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RESEARCH PAPER

Changes in Crude Protein Content of Selected Pearl Millet (*Pennisetum glaucum L.)* Varieties Following Infestation by *Sitotroga cerealella* (Olivier).

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Abstract

Sitotroga cerealella is one of the most destructive storage pests of pearl millet, causing deterioration in grain quality and nutritional composition. The present study evaluated changes in crude protein content of four pearl millet varieties before and after infestation by *S. cerealella* using the Kjeldahl method. Crude protein content increased in all varieties following insect infestation. The highest percentage increase was observed in the susceptible variety NDFB-3 (13.46%), followed by ICMB-155 (9.17%), ICTP-8203 (6.09%), whereas the resistant variety WCC-75 showed the lowest increase (5.36%). The apparent increase in crude protein is likely associated with the accumulation of insect-derived nitrogenous materials, including frass, exuviae and insect body fragments, together with carbohydrate depletion during feeding, rather than an actual improvement in nutritional quality. The observed trend suggests that resistant varieties undergo comparatively smaller biochemical alterations than susceptible varieties following insect infestation. These findings emphasize the importance of host plant resistance and effective storage management for maintaining the nutritional quality of pearl millet during storage.

KEYWORDS:
Pearl millet, *Sitotroga cerealella*, crude protein, Kjeldahl method, storage pests, grain quality.

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Introduction

Pearl millet (*Pennisetum glaucum L.*) is one of the oldest domesticated cereal crops and serves as a staple food for millions of people living in the arid and semi-arid regions of Asia and Africa. Owing to its remarkable tolerance to drought, high temperature, and poor soil fertility, pearl millet has become an important crop under changing climatic conditions. In India, it is cultivated extensively in Rajasthan, Uttar Pradesh, Haryana, Gujarat and several other states, where it contributes significantly to food security, nutritional security and livestock feed.

Climate variability has significantly influenced the cultivation pattern of pearl millet in North India. According to the Directorate of Economics and Statistics (DES), Department of Agriculture and Farmers Welfare, Government of India, the cultivated area under pearl millet in Kanpur district changed from 3,958 hectares in 2024–25 to 3,970 hectares in 2025–26. This shift in cultivated area reflects changing cropping patterns associated with climatic variability and irregular rainfall. Such changes further emphasize the importance of protecting harvested pearl millet from storage losses caused by insect pests such as *Sitotroga cerealella*

Among cereal grains, pearl millet is recognized for its superior nutritional composition. It contains comparatively higher levels

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of protein, essential amino acids, dietary fibre, iron, zinc and other micronutrients than many commonly consumed cereals. Because of these nutritional attributes, pearl millet is increasingly promoted as a "nutri-cereal" and plays an important role in combating malnutrition and micronutrient deficiencies.

Although pearl millet possesses excellent nutritional value at harvest, maintaining grain quality during storage remains a major challenge. Improper storage conditions frequently lead to infestation by insects, fungi and mites, resulting in significant quantitative and qualitative losses. Storage insect pests not only reduce grain weight and seed viability but also alter important biochemical constituents such as proteins, carbohydrates, lipids and vitamins. These changes ultimately reduce the nutritional and commercial value of the stored grain.

Among the major insect pests of stored cereals, the Angoumois grain moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae), is considered one of the most destructive internal feeders. Female moths deposit eggs on the surface of grains, and after hatching, the larvae bore into individual kernels where they complete their development. Since feeding occurs entirely within the grain, infestation often remains unnoticed until adult emergence. This concealed mode of feeding causes severe internal damage, loss of grain weight, reduction in germination capacity and deterioration of grain quality.

In addition to physical damage, infestation by *S. cerealella* causes several biochemical changes in stored grains. During larval development, carbohydrates and other storage reserves are consumed as an energy source. Simultaneously, insect-derived materials such as frass, exuviae and dead insect fragments accumulate within infested grains. These changes can influence the chemical composition of grains and may affect the estimation of crude protein when determined using nitrogen-based analytical methods such as the Kjeldahl method.

Several studies have demonstrated that insect infestation can modify the apparent protein content of stored cereals. However, the observed increase in crude protein percentage should not be interpreted as an improvement in nutritional quality. Rather, it reflects a relative increase in nitrogenous materials associated with insect activity and the depletion of non-protein components, particularly carbohydrates. Therefore, understanding the biochemical changes associated with insect infestation is important for accurate evaluation of grain quality during storage.

Despite the economic importance of pearl millet and the widespread occurrence of *S. cerealella*, limited information is available regarding changes in crude protein content among different pearl millet varieties following insect infestation. Comparative evaluation of different varieties may help identify genotypes that better maintain their nutritional quality during storage and provide useful information for storage management programmes and future breeding efforts.

