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Proximate composition of bovine digital cushion

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Abstract
The digital cushion in cattle, comprised of fat and connective tissues, plays a critical role in supporting hoof integrity and mitigating lameness. However, little is known about its proximate composition in different age groups and its association with claw horn disruption lesions (CHDL). In this study, digital cushions were collected from cattle at a slaughter facility and categorised into four groups, *viz.* heifers, cows of first to third parities, cows beyond third parity, and cows with CHDL. Proximate composition analysis revealed significant variations in moisture content, total ash, protein, fibre, and fat among these groups. Heifers exhibited the highest protein content, possibly attributed to the prevalence of elastic fibres. In contrast, cows in their first to third parities displayed the highest fat content, indicating fat deposition with maturity. Animals suffering from CHDL had the lowest moisture and fat content in their digital cushions. These findings can contribute to our understanding of digital cushion health and its potential role in preventing CHDL, enhancing the welfare of cattle, and maintaining their productivity.

Keywords: Proximate composition, hoof, crossbred cattle, Kerala

1. Introduction
The digital cushion in cattle is a complex structure consisting of both fat and connective tissues situated beneath the distal phalanx. This cushion comprises three distinct fat pads: the axial, middle, and abaxial pads. The primary function of these pads is to absorb and reduce the impact forces experienced by the corium located beneath the fat pad (Iqbal *et al.*, 2016) [1]. Within the hoof capsule, structural support is provided by the solar corium, which is accompanied by loose connective tissue and digital cushions containing varying amounts of adipose tissue (Bergsten, 2003) [2]. These digital cushions exhibit complexity in terms of their thickness and size. They play a crucial role in dispersing the forces experienced within the hoof, and supporting a significant portion of the animal's weight (Räber *et al.*, 2004) [3]. As the animal moves, the initial ground contact and load on the hind foot occur at the proximal region of the heel and gradually shift forward toward the toe (Greenough *et al.*, 1981) [4]. During this process, the heel flattens upon loading, the claw walls expand laterally, and the digital cushion effectively absorbs a substantial portion of the pressure. Therefore, the digital cushion serves to diminish the level of compression experienced by the corium tissue responsible for generating the sole horn beneath the distal phalanx. Any deviations from the typical anatomical structure of this corium can lead to the development of claw horn disruption lesions (Lischer *et al.*, 2002; Raber *et al.*, 2004; Shearer *et al.*, 2015) [5, 3, 6]. Digital cushion thickness at the typical sole ulcer site beneath the distal phalanx has been shown to be a strong predictor of lameness and the claw horn disruption lesions (CHDL) of sole ulcers and white line disease (Bicalho *et al.*, 2009; Newsome *et al.*, 2017; Stambuk *et al.*, 2019) [7, 8, 9]. These claw horn disruption lesions are the most prevalent claw diseases associated with lameness and pain (Murray *et al.*, 1996; Oikonomou *et al.*, 2013) [10, 11].
Understanding the composition of the digital cushion is crucial for maintaining its structural integrity. Limited literature is available about the proximate composition of the bovine digital cushion. Consequently, this research aims to address this gap by estimating the proximate composition of the bovine digital cushion in various age groups of crossbred cattle from Kerala, along with a group affected by claw horn disruption lesions (CHDL).

2. Materials and Methods

The materials for the present study, the digital cushion was obtained from cattle bought for slaughter at the Meat Technology Unit, Mannuthy, Kerala Veterinary and Animal Sciences University. Before slaughter, all the animals underwent a comprehensive clinical examination of their feet. Those with a moderate to good body condition score (BCS) and healthy hooves were chosen and categorized into three groups, *viz.* heifers, cows of parity first to third, and cows with parity beyond third. Another group of animals was selected from crossbred cattle that had been culled due to a history of claw horn disruption lesions (CHDL). Following the completion of the slaughter procedure, the hooves were separated from the carcass by cutting at the carpal joint in forelimb and at the tarsal joint in hindlimb.

Proximate composition of digital cushion was estimated as per the procedure described below.

2.1 Moisture Content

A hot air oven was used to determine the moisture content of the samples. Samples weighing 2g each were processed according to ASTM D1576-90 and the average moisture content was determined using the formula:

Moisture content = W1 - W2 /W1 *100

W1 = Original mass of sample (g) and W2 = Oven dry mass of sample (g).

2.2 Crude Protein and Fat Content

Samples of the digital cushion were dried to constant mass at 90 to 95 °C for 24 h. Total nitrogen and fat content of the dry matter were determined using two samples for each analysis. Total nitrogen was measured by a micromethod (Conway, 1957) [12] and fat by 24 h petroleum-ether extraction in a Soxhlet apparatus (Montemurro and Stevenson, 1960) [13]. Protein content was calculated according to the Kjeldahl method.

2.3 Total Ash

Ash is the inorganic residue obtained after combustion of biomass and is an approximate measure of the mineral salts and inorganic matter in digital cushion. The ash content was calculated in relation to the dry weight of the original sample after overnight ignition of the sample at 575±25 ºC.

