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# Image Based Morphometric Evaluation of Process Induced Brown top Millet Grains

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**Abstract**
Browntop millet (*Brachiaria ramosa*) is tightly encased in hard, persistent husks, making dehusking a major challenge in primary processing. In this study, grains obtained from local markets were subjected to controlled treatments: untreated whole grains (BTM-W), directly dehulled grains (BTM-C), and abrasive pre-treatments of two, four, and six minutes (BTM-A2, BTM-A4, BTM-A6). Dimensional characterization using digital image analysis revealed significant reductions in grain length, width, and perimeter across treatments. The untreated whole grain (BTM-W) exhibited the maximum mean length of 3.240 ± 0.165 mm**,** whereas BTM-C (2.001 ± 0.044 mm) and BTM-A2 (1.922 ± 0.189 mm) recorded substantially lower values. Width measurements showed BTM-W at 1.813 ± 0.051 mm, with processed variants ranging between 1.560–1.627 mm, reflecting moderate reductions. Perimeter values followed a similar trend, with BTM-W at 7.923 ± 0.282 mm, while BTM-C (5.700 ± 0.140 mm) and BTM-A2 (5.663 ± 0.254 mm) showed the most pronounced decreases. Digital imaging through a stereo zoom microscope provided detailed visual evidence of these morphological transformations, confirming that pre-treatment disrupts husk adhesion and modifies pericarp integrity, thereby facilitating husk removal. The findings demonstrate that abrasive pre-treatment induces measurable changes in grain morphology, supporting the development of standardized protocols for Browntop millet processing. Image-assisted morphometric analysis proved to be a robust, non-invasive, and economical approach for evaluating grain quality parameters, strengthening the scientific basis for millet-specific processing innovations and contributing to dietary diversification and food security.
**Keywords:** browntop millet, image analysis, digital morphometry, grain dimensions, pre-treatment, processing

## 1. Introduction

Despite their well-established health benefits and cultural significance, millet cultivation and promotion continue to face several challenges. For successful integration of millets into mainstream diets and Indian agriculture, these barriers must be addressed. Farmers cultivating millets often encounter restricted market access, which reduces profitability and discourages production. The gradual erosion of traditional knowledge related to millet farming practices and regional culinary uses has further hindered promotion efforts. Furthermore, advancements in food processing technologies will facilitate the development of functional millet-based foods, thereby enhancing consumer demand and expanding the crop's role in sustainable agriculture (Ankita & Upasna Seth, 2025).

Among the diverse group of small millets, Browntop millet (*Brachiaria ramosa*) holds particular importance. It is cultivated for multiple purposes like human consumption, animal forage, bird feed, and industrial applications (Sheahan, 2014). In India and Africa, millets are consumed either as whole grains or flour, while in Japan they are primarily used as bird feed (Asharani et al., 2010). Browntop millet is deeply embedded in traditional food systems of southern India, where it forms the basis of several dishes such as *anna*, *dosai*, *kheer*, *roti*, and *nuchina mudda*. Its persistence in cultivation is partly attributed to its ritual significance and adaptability to diverse agro-ecological conditions.

Browntop millet, faces considerable barriers to mainstream integration due to limited consumer awareness and the absence of specific equipment and standardized protocols for primary processing. Seed shape and size are critical agronomic traits that directly influence yield potential, eating quality, and market value. Quantitative assessment of seed morphology is therefore essential for crop improvement and the advancement of processing technologies, particularly in underutilized grains. Conventional manual methods, such as caliper-based measurements of seed length and width, provide basic data but suffer from low throughput and limited precision. Other traditional techniques including grain shape testers, dial micrometers, and graphical methods are often slow, labor-intensive, and restricted to single-grain measurements, thereby increasing both time requirements and the likelihood of human error. These limitations highlight the need for more accurate and efficient approaches that meet quality standards while overcoming the drawbacks of manual procedures.

Computational phenotyping through digital imaging offers a high-resolution, automated means of evaluating multiple shape parameters simultaneously. This technique generates robust datasets for genetic studies, functional analyses, and breeding programs, enabling precise and efficient classification compared to conventional practices (Brewer *et al*, 2006; Bylesjö *et al*, 2008; Weight C *et al*, 2008; Harshith *et al*, 2023). Image analysis is non-invasive, economical, and minimizes reliance on manual effort, thereby enhancing both precision and objectivity. Grain quality is determined by a combination of physical and chemical attributes, with physical factors including dimensions, form, chalkiness, whiteness, milling efficiency, bulk density, and moisture content. The present study focuses on the dimensional characterization of Browntop millet grains under different processing treatments, aiming to provide a comprehensive understanding of their physical parameters and responses to mechanical processing.

