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Proximate Composition Analysis of Ethanol Extracts of Thaumatococcus danielli Leaf and Root: An Educational Perspective

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ABSTRACT

Plants and their parts have long been utilized for nutritional, medicinal, and cultural purposes, particularly within indigenous communities. This study comparatively examined the proximate composition of ethanol extracts of the dried leaf and root of Thaumatococcus danielli using standard biochemical methods. The findings indicated that the leaf exhibited higher carbohydrate, protein, and ash contents than the root, whereas the root showed higher moisture, fibre, and lipid contents. The relatively low fat and moisture levels observed in the leaf support its traditional use as a natural food packaging material. Beyond nutritional and medicinal relevance, these results provide a scientific foundation for integrating indigenous plant knowledge into science, food technology, and biotechnology education. The study demonstrates how locally sourced biological materials can be utilized as contextual learning resources in laboratory-based instruction and community-oriented science education, thereby strengthening the connection between scientific analysis, traditional practices, and sustainable education.

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1. INTRODUCTION

Wrapping materials, both natural and synthetic, are designed to serve functional, economic, and cultural purposes, including food preservation, shelf-life extension, and consumer acceptance. While synthetic food packaging materials are often engineered to enhance durability and market appeal, natural food wrappers, particularly plant leaves, have been traditionally used to improve flavor, preserve food quality, and extend shelf life through indigenous practices (Adegunloye *et al*., 2006; Ebulue, 2022). In many developing regions, especially in rural communities, the utilization of plant-based packaging materials reflects not only local wisdom but also an important context for learning about food science, biotechnology, and sustainable resource use. Such practices provide valuable opportunities for integrating indigenous knowledge into formal science and biotechnology education.

Thaumatococcus danielli is a multipurpose monocotyledonous tropical plant indigenous to the rainforest regions of Nigeria and Ghana (Ojekale *et al*., 2006). In Nigeria, the leaves of this plant are widely used among different ethnic groups for packaging and preserving cooked foods such as rice, meat, beans, maize meal, and bean cake. Beyond its traditional applications, the plant is globally recognized for thaumatin, a natural non-caloric sweet protein found in its arils and leaves, which is extensively utilized in the food and beverage industries as a sweetener and flavor modifier (Van der Wel & Loeve, 1972; Zemanek & Wasserman, 1995). The domestication and commercialization of T. danielli in several regions of Nigeria have also contributed to rural livelihoods and local economies (Arowosoge & Labode, 2006; Osemeobo, 2005), reinforcing its relevance as a contextual biological resource for applied science and vocational education.

All parts of T. danielli possess nutritional and medicinal significance, with documented uses of the leaves, roots, fruits, and seeds in traditional medicine and food systems (Elemo *et al*., 1999; Emudainohwo *et al*., 2015; Shalom *et al*., 2014). Previous studies have reported its antimicrobial, phytochemical, and nutritional properties, yet its potential role as a contextual learning material in science, food technology, and biotechnology education remains underexplored. Establishing the proximate composition of the leaf and root extracts is therefore important not only for understanding their nutritional and medicinal relevance but also for providing empirical data that can support laboratory-based instruction and the integration of indigenous plant knowledge into science education curricula. Consequently, this study aims to comparatively analyze the proximate composition of ethanol extracts of Thaumatococcus danielli leaf and root, while highlighting its educational relevance as a locally grounded resource for teaching nutrition, biotechnology, and sustainable food systems.

2. METHODS

2.1. Plant Collection and Identification

Thaumatococcus danielli plants were collected from a rainforest area in a rural community in Imo State, Nigeria. The plant was uprooted from the wild, non-reserved forest area, where no governmental or institutional restrictions exist regarding the collection of plant materials for academic research purposes. The collected plant samples were identified and authenticated at the Department of Plant Science and Biotechnology, Federal University of Technology Owerri, Imo State, Nigeria, as *Thaumatococcus danielli*. This identification process ensured scientific accuracy and provides a replicable reference for laboratory-based instruction and educational research involving indigenous plant species.

2.2. Sample Preparation and Ethanol Extraction

The roots and leaves of the plant were separately washed, shade-dried at room temperature until a constant weight was achieved, and ground into fine powder. The powdered samples were packed in polythene bags and stored before analysis. Approximately 200 g of each powdered sample was macerated in 1 L of ethanol at room temperature for 72 hours. The mixtures were filtered using Whatman No. 1 filter paper, and the filtrates were concentrated using a rotary evaporator at 40–42 °C to remove the solvent. The resulting crude extracts were further dried in a water bath at 37–40 °C and stored at 4 °C in a refrigerator until analysis. These procedures follow standard laboratory practices commonly applied in food science and biotechnology education.

2.3. Proximate Analysis

Proximate composition analyses of the leaf and root extracts were conducted to determine moisture, ash, crude protein, crude fibre, crude fat, and carbohydrate contents using standard analytical methods. Moisture content was determined using the oven-drying method, while ash content was determined by the furnace method as described by the Association of Official Analytical Chemists. Crude protein content was analyzed using the Kjeldahl method, crude fibre was determined, and crude fat was analyzed using the Soxhlet extraction method. Total carbohydrate content was calculated by difference using the Equation (1):

$$100 - (\%\ \text{moisture} + \%\ \text{ash} + \%\ \text{protein} + \%\ \text{fat} + \%\ \text{fibre}) \quad (1)$$

Energy values were estimated using conversion factors of 4, 9, and 4 for protein, fat, and carbohydrate, respectively. These standardized procedures support methodological transparency and reproducibility, which are essential for laboratory-based learning in science and biotechnology education.

2.4. Statistical Analysis

All analyses were carried out in triplicate, and results were expressed as mean ± standard deviation (SD). The use of basic descriptive statistics facilitates clarity in data interpretation and supports the use of this experimental design as a teaching model for introductory laboratory and applied science courses.

3. RESULTS AND DISCUSSION

The comparative proximate composition of ethanol extracts of Thaumatococcus danielli leaf and root is presented in **Table 1**. The results reveal distinct nutritional profiles between the two plant parts, reflecting their different biological functions and traditional applications. The leaf extract demonstrated higher carbohydrate, protein, and ash contents, whereas the root extract showed higher moisture, crude fibre, and lipid contents. These variations provide not only biochemical insight but also a scientific foundation for educational use in food science, nutrition, and biotechnology learning contexts.

The higher carbohydrate content observed in the leaf extract suggests its role as an energy-associated plant component. Carbohydrates are fundamental macronutrients required for metabolic processes and energy supply in human nