	2.30 $\pm$ 0.13	2.20 $\pm$ 0.10
Type of floor	2	1.05 $\pm$ 0.09	1.20 $\pm$ 0.09	1.12 $\pm$ 0.07
Microclimate protection measures inside animal houses & other practices for protection against heat and cold stress	5	1.90 $\pm$ 0.23	2.40 $\pm$ 0.26	2.15 $\pm$ 0.25
Feeding & watering space availability, feeding & watering systems with frequency	5	2.70 $\pm$ 0.22	2.90 $\pm$ 0.18	2.80 $\pm$ 0.10
Availability of milking parlour / separate milking place, water for bathing cows, udder washing, cleaning of milking utensils and availability of lighting	5	1.20 $\pm$ 0.14	1.60 $\pm$ 0.21	1.40 $\pm$ 0.20
Total score	30	14.65 $\pm$ 0.70	15.70 $\pm$ 0.69	15.17 $\pm$ 0.52

Component B of the Dairy Cattle Welfare Score (DCWS)

Component B of the Dairy Cattle Welfare Score (DCWS) assessed feeding and nutritional management using four indicators: availability of quality feeds and fodder, feeding practices, feed and fodder storage facilities, and colostrum and milk feeding to calves. The overall mean welfare score was 20.90 ± 0.50 out of 30, indicating satisfactory feeding management. Medium dairy farms (21.40 ± 0.71) scored slightly higher than small farms (20.40 ± 0.49), although the difference was not statistically significant. Improved feeding management has been consistently associated with enhanced animal welfare and productivity (Rushen *et al.*, 2008) ^[39].

The mean score for availability of quality feeds and fodder was 7.25 ± 0.15 out of 10, with medium farms performing marginally better because of greater availability of green fodder, dry fodder, concentrates, silage, and mineral supplements. Similar findings were reported by Kamboj and Kumar (2016). Adequate and balanced feed resources are essential for maintaining health, immunity, milk production, and overall welfare (Fraser, 2008; Webster, 2005) ^[44].

The overall welfare score for feeding practices was 6.80 ± 0.10 out of 10, with medium farms adopting improved feeding strategies such as total mixed ration (TMR), balanced concentrate supplementation, and ad libitum feeding of green and dry fodder. Most farmers followed feeding recommendations of veterinary universities, dairy development organizations, and milk cooperatives. Appropriate feeding frequency, balanced nutrient supply, and maintenance of rumen health are key determinants of dairy cattle welfare and productivity (Grant & Albright, 2001; National Research Council, 2001) ^[18, 32].

Feed and fodder storage facilities recorded a mean score of

3.05 ± 0.05 out of 5, with no significant difference between farm categories. Most farms maintained adequate storage facilities, ensuring year-round feed availability while minimizing nutrient losses and fungal contamination

The mean welfare score for colostrum and milk feeding to calves was 3.77 ± 0.17 out of 5. Most farmers provided colostrum within 2–4 hours after birth for 4–5 days, promoting passive immunity and improving calf survival and long-term productivity (Vasseur *et al.*, 2009; Godden, 2008) ^[42, 17].

Overall, feeding and nutritional management was satisfactory in both farm categories, with medium dairy farms showing relatively better performance. Adequate nutrition, balanced feeding practices, proper feed storage, and timely colostrum management collectively improve dairy cattle welfare, health, and productivity (National Research Council, 2001; Fraser, 2008) ^[32, 12].

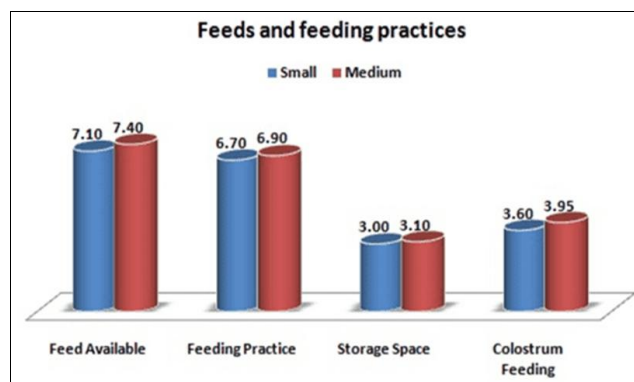


Fig 1: Mean welfare scores of feeds and feeding practices component in small, medium dairy farm