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## 2. Materials and Methods

### 2.1 Grain Samples and Treatments

Browntop millet grains were sourced from local markets, with whole grains designated as the control sample (BTM-W). Experimental treatments comprised directly dehulled grains (BTM-C) and grains subjected to abrasive pre-treatment for durations of two minutes (BTM-A2), four minutes (BTM-A4), and six minutes (BTM-A6). The progressive variation in pre-treatment time was selected to examine the temporal influence of mechanical abrasion on grain morphology and husk adhesion characteristics.

### 2.2 Image Acquisition and Morphometric Analysis

Grain dimensions including length (mm), width (mm), and perimeter (mm) were determined using a digital image capture method. Observations were carried out under a stereo zoom microscope (Make: Lawrence and Mayo) equipped with TC Capture software at 1X magnification. High-resolution images were obtained using a camera mounted on the microscope body, with detailed dimensional parameters subsequently measured from the captured images and calibration performed using the scale set for 1X magnification.

The initial stage of sample preparation involved the careful selection of clean grains, free from dust or foreign matter. These grains were then placed on a contrasting white background to enhance visibility, with consistent orientation maintained to ensure uniform measurement. Illumination was adjusted on the stereo zoom microscope to correspond with the translucency of the grains. High-resolution images were subsequently captured using the microscope's integrated digital camera, with fine and coarse adjustment knobs employed for precise focusing. The primary parameters measured included grain length (tip to tip along the longitudinal axis), width (maximum breadth perpendicular to the length), and perimeter (traced by dragging the cursor around the grain edge).

### 2.3 Statistical Analysis

The statistical evaluation was carried out for mean values using paired sample T-test to determine significant differences among treatment groups [1]. Significance levels were established at $p \leq 0.05$ and $p \leq 0.01$ for moderate and high confidence intervals, respectively.

## 3. Results and Discussion

### 3.1 Dimensional Characterization of Browntop Millet Grains

Browntop millet grains are tightly enclosed within hard indigestible husks, making dehusking a challenging process. Following abrasive pre-treatment, dimensional analysis revealed marked reductions in grain length, width, and perimeter, reflecting significant morphological alterations induced by mechanical processing. (Table 1).

**Table 1:** Dimensions of browntop millet grain captured in stereo zoom microscope

| Particulars | BTM-W | BTM-C | BTM-A2 | BTM-A4 | BTM-A6 |
|---|---|---|---|---|---|
| **Length (mm)** | 3.240± 0.165 | 2.001 ± 0.044$^{**}$ | 1.922 ± 0.189$^{**}$ | 1.967 ± 0.055$^{**}$ | 1.922±0.072$^{**}$ |
| **Width (mm)** | 1.813 ± 0.051 | 1.580 ± 0.078$^{*}$ | 1.560 ± 0.082$^{@}$ | 1.597 ± 0.060$^{@}$ | 1.627±0.070$^{@}$ |

| | | | | | |
|---|---|---|---|---|---|
| **Perimeter (mm)** | 7.923± 0.282 | 5.700 ± 0.140** | 5.663 ± 0.254** | 5.717 ± 0.093** | 5.687 ± 0.151* |

@-Not significant; *-Significant at 0.05 level; **-Significant at 0.01 level BTM-W: Browntop millet Whole grain; BTM-C: Browntop millet dehulled; BTM-A2: Browntop millet pre-treated for 2 minutes; BTM-A4: Browntop millet pre-treated for 4 minutes; BTM-A6: Browntop millet pre-treated for 6 minutes.