Therefore, the present investigation was undertaken to evaluate the changes in crude protein content of selected pearl millet varieties before and after infestation by *Sitotroga cerealella* using the Kjeldahl method and to assess the possible implications of insect infestation on grain nutritional quality.

2. Materials and Methods

2.1 Experimental Material

Four pearl millet (*Pennisetum glaucum L.*) varieties, namely ICMB-155, WCC-75, NDFB-3 and ICTP-8203, were selected for biochemical evaluation. Healthy, clean and insect-free grains were used throughout the study. Prior to experimentation, grains were cleaned manually to remove broken kernels, dust and other foreign materials.

2.2 Insect Culture

A laboratory culture of the Angoumois grain moth, *Sitotroga cerealella* (Olivier) (Lepidoptera: Gelechiidae), was maintained under controlled laboratory conditions. The culture was regularly reared on pearl millet grains to obtain healthy and uniform insects for infestation studies. Newly emerged adults from the laboratory culture were used for the experiment.

2.3 Grain Infestation

Equal quantities of grains from each pearl millet variety were placed in separate glass containers and artificially infested with *S. cerealella*. The experiment was conducted with three biological replications for each variety. Uninfested grains served as the control (before infestation), whereas infested grains were analysed after completion of the infestation period. Grain samples were collected carefully to avoid contamination before biochemical analysis.

2.4 Estimation of Crude Protein

Crude protein content of pearl millet grains was estimated using the Kjeldahl method, a standard procedure for nitrogen determination.

Briefly, a known quantity of finely powdered grain sample was digested with concentrated sulphuric acid in the presence of a digestion catalyst until a clear digest was obtained. After digestion, the sample was neutralized with sodium hydroxide, and the liberated ammonia was distilled into a boric acid solution. The trapped ammonia was titrated with standard hydrochloric acid to determine the nitrogen content. Crude protein percentage was calculated by multiplying the nitrogen percentage by the

conventional conversion factor of 6.25.
Protein estimation was carried out for both uninfested (before infestation) and insect-infested grain samples.

2.5 Data Recording

The crude protein content (%) of each variety was recorded before and after infestation. The mean protein values obtained for each variety were compared to determine the apparent changes associated with insect infestation.

2.6 Statistical Analysis

The study was conducted with three replications. However, only the final mean protein values were available for analysis. Therefore, the results are presented using descriptive statistics, and percentage changes in crude protein content before and after infestation were compared among the four pearl millet varieties. Further statistical comparisons may be performed in future studies when individual replicate observations are available.

3. Results

3.1 Effect of *Sitotroga cerealella* Infestation on Crude Protein Content of Pearl Millet Varieties. The crude protein content of four pearl millet varieties was estimated before and after infestation by *Sitotroga cerealella* using the Kjeldahl method. An apparent increase in crude protein percentage was observed in all the varieties following insect infestation (Table 1).

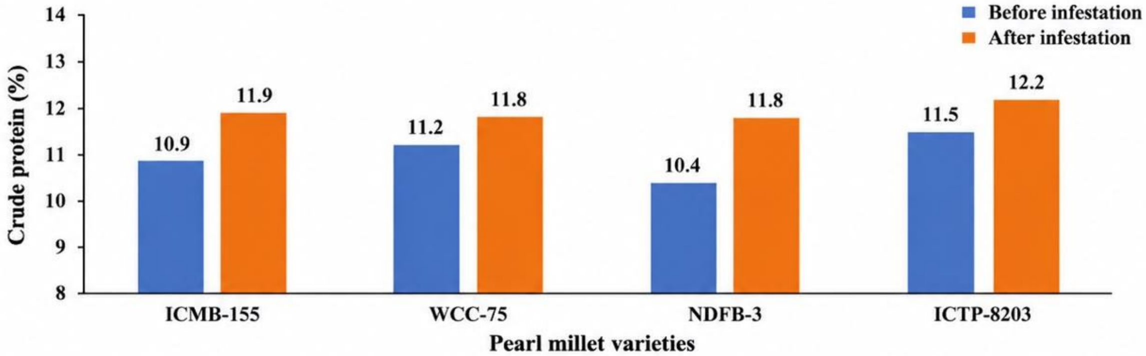
Table 1. Crude protein content of selected pearl millet varieties before and after infestation by *Sitotroga cerealella*.