Component C: Animal health, performance, and behaviour

The mean welfare score for average productivity was 4.42 ± 0.22 out of a maximum score of 8, with medium dairy farms recording slightly higher scores than small farms. This finding suggests comparatively better productive performance in medium farms, which may be attributed to improved genetics and management practices. However, milk yield alone cannot be considered a reliable indicator of animal welfare because high productivity may coexist with increased health disorders and welfare challenges (Whay *et al.*, 2003; Kelm *et al.*, 2000; Fraser *et al.*, 2013) [47, 29, 14]. The overall mean welfare score for body condition score (BCS) was 2.27 ± 0.12 , with small farms showing relatively better body condition, possibly due to unrestricted availability of fodder and lower production stress. Previous studies have emphasized that body condition reflects the nutritional and health status of dairy cattle and is closely associated with fertility and metabolic health (Johnson *et al.*, 2001; Gillund *et al.*, 2001) [24, 16].

The overall welfare scores for cow comfort index (CCI), cow cleanliness score (CCS), hock injury score (HIS), human–animal relationship (HAR), lameness score (LS), mastitis incidence (MI), reproductive efficiency, and abnormal behaviour were 2.90 ± 0.12 , 1.80 ± 0.10 , 2.27 ± 0.07 , 2.27 ± 0.07 , 3.55 ± 0.05 , 2.22 ± 0.07 , 1.47 ± 0.07 , and 0.80 ± 0.10 , respectively. Small farms exhibited better scores for cow comfort and human–animal relationship, reflecting greater opportunities for positive human interaction and longer resting periods (Hemsworth *et al.*, 2002; Haley *et al.*, 2007) [20, 19]. Medium farms recorded comparatively higher scores for hock injury and productivity, while no significant differences were observed between farm categories for lameness, mastitis incidence, reproductive efficiency, or abnormal behaviour. The prevalence of these welfare issues was influenced by housing conditions, flooring, hygiene, nutrition, and overall management practices, which are recognized determinants of dairy cattle welfare (Cook, 2003; Rushen *et al.*, 2008; Contreras and Rodríguez, 2011) [8, 39, 7].

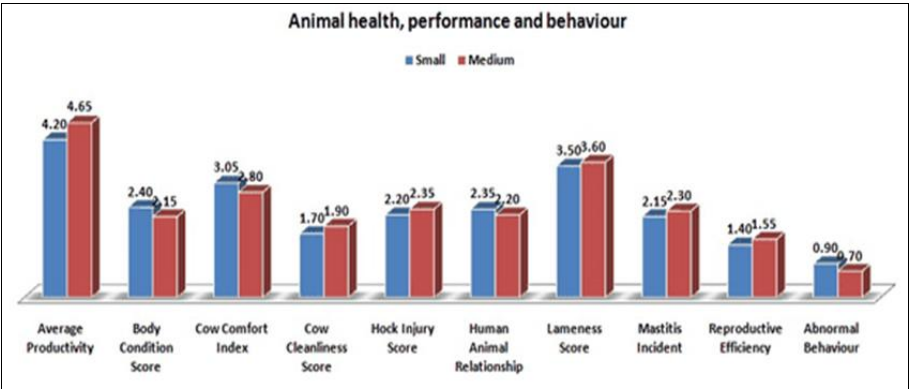


Fig 2: Mean welfare score of Component C ‘animal health and physiology’ components in small & medium dairy farms