The untreated whole grain (BTM-W) exhibited the maximum mean length of 3.240 ± 0.165 mm, whereas BTM-C (2.001 ± 0.044 mm) and BTM-A2 (1.922 ± 0.189 mm) recorded substantially lower values. These dimensional reductions indicate that processing treatments fundamentally altered grain structure. Width measurements showed the untreated whole grain (BTM-W) measuring 1.813 ± 0.051 mm, with processed variants demonstrating more moderate reductions, ranging from 1.560 to 1.627 mm across BTM-A2, BTM-A4, and BTM-A6 treatments. Pre-treatment variants BTM-C, BTM-A4, and BTM-A6 maintained intermediate width values, suggesting differential husk loosening responses [1]. Perimeter values followed a similar trend, with BTM-W grains showing the highest perimeter at 7.923 ± 0.282 mm, and all pre-treatments significantly reducing perimeter, particularly BTM-C (5.700 ± 0.140 mm) and BTM-A2 (5.663 ± 0.254 mm) and the grain pictures were shown in Figure 1.
The comparative dimensional analysis of browntop millet grains under pre-treatment revealed pronounced variations in length, width, and perimeter, expressed as percentage changes relative to untreated whole grains (BTM-W).

### 3.2 Variation in Grain Length

Grain length exhibited the most pronounced reduction (Figure 1), with BTM-C, BTM-A2, BTM-A4, and BTM-A6 showing decreases of 38.24%, 40.67%, 39.28%, and 40.68%, respectively, compared to BTM-W. The results indicate that dehulling removed the pericarp, leading to a significant reduction in grain length. Further comparison between the dehulled control and the treated samples revealed that BTM-A4 showed a comparatively smaller reduction, whereas BTM-A2 and BTM-A6 followed a similar trend of contraction. These findings confirm that pre-treatment significantly altered grain elongation, with certain treatments (BTM-A2 and BTM-A6) exerting stronger effects on length reduction. Thus grain length showed the most pronounced reduction across processing treatments. The substantial reductions in grain length relative to untreated grains (BTM-W) suggest that pre-treatment disrupts husk adhesion and pericarp integrity, thereby facilitating husk removal. These morphological changes indicate that mechanical force exposure plays a critical role in loosening husk layers and modifying grain structure. Comparable findings were reported by Harini & S Naik, 2026, who demonstrated that dehulling and subsequent processing significantly influenced the dimensional attributes of Browntop millet grains.

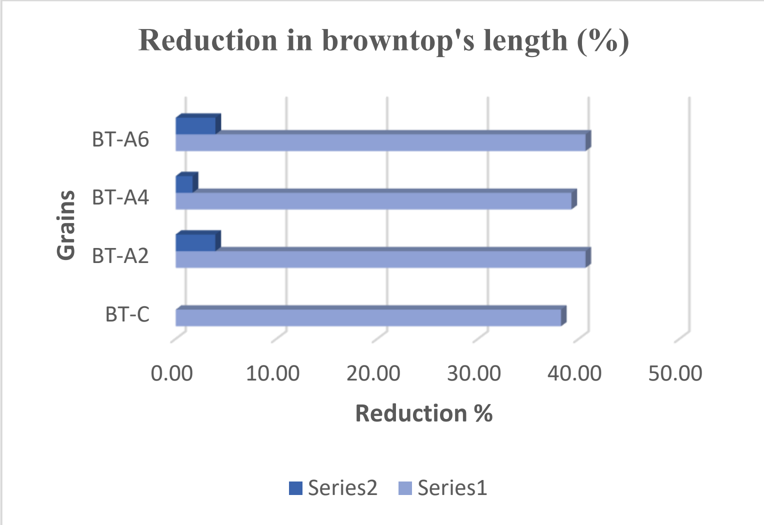


**Figure 1:** Comparision of browntop millet grain length: Whole Vs dehulled grains

3.3 Variation in Grain Width

The grain width, defined as the broadest portion of the kernel, exhibited variable reductions across treatments. Among all experimental samples, BTM-A6 recorded the lowest reduction (10.38%), followed by BTM-A4, BTM-C, and BTM-A2 (Figure 2). Overall, the percentage reduction did not follow a consistent treatment-dependent pattern but decreased irregularly when compared with whole grains. Notably, when compared against the dehulled control, BTM-A6 exceeded the control width, indicating that this sample remained largely unaffected with respect to grain width, a characteristic attributable to the inherently slender nature of Browntop millet