2.4 Crude Fibre

Crude fibre is considered as a mixture of largely undigestible substances of vegetable origin obtained as the residue of a precisely defined digestion procedure using acetic, nitric and trichloro-acetic acids (AACC, 2000) [14].

3. Results and Discussion

3.1 Proximate composition of digital cushion

3.1.1 Moisture content

The highest moisture content was found in the digital cushions of heifers (56.27 percent), followed by cows in their first to third parity (52.67 percent), and cows beyond three parities (48.56 percent). Animals suffering from CHDL exhibited the lowest moisture content (33.28 percent) (Table 1). Similarly, Bray *et al.* (1951) [15] reported that that the moisture content of connective tissue in cattle decreased as they aged.

Table 1: Proximate composition of digital cushion in different groups of animals under study

Particulars	Group I Heifers	Group II C1 to C3	Group III Above C3	Group IV CHDL group
Moisture (%)	56.27	52.67	48.56	33.28
Total ash (% Dry matter)	1.35	1.7	1.33	1.89
Crude protein (% Dry matter)	41.06	23.48	37.37	53.26
Crude fibre (% Dry matter)	0.31	1.13	0.43	1.18
Crude fat (% Dry matter)	40.78	68.32	53.71	21.09

The differences observed in the moisture content of the digital cushion among various age groups and animals affected by CHDL could potentially be attributed to variations in the composition of the ground substance, specifically hyaluronic acid in different age groups of animals. Hyaluronic acid is a ground substance which helps the tissues to keep hydrated.

3.1.2 Total ash

The total ash content displayed variation among the different groups, with the highest value observed in animals suffering from CHDL (1.89 percent of dry matter), and the lowest value found in cows beyond three parities (1.33 percent of dry matter). The digital cushions of heifers had a total ash content of 1.35 percent of dry matter, while cows in their first to third parity exhibited a total ash content of 1.7 percent of dry matter (Table 1). Aged and disease affected cows showed a higher total ash content. In contrast to this finding, Bray *et al.* (1951) [15] reported that the total ash content in cattle connective tissue exhibited a declining pattern as the animals aged.

The rise in the total ash content observed in older cows and those affected by diseases may be attributed to increased mineral deposition that occurs during aging and due to diseases.

3.1.3 Crude protein

The digital cushion exhibited substantial protein content. The highest protein content was found in the digital cushion of animals suffering from CHDL (53.26 percent of dry matter), while the lowest protein content was observed in cows in their first to third parities (23.48 percent of dry matter). Heifers had a measured protein content of 41.06 percent of dry matter, whereas cows beyond three parities exhibited a protein content of 37.37 percent of dry matter. In comparison to other chemical constituents, protein constituted the highest proportion in heifers and in animals suffering from CHDL (Table 1).

Räber *et al.* (2004) [3] reported that heifers were observed to have cushions consisting of a higher proportion of white, flexible, and elastic loose connective tissue. In contrast, cows with two or three parities exhibited cushions characterized by a greater presence of smooth yellow adipose tissue. Furthermore, after three parities, the digital cushion contained an increased amount of collagenous connective tissue.

The increased proportion of protein observed in the digital cushion of heifers could be attributed to a higher content of elastic fibres within the connective tissue. In cows within their first to third parity, the presence of yellow adipose tissue was more prominent, leading to a relatively reduced protein component. However, in cows with more than three parities and in animals affected by CHDL, the proportion of collagen fibres increased, resulting in a proportionate rise in the protein content within the digital cushion.

3.1.4 Crude fibre
Overall, the digital cushion exhibited a notably low crude fibre content that represents the carbohydrate portion contributed by the ground substance. The highest carbohydrate content was found in animals suffering from CHDL (1.18 percent of dry matter), followed by cows in their first to third parities (1.13 percent of dry matter), and cows beyond three parities (0.43 percent of dry matter). The lowest values were observed in heifers (0.31 percent of dry matter) (Table 1).

3.1.5 Crude fat
The digital cushion displayed a significant proportion of fat. The highest fat content was observed in cows in their first to third parity (68.32 percent of dry matter), followed by cows beyond three parities (53.71 percent of dry matter), and heifers (40.78 percent of dry matter). The lowest fat content was found in animals suffering from CHDL (21.09 percent of dry matter). Among the various chemical constituents of digital cushion, fat contributed the highest proportion in cows in their first to third parity and in cows beyond three parities (Table 1).

Bray *et al.* (1951) [15] observed an increase in the fat content of connective tissue as the animals aged. Similar observations were made by Räber *et al.* (2004) [3] and reported that the digital cushion in heifers exhibited relatively less fat content. However, over the course of two to three parities, the amount of fat increased. After three parities, the fat content tended to decrease, and connective tissue replaced the adipose tissue. Smilie *et al.* (1999) [16] and Räber *et al.* (2006) [17] also reported regarding lower fat content in the digital cushion of heifers compared to the cows of higher parities.