Overall assessment of dairy cattle welfare

The overall welfare status of dairy cattle was assessed using the Dairy Cattle Welfare Score (DCWS) comprising housing and other facilities, feeds and feeding practices, and animal health, physiology and behaviour. The overall mean welfare score was 59.98 ± 1.31 out of 100. Medium dairy farms recorded a slightly higher mean welfare score (61.30 ± 1.62) than small dairy farms (58.67 ± 1.19), although the difference was not statistically significant. Among the three components, animal health, physiology and behaviour achieved the highest score, whereas housing and other facilities recorded the lowest score. The findings indicate a moderate level of dairy cattle welfare, with scope for

improvement, particularly in housing management. Robbins *et al.* (2016) [36] reported that larger dairy farms generally provide more specialized and professional management of animal health. Such farms are more likely to adopt science-based standard operating procedures, provide employee training, utilize technologies for animal monitoring, and invest in welfare-improving measures (Robbins *et al.*, 2015[15]). The commonly held assumption that smaller and more traditional farms inherently ensure better animal welfare is not supported by evidence. Instead, effective management practices, rather than farm size alone, play a crucial role in determining animal welfare standards.

Table 3: Mean welfare score of different components of DCWS in small, medium dairy farms

Indicator	Max. score	Mean ± SE of welfare scores		Overall
		Small farms	Medium farms	
Component ‘A’ ‘Housing and other facilities’	30	14.65±0.70	15.70±0.69	15.17±0.52
Component ‘B’ ‘Feeds and feeding practices’	30	20.40±0.49	21.40±0.71	20.90±0.50
Component ‘C’ ‘Animal health, physiology and behaviour’	40	23.85±0.67	23.95±0.70	23.90±0.05
Total score	100	58.67±1.19	61.30±1.62	59.98±1.31

These results are in agreement with the findings of Kamboj and Kumar (2016) ^[28] who found better welfare score (68.1 ± 1.18) at large dairy farms of Haryana while for small and medium dairy farms it was 60.5 ± 2.74 and 59.35 ± 2.17 , respectively.

Overall ranking of dairy farms

The present study assessed the overall welfare status of dairy farms using the Dairy Cattle Welfare Score (DCWS) and categorized farms into different welfare classes based on their overall scores. The results revealed that 52.5% of the dairy farms were classified under the good (acceptable) welfare category, while the remaining 47.5% were placed in the average (unacceptable) category. None of the farms qualified for the excellent or poor welfare categories. Considering a welfare score of 60 or above as the acceptable threshold, just over half of the farms achieved an acceptable level of welfare, whereas nearly half required improvement. Among the farm categories, 55% of small dairy farms and 50% of medium dairy farms attained acceptable welfare scores, while the remaining farms were categorized as average. Although medium farms generally recorded slightly higher mean welfare scores, the overall distribution of welfare categories was comparable between small and medium dairy farms.

The findings indicate that dairy cattle welfare in the study area was generally moderate, with considerable scope for improvement in farm management and welfare practices. The observed trend was broadly consistent with the findings of Kumar (2016) ^[31], who reported that 54% of dairy farms in Haryana achieved acceptable welfare standards, although welfare levels varied according to farm size. Similar observations regarding the influence of management practices on dairy cattle welfare have also been reported by Whay *et al.* (2003) ^[47] and Rushen *et al.* (2008) ^[39]. However, the present findings differed from those reported by Popescu *et al.* (2010) ^[33] and Benatallah *et al.* (2015) ^[4], who observed a predominance of farms with unacceptable welfare conditions. Likewise, Coignard *et al.* (2013) ^[6] found that most French dairy herds belonged to the intermediate welfare category, whereas de Vries *et al.* (2013) ^[43] reported that the majority of Dutch dairy herds achieved acceptable or enhanced welfare standards. In contrast, Salas *et al.* (2017) ^[40] reported that all evaluated dairy production units in Mexico met the criteria for acceptable welfare. These comparisons suggest that dairy cattle welfare varies considerably across regions and production systems, emphasizing the importance of adopting improved housing, feeding, health care, and management practices to enhance animal welfare and farm productivity, as also emphasized by Fraser (2008) ^[12] and Webster (2005) ^[44].