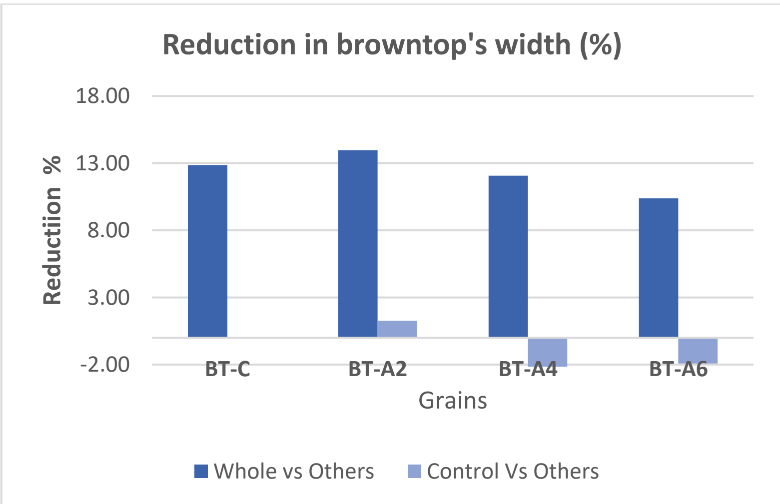


**Figure 2**: Comparision of browntop millet grain width: Whole Vs dehulled grains

3.4 Variation in Grain Perimeter

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The grain perimeter, defined as the calculated outer boundary of the kernel, showed only slight variations in percentage reduction across treatments when compared with both whole grains and the dehulled control (Figure 3). This reduction pattern was irregular rather than treatment-dependent, reflecting the inherent slenderness of Browntop millet grains, which remained largely unaffected by pre-treatment.

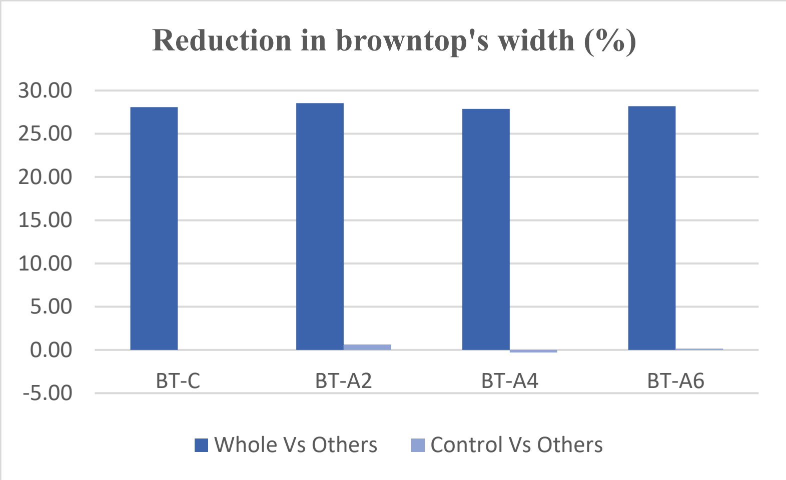


**Figure 3. Comparision of browntop millet grain width: Whole Vs dehulled grains**

3.5 Mechanistic Interpretation

The present investigation revealed significant reductions in grain length and perimeter following dehulling and abrasive pre-treatments, consistent with the structural modifications observed in the pericarp and husk adhesion zones. Harini similarly reported that dehulling and processing of Browntop millet induced measurable changes in grain dimensions, reinforcing the conclusion that mechanical treatments substantially alter grain morphology. Together, these findings highlight the broader relevance of dimensional characterization in understanding processing efficiency and guiding equipment design for millet dehusking

## 4. Conclusion

The study demonstrated that abrasive pre-treatment induced measurable dimensional changes in Browntop millet grains, with significant reductions observed in length, width, and perimeter across all processing conditions. These morphological alterations highlight the impact of mechanical abrasion on grain physical properties, particularly through disruption of husk adhesion zones and modification of the pericarp structure. The integration of computational imaging methods enhanced measurement precision and throughput, generating datasets of high value for breeding programs and equipment design. Dimensional characterization under varying pre-treatment durations revealed structural modifications that facilitate husk removal, thereby supporting improved mechanization of Browntop millet processing. The findings underscore the importance of developing standardized protocols for primary processing and confirm that image-assisted morphometric analysis provides a robust, non-invasive, and cost-effective approach for evaluating grain quality attributes. Adoption of high-throughput phenotyping techniques strengthens the scientific foundation for millet-specific processing innovations, ultimately contributing to dietary diversification and enhanced food security

**Author Contributions**

**Pradeepa:** conceptualization, investigation, formal analysis, Visualization, Methodology, writing – original draft. **Sharada:** validation, resources, validation, Methodology, project administration, writing – review and editing

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**Conflicts of Interest**

The authors declare no conflicts of interest.

**Data Availability Statement**

The data that support the findings of this study are available from the corresponding author upon reasonable request

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