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Indigenous Indian Cattle and Buffalo Breeds as a Resource for Sustainable Hide Production*

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Abstract

India possesses the world’s largest livestock population, positioning the country as a major hub for hide and leather production and export, with shipments valued at about US$438.85 million in 2024. The sector is supported predominantly by Zebu (Bos indicus) cattle, over 50 recognized indigenous cattle breeds, around 20 buffalo breeds, and a substantial population of non-descript animals. Leather from Zebu cattle exhibit high tensile strength, greater grain crack strength, and superior ball bursting strength when processed into leather, indicating strong resistance to tearing and mechanical stress — desirable traits for heavy-duty leather applications. These enhanced strength properties reflect the denser collagen structure and higher hide thickness typical of Zebu cattle hides. Buffalo leather is characterized by exceptional thickness and strength but comparatively coarse grain, making it ideal for durable, heavy-use leather products rather than fine or fashion goods. Genetic diversity analyses using high-density SNP markers in breeds such as Sahiwal, Gir, Kankrej, and Ongole confirm that Indian cattle possess distinct genomic backgrounds with predominantly Bos indicus ancestry and low inter-breed variation compared to Bos taurus breeds, reflecting long-term adaptation to tropical environments. Studies of skin morphology show that Bos indicus cattle have higher sweat gland density and volume than Bos taurus, contributing to enhanced heat tolerance — an indirect indicator of skin physiology that may influence hide condition under thermal stress. Although indicine genomic

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studies have identified genes related to heat tolerance and skin biology, direct links with key leather quality traits are still scarce, underscoring the need for hidefocused genomic selection. Indigenous cattle and buffalo hide also face challenges such as uneven thickness, coarser grain, and sensitivity to poor preslaughter management, which reduce leather yield and quality. Despite these constraints, buffalo leather remains highly valued for heavy-duty applications due to its strength and durability. Breeds such as Murrah, Jaffarabadi, Surti, and Mehsana supply hides that perform well during chrome tanning, owing to their thickness and resistance to mechanical damage. Buffalo leather strengthens India’s position in durability-driven global markets, supported by the rich genetic diversity and adaptive skin traits of indigenous cattle and buffalo breeds. However, indiscriminate crossbreeding has diluted these advantages, and hide-focused phenotyping and genomic research remain limited. Integrating standardized hide evaluation with genomic selection and breed conservation is essential to improve leather quality and industry competitiveness. Indigenous cattle and buffalo breeds possess inherent genetic and skin structural traits that yield strong and durable leather. Targeted conservation, selective breeding, and genetic evaluation can enhance leather quality, reduce defects, and strengthen India’s position in global leather markets.

Key words: Hide quality, Leather, Buffalo, Indigenous Cattle, India

Introduction

India is home to the world’s largest livestock population and stands at the heart of an ever-growing livestock economy. This makes India a potential hub and one of the leading producer and exporter of hide or leather and the country exported raw hides and skins and leather to the tune of US$438.85 million during 2024, as per the United Nations COMTRADE database on international trade. India’s livestock sector forms a vital component of its agrarian economy and industrial value chains. As one of the leading exporters of hides, skins, and leather products, India benefits from a large population of indigenous cattle and buffaloes adapted to tropical and subtropical environments Despite the significant potential value of these raw materials, skins in India are predominantly treated as by-products, often subjected to minimal standards of initial processing and preservation. This lack of attention to quality at the outset adversely affects their suitability for leather

production. Additionally, periodic spikes in skin availability—particularly during certain religious festivals—further strain the limited processing infrastructure, resulting in bottlenecks that compromise both quality and resource utilization. Despite India's significant position in the global leather sector and its large livestock population, there remains a pronounced lack of in-depth, breed-specific research on the intrinsic quality of hides and skins from the country's diverse cattle and buffalo populations. Existing studies on raw material characteristics, preservation, and quality determinants are limited, even though hide and skin quality is a critical factor in determining the grade and economic value of finished leather products. Quality in hides and skins can be influenced by many variables including animal husbandry, breed traits, handling practices, post-slaughter procedures, and microbial activity during storage and transport, yet systematic investigations into these aspects—especially across different Indian breeds—are sparse. Furthermore, the country's unique socio-cultural landscape affects raw material flows; in regions where cattle slaughter is restricted for religious reasons, hides are often recovered from animals that have died of natural causes. Such skins are typically more susceptible to decay and lower quality

because of delays in recovery and processing. This mismatch between supply patterns and processing capabilities can cause significant waste and inefficiencies in the value chain. Addressing these gaps is essential to unlock the full potential of indigenous breeds for sustainable leather production.

Diversity of Indigenous Indian Cattle and Buffalo Breeds

Indian livestock populations are dominated by Bos indicus cattle and river buffaloes (Bubalus bubalis), both of which have evolved under prolonged environmental and nutritional stress. India houses mainly the Zebu or Bos indicus breeds of cattle and there are more than 50 recognised Indian breeds of cattle and 20 breeds of buffaloes along with huge population of non-descript cattle and buffaloes. This long-term adaptation has resulted in distinctive skin attributes, including enhanced dermal development, pigmentation, and thermoregulatory capacity. Buffalo breeds such as Murrah, Jaffarabadi, Surti, and Mehsana, along with cattle breeds like Sahiwal, Gir, Kankrej, Ongole, and Sindhi, form the backbone of India's hide supply. These breeds collectively represent a resilient and renewable resource base for leather manufacture.

Histological Characteristics of Indigenous Cattle and Buffalo Skin

Skin morphology studies consistently demonstrate that indigenous cattle and buffaloes possess a well-developed reticular layer, which constitutes the major portion of total skin thickness and plays a decisive role in leather strength. In indigenous cattle such as Sindhi, the reticular layer increases in thickness with age, reflecting progressive dermal maturation. Comparable trends are observed in Murrah and graded Murrah buffaloes, where the reticular layer accounts for nearly four-fifths of total skin thickness. Such structural dominance enhances tensile strength, tear resistance, and overall leather durability (Muralidharan & Ramesh, 2005). Regional variation within the hide is also pronounced. Areas such as the head, back, and ventral abdomen exhibit greater dermal thickness and collagen

compactness compared to the shoulder and thigh, indicating that selective utilization of hide regions can improve leather quality outcomes (Hossain et al., 2016).

Collagen Composition and Its Relevance to Leather Quality

Collagen content and organization are primary determinants of hide strength and leather performance. Indigenous buffalo skins exhibit higher collagen concentration and more compact fiber bundles than cattle skins, contributing to superior mechanical properties. Agerelated increases in collagen density further enhance hide robustness. Biochemical analyses reveal that buffalo collagen is predominantly type I collagen with high imino acid content, conferring greater thermal stability and resistance to processing stress. These attributes explain the preference for buffalo leather in heavy-duty applications such as sole leather, industrial belts, and upholstery (Rizk & Mostafa, 2016).

Genetic Basis of Hide and Skin Quality

Genomic studies provide emerging evidence that adaptation-driven selection in indigenous cattle has shaped skin integrity, pigmentation, and collagen metabolism. Genome-wide selection signatures identified in cattle from arid and semi-arid regions highlight genes associated with epidermal development, extracellular matrix organization, and dermal resilience. Selection in pathways regulating thermoregulation, skin barrier function, and wound healing indirectly contributes to improved hide uniformity and reduced surface defects (Kanaka et al., 2025). However, direct associations between specific genetic markers and leather quality traits remain limited, underscoring the need for hide-focused genomic research.

Species-Specific Hide Structure and Leather Applications

Comparative studies reveal clear structural differences between buffalo and cattle hides. Buffalo hides are characterized by lower hair pore density but larger pore size and greater inter-pore distance, resulting in thicker,

coarser-grained leather with exceptional strength. In contrast, cattle hides exhibit higher pore density and more uniform grain, making them suitable for upper leather and fine finished products. Quantitative surface morphology analysis has enabled objective classification of hides and supports more efficient grading and utilization strategies (Jawahar et al., 2016).

Influence of Sex, Age, and Body Region

Sex-based variation in skin structure is evident in indigenous cattle, with males generally exhibiting thicker epidermis, reticular layer, and total skin thickness than females. Higher collagen fiber density and glandular development in males contribute to superior hide robustness. Anatomical location also influences hide quality, with ventral abdominal regions showing greater collagen compactness and suitability for high-quality leather production (Hossain et al., 2016).

Pre- and Post-Slaughter Factors Affecting Hide Quality

Despite favorable genetic and structural traits, hide quality in India is often compromised by poor nutrition, parasitic infestation, branding, rough handling, and delayed recovery after death. Post-slaughter preservation plays a critical role; untreated buffalo hides stored under ambient conditions undergo rapid microbial proliferation, leading to collagen degradation, lipolysis, and structural failure within a few days. These changes severely reduce leather yield and quality, highlighting the importance of timely curing and scientific preservation methods (Shede et al., 2009).

Sustainability and Future Perspectives

Indigenous cattle and buffalo breeds offer inherent advantages for sustainable leather production due to their adaptive genetics, robust skin structure, and low input requirements. However, indiscriminate crossbreeding with Bos taurus has diluted adaptive skin traits in some populations. Future strategies should prioritize breed conservation, standardized hide phenotyping, biomechanical testing, and integration of genomic tools to

identify hide-specific quantitative trait loci. Aligning livestock breeding objectives with leather industry requirements can significantly enhance value addition, reduce waste, and strengthen India’s position in global leather markets.

Conclusion

Indigenous Indian cattle and buffalo breeds represent a valuable yet underutilized resource for sustainable hide and leather production. Their genetically determined skin thickness, collagen density, and structural resilience provide a strong foundation for producing durable leather. Bridging gaps in breed-specific research, preservation practices, and genomic selection will be critical for maximizing this potential and ensuring long-term sustainability of the leather value chain. Native buffaloes and cow breeds have innated genetic and skin structure advantages that produce robust and long-lasting leather. Selective breeding, conservation, and strategic genetic evaluation can improve leather quality, lower flaws, and boost India’s competitiveness in the international leather market.

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