Table 4: Overall welfare ranking of dairy farms

Indicator	Welfare score	Farm size		Total farms
		Small farms	Medium farms	
Excellent	>80	-	-	-
Good	60-80	11 (55%)	10 (50%)	21 (52.50%)
Average	40-59	9 (45%)	10 (50%)	19 (47.50%)
Poor	<40	-	-	-

*Figures in parenthesis indicate the percentage of total farms

Principal Component Analysis (PCA)

A total of 40 dairy farms were evaluated using 20 welfare indicators grouped under housing, feeding, health, behaviour, and management components. Welfare scores were analysed using descriptive statistics, independent *t*-test, correlation analysis, and Principal Component Analysis (PCA). Overall, 52.5% of the farms achieved acceptable welfare standards ($DCWS \geq 60$), while 47.5% fell under the average (unacceptable) category, indicating considerable scope for welfare improvement. Medium farms exhibited slightly higher mean welfare scores than small farms, although the differences were not statistically significant. PCA identified seven principal components with eigenvalues greater than one, explaining 73.98% of the total variance. The first principal component was mainly associated with housing conditions, cow comfort index, hock injury score, and abnormal behaviour, highlighting the importance of housing and health in determining overall welfare (Rushen *et al.*, 2008; Welfare Quality®, 2009) ^[39, 46]. Feeding practices, body condition score, mastitis incidence, human-animal relationship, lameness, and reproductive efficiency also contributed substantially to welfare variation. The findings demonstrate that PCA is an effective multivariate tool for identifying critical welfare determinants and prioritizing intervention strategies (Jolliffe, 2002) ^[25]. The study concludes that improving housing, feeding management, health care, and stockmanship can substantially enhance dairy cattle welfare and productivity. The developed DCWS provides a practical framework for routine welfare assessment and may support evidence-based decision-making for improving dairy farm management under Indian conditions

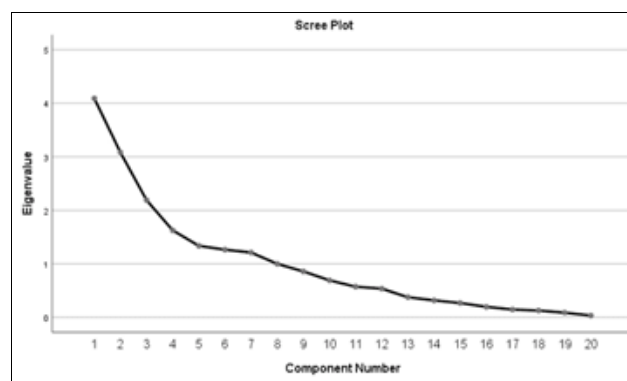


Fig 3: Scree plot showing component number with eigen values

Conclusion

The present study highlights that the welfare of dairy cattle can be substantially improved through better housing, nutrition, health care, reproductive management, and stockmanship practices. Adoption of loose housing systems with adequate floor space, non-slippery and well-drained flooring, effective microclimate protection, and dedicated hygienic milking areas would significantly enhance animal comfort and welfare. Maintaining optimal body condition, cleanliness, udder health, and reproductive efficiency through balanced nutrition, proper management, and timely veterinary care is essential for sustaining productivity. Furthermore, minimizing abnormal behaviours by providing comfortable housing, sufficient space, social interaction, and

low-stress handling practices will promote both animal well-being and farm profitability. Overall, implementation of these recommendations can improve Dairy Cattle Welfare Scores (DCWS), enhance milk production, reduce disease incidence, and support sustainable and welfare-oriented dairy farming.

Future Scope of Research

Future research should focus on assessing dairy cattle welfare across a larger number of farms and diverse production systems to improve the reliability and applicability of welfare assessment. Advanced technologies such as wearable sensors, imaging systems, and artificial intelligence may be integrated for continuous, real-time monitoring of animal health, behaviour, and environmental conditions. Further refinement and standardization of dairy cattle welfare assessment protocols are needed to ensure uniformity and wider adoption. Collaborative efforts among researchers, dairy farmers, veterinarians, and industry stakeholders will facilitate the development of practical, science-based welfare assessment tools for sustainable dairy production.

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