Pearl millet variety	Protein before infestation	Protein after infestation	Absolute increase (%)	Percentage increase (%)
ICMB-155	10.9	11.9	1.0	9.17
WCC-75	11.2	11.8	0.6	5.36
NDFB-3	10.4	11.8	1.4	13.46
ICTP-8203	11.5	12.2	0.7	6.09

The results revealed that crude protein content increased in all four pearl millet varieties after infestation. Before infestation, protein content ranged from 10.4% (NDFB-3) to 11.5% (ICTP-8203). Following infestation, protein content ranged from 11.8% to 12.2%, with ICTP-8203 recording the highest value (12.2%) and WCC-75 and NDFB-3 the lowest (11.8%).
Among the tested varieties, NDFB-3 exhibited the greatest increase in crude protein content, showing an absolute increase of 1.4 percentage points, corresponding to a 13.46% increase over the pre-infestation value. In contrast, WCC-75 showed the smallest increase (0.6 percentage points; 5.36%). ICMB-155 and ICTP-8203 exhibited intermediate increases of 9.17% and 6.09%, respectively.
Although all varieties exhibited an increase in apparent crude protein content after infestation, the magnitude of change varied among the varieties, suggesting varietal differences in the biochemical response to insect infestation.

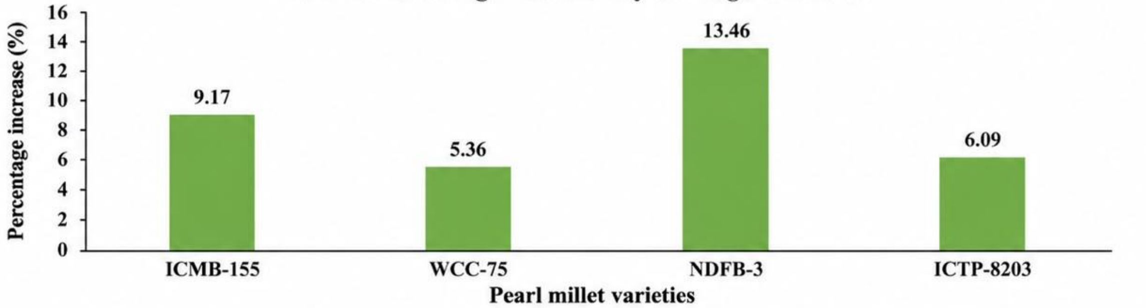
Figure Legend

Figure 1. Comparison of crude protein content (%) of selected pearl millet varieties before and after infestation by *Sitotroga cerealella*.



Crude protein content (%) of four pearl millet varieties before and after infestation by *Sitotroga cerealella* using the Kjeldahl method.

Figure 2. Percentage increase in crude protein content of selected pearl millet varieties following infestation by *Sitotroga cerealella*.



The percentage increase was calculated as: [(Protein after − Protein before) / Protein before] × 100.
Increases in crude protein content may result from insect-derived nitrogenous materials and depletion of carbohydrates.

4. Discussion

The present study revealed an apparent increase in crude protein content in all four pearl millet varieties following infestation by *Sitotroga cerealella*. Similar observations have been reported in stored cereal grains, where insect infestation alters the biochemical composition of grains.

The increase in crude protein content does not necessarily indicate an improvement in nutritional quality. Since the Kjeldahl method estimates total nitrogen, the higher protein values may result from the accumulation of insect-derived nitrogenous materials such as frass, exuviae, and insect body fragments, together with the depletion of carbohydrate reserves during larval feeding.

Variation among the pearl millet varieties suggests that host characteristics may influence the extent of biochemical changes caused by insect infestation. Among the tested varieties, NDFB-3 exhibited the highest increase in crude protein content (13.46%), whereas WCC-75 showed the lowest increase (5.36%). ICTP-8203 (6.09%) and ICMB-155 (9.17%) exhibited intermediate increases. This trend is consistent with the biological response of these varieties, where the resistant genotype (WCC-75) experienced comparatively smaller biochemical changes than the susceptible genotype (NDFB-3), likely due to reduced insect infestation.

Overall, the findings indicate that *S. cerealella* infestation can modify the apparent crude protein content of pearl millet during storage. Therefore, crude protein values of insect-infested grains should be interpreted cautiously, as an increase in protein percentage does not necessarily reflect improved nutritional quality. Further studies involving additional biochemical parameters and statistical validation are required to better understand the impact of storage insect infestation on grain quality.

5. Conclusion

The present study demonstrated that infestation by *Sitotroga cerealella* resulted in an apparent increase in the crude protein content of all four pearl millet varieties. The observed increase is likely associated with insect-derived nitrogenous materials and the relative depletion of carbohydrates rather than an actual improvement in grain nutritional quality. Among the evaluated varieties, NDFB-3 exhibited the highest increase in crude protein content (13.46%), whereas WCC-75 showed the lowest increase (5.36%). ICMB-155 and ICTP-8203 exhibited intermediate increases of 9.17% and 6.09%, respectively. The lower increase observed in the resistant variety WCC-75 and the higher increase in the susceptible variety NDFB-3 are consistent with their differential response to *Sitotroga cerealella* infestation. These findings emphasize that biochemical changes caused by storage insect infestation should be carefully interpreted and highlight the importance of adopting effective storage management practices to preserve the nutritional quality of pearl millet.

References

1. Seifelnasr, Y. E., & Mills, R. B. (1985). Resistance of pearl millet cultivars to *Sitophilus oryzae*, *Sitotroga cerealella*, and *Rhyzopertha dominica*. Journal of Economic Entomology, 78(1), 181–184. https://doi.org/10.1093/jee/78.1.181
2. Yadav, O. P., Rai, K. N., Rajpurohit, B. S., Hash, C. T., Mahala, R. S., Gupta, S. K., Sehgal, S., Sheoran, R. K., Bishnoi, H. R., Rathore, M. S., & Kumar, A. (2012). Twenty-five years of pearl millet improvement in India. All India Coordinated Pearl Millet Improvement Project (AICPMIP), ICAR, Jodhpur.
3. FAO. (2023). FAOSTAT: Crops and livestock products database. Food and Agriculture Organization of the United Nations.
4. Tanwar, R., Panghal, A., Kumari, A., & Chhikara, N. (2025). Nutritional, phytochemical and functional potential of pearl millet: A review. Chemistry & Biodiversity, 22(7), e202402437.
5. Sharma, H. C., & Ortiz, R. (2002). Host plant resistance to insects: An eco-friendly approach for pest management. Journal of Environmental Biology, 23, 111–135.
6. Rai, K. N., Govindaraj, M., & Rao, A. S. (2013). Genetic enhancement of grain iron and zinc content in pearl millet. Quality Assurance and Safety of Crops & Foods, 5, 327–336.
7. ICAR–Indian Institute of Millets Research (IIMR). (2023). Annual Report 2022–23. Hyderabad, India.
8. Kumar, D., Kalita, P., & Mahapatra, B. S. (2017). Storage losses in cereals and millets due to insect infestation: A review. Journal of Stored Products and Postharvest Research, 8(3), 25–34.
9. IPCC. (2023). Climate Change 2023: Synthesis Report. Intergovernmental Panel on Climate Change.
10. Directorate of Economics and Statistics. (2024). Agricultural Statistics at a Glance 2024. Ministry of Agriculture & Farmers Welfare, Government of India.
11. Government of Uttar Pradesh, Department of Agriculture. (2025). District-wise crop area statistics for Kharif 2025. Lucknow, India.
12. Directorate of Economics and Statistics. (2025). Area, Production and Yield (APY) Statistics. Department of Agriculture and Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Government of India.
13. Rani, S., & Singh, R. (2018). Pearl millet processing: A review. Nutrition & Food Science, 48(1), 30–44. https://doi.org/10.1108/NFS-04-2017-0070
14. Food and Agriculture Organization (FAO). (2021). The State of Food and Agriculture 2021: Making agrifood systems more resilient to shocks and stresses. Rome: FAO.
15. Taylor, J. R. N., & Emmambux, M. N. (2008). Gluten-free foods and beverages from millets. In E. Gallagher (Ed.), Gluten-Free Food Science and Technology (pp. 119–148). Elsevier.
16. Adeola, A. A., & Aworh, O. C. (2020). The nutritional use of millet grain for food and feed: A review. *Agriculture & Food Security*, 9, 45.
17. Satyavathi, C. T., Ambawat, S., Khandelwal, V., & Srivastava, R. K. (2021). Pearl millet: A climate-resilient nutri cereal for mitigating hidden hunger and providing nutritional security. *Frontiers in Plant Science*, 12, 659938.
18. Tanwar, R., Panghal, A., Kumari, A., & Chhikara, N. (2025). Nutritional, phytochemical and functional potential of pearl millet: A review. *Chemistry & Biodiversity*, 22(7), e202402437. https://doi.org/10.1002/cbdv.202402437
19. Kumar, A., Tomer, V., Kaur, A., Kumar, V., & Gupta, K. (2018). Millets: A solution to agrarian and nutritional challenges. *Agriculture & Food Security*, 7, 31.
20. Kumar, R., Meena, S., Dhotre, A. V., & Joshi, M. (2024). Nutritional and functional exploration of pearl millet and its processing and utilization: An overview. Food and Humanity.
21. Ramesh Singh. (2025, July 22). Dhan–Makka ka fasal karna se pichhat rahe kisan. Dainik Jagran.