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PRODUCTION AND UTILIZATION OF LOW-COST PAPER FROM STALK OF TRIGONELLA FOENUM-GRAECUM.

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Abstract
Trigonella foenum-graecum is an indigenous crop plant. Commonly cultivated for its food value, these renewable crop plants can contribute largely to the local economic sector. The stalk of this plant remain largely unused. The low-cost stalk which is considered a waste can be used as raw material to prepare paper. The paper was prepared by blending the stalk of *Trigonella foenum-graecum.* The paper prepared from this is eco-friendly and biodegradable. It is a good substitution for wood pulp and thus plays a crucial role to decrease the rate of deforestation. The paper made from this can be utilized to prepared herbarium sheets, greeting cards, bookmarks etc.
Key Words- *Trigonella foenum-graecum*, indigeneous, deforestation

Introduction

Deforestation, loss of biodiversity, and environmental degradation have resulted from the immense pressure that the increasing global demand for paper has placed on forest resources (Tombari *et al.* 2021). In response to these challenges, production of environment friendly and economically viable alternatives for paper production is becoming increasingly essential (Chibuye *et al.* 2023, Kimia *et al.* 2023).

One promising solution is the use of agricultural waste, particularly *Trigonella foenum-graecum* stalks, as a raw material for paper-making (Limenew *et al*. 2023). These plant fibres, which often go to waste or are underutilized, have the potential to effectively replace wood pulp in a cost-effective and sustainable manner (Adane *et al.* 2021). Cellulose, hemicellulose, and lignin are present in *Trigonella foenum-graecum* stalks (Deborah *et al* 2024). By utilising these readily available resources, we can lessen the demand for raw plant materials while
simultaneously adding value to agricultural waste (Roohallah *et al*. 2024). Furthermore, promoting waste valorisation through the use of vegetable stalks in paper manufacturing can reduce the environmental impact of traditional production and support the circular economy (Rakesh *et al.* 2024, Maria *et al.* 2024).

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The present work aims to investigate the production and application of economical paper made from *Trigonella foenum-graecum* stalks, evaluating its potential as a sustainable alternative to conventional paper. The main objectives of the study are to compare the financial sustainability of vegetable stalk-based paper with that of traditional wood pulp paper, improve processing methods, and assess the quality of the final product (Unnati *et al*. 2024; Anunay *et al*. 2024).

By focusing on utilising agricultural by-products for environmentally friendly manufacturing processes, this research aims to address significant issues We aim to support the advancement of more cost-effective and sustainable methods for paper production. (Abid et al 2024, Natalya et al 2024). By doing this, we can create additional opportunities to reduce waste, preserve natural resources, and encourage alternative methods of paper production. All of these ultimately benefit the environment and the agricultural sector.

Materials and Methods

Raw Material Collection**:** 500 g of *Trigonella foenum-graecum* stalks were collected from local farms and from markets.

Fiber Extraction and Preparation: The stalk of *Trigonella foenum-graecum* was cut into small pieces measuring between 2- 3 centimetres long and then crushed with distilled water. To enhance the colour of the paper, natural pulps from blue peas, turmeric, and beetroot were used as staining agents.(Obeta et al 2022)

Sheet Formation: To create sheets, the pulp was placed onto a mould. To produce a consistent paper structure, the forming process was done to ensure that the pulp fibres are dispersed equally.

Pressing and Drying: The sheets were dried under carefully controlled conditions after pressing. For consistent moisture removal, the drying process was done in an oven set at 70°C for 24 hours.

Results

The extracted fibres not only offered good opacity and smoothness but also showed tensile and bursting strength similar to traditional wood pulp paper. The resulting paper had unique texture and durability, making it suitable for various applications.

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Natural colouring agents from blue pea, turmeric, and beetroot enhanced its visual appeal without compromising resilience. Additionally, the production process using *Trigonella foenum-graecum* stalks proved more economical than traditional methods, requiring fewer raw materials and less energy. This approach also minimizes deforestation and resource use, leading to a smaller carbon footprint. Overall, producing paper from *Trigonella foenum- graecum* stalks presents a practical and eco-friendly alternative for the paper industry, supporting sustainable practices and waste reduction.

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Figure 1 **A**: raw *Trigonella foenum-graecum stalks.* **B&C:** paper after the pulp has been dried and shaped. Figures **D&E**: herbarium samples prepared on paper made from *Trigonella foenum-graecum stalks*, **F**: drawing on paper created from the stalks.

Conclusion

The technique is cost-effective as it uses agricultural waste, lowering raw material costs and minimising environmental impact. *Trigonella foenum-graecum* stalk-based paper production provides an eco-friendly alternative in the paper industry.

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