In the present study, among the various chemical constituents, fat contributed the highest proportion in cows with a parity ranging from first to third and in cows with more than three parities. The findings suggest that fat deposition increases after attaining maturity. Additionally, factors such as the stage of lactation, production levels, feeding regime, and flooring type can also influence the fat content of the digital cushion. During peak production, the depletion of stored fat can lead to thinning of the digital cushion, making the animals more susceptible to developing CHDL. Consequently, animals affected by CHDL displayed the lowest fat content in their digital cushions.

4. Conclusion
Information on proximate composition of the digital cushion in cattle can provide valuable insights into its structural integrity. In the present study, the moisture content varied among different age groups and was lowest in animals with claw horn disruption lesions (CHDL). Total ash content increased with age and in animals with hoof diseases. Protein content was highest in heifers, possibly due to more elastic fibres present in their digital cushion. Fibre content was generally low in all groups of animals studied, while fat content was highest in cows with one to three parities, reflecting fat deposition with maturity. Understanding these variations contributed to our knowledge of digital cushion health and in developing strategies to prevent the occurrence of CHDL. Further research is needed to explore the influence of additional factors like lactation, diet, and flooring type on digital cushion composition.

5. References

1. Iqbal ZM, Akbar H, Hosseini A, Ruspoli B, Forteguerri E, Osorio JS. Digital Cushion Fatty Acid Composition and Lipid Metabolism Gene Network Expression in Holstein Dairy Cows Fed a High-Energy Diet. Plos One. 2016;11(7):e0159536.
2. Bergsten C. Causes, risk factors, and prevention of laminitis and related claw lesions. Acta Veterinaria Scandinavica. 2003;98:157-166.
3. Räber M, Lischer CJ, Geyer H, Ossent P. The bovine digital cushion-a descriptive anatomical study. The Veterinary Journal. 2004;167:258-264.
4. Greenough PR, Mac Callum FJ, Weaver AD. Anatomy of the digital region. In: Weaver AD (Ed.), Lameness in Cattle. John Wright and Sons Ltd, Bristol; c1981. p. 135-150.
5. Lischer CJ, Ossent P, Räber M, Geyer H. Suspensory structures and supporting tissues of the third phalanx of cows and their relevance to the development of typical sole ulcers (*Rusterholz ulcers*). The Veterinary Record. 2002;151:694-698.
6. Shearer, JK, Plummer PJ and Schleining JA. Perspectives on the treatment of claw lesions in cattle. Veterinary medicine (Auckland, N.Z.). 2015;6:273-292.
7. Bicalho RC, Machado VS, Caixeta LS. Lameness in dairy cattle: a debilitating disease or a disease of debilitated cattle? A cross-sectional study of lameness prevalence and thickness of the digital cushion. Journal of Dairy Science. 2009;92:3175-3184.
8. Newsome R, Green MJ, Bell NJ, Bollard NJ, Mason CS, Whay HR, et al. A prospective cohort study of digital cushion and corium thickness. Part 1: associations with body condition, lesion incidence, and proximity to calving. Journal of Dairy Science. 2017;100:4745-4758.
9. Stambuk CR, McArt JAA, Bicalho BC, Miles AM, Huson HJ. A longitudinal study of digital cushion thickness and its function as a predictor for compromised locomotion and hoof lesions in Holstein cows. Translational Animal Science. 2019;3:74-83.
10. Murray RD, Downham DY, Clarkson MJ, Faull WB, Hughes JW, Manson FJ, *et al*. Epidemiology of lameness in dairy cattle: Description and analysis of foot lesions. The Veterinary Record. 1996;138:586-591.
11. Oikonomou G, Cook NB and Bicalho RC. Sire predicted transmitting ability for conformation and yield traits and previous lactation incidence of foot lesions as risk factors for the incidence of foot lesions in Holstein cows. Journal of Dairy Science. 2013; 96:3713-3722.
12. Conway EJ. Microdiffusion Analysis and Volumetric Error. (4th Ed.), Crosby Lockwood and Son Ltd., London; c1957. p. 357.
13. Montemurro DG, Stevenson JAF. Survival and body composition of normal and hypothalamic obese rats in acute starvation. American Journal of Physiology. 1960;198(4):757-761.
14. AACC. Approved Methods of the American Association of Cereal Chemists, (10th Ed), American Association of Cereal Chemists, St. Paul, MN, USA; c2000. p. 700-710.
15. Bray RW, Phillips PH, Bohstedt G. Moisture, Ash, and Fat Content of Connective Tissue from Cattle of Different Ages. Journal of Animal Science. 1951;10(2):394-398.
16. Smilie RH, Hoblet KH, Eastridge ML, Weiss WP, Schnitkey GL, Moeschberger ML. Subclinical laminitis in dairy cows: use of severity of hoof lesions to rank and evaluate herds. Veterinary Record. 1999;144:17-21.
17. Räber M, Scheeder MRL, Ossent P, Lischer CHJ, Geyer H. The content and composition of lipids in the digital cushion of the bovine claw with respect to age and location - A preliminary report. The Veterinary Journal. 2006;172:173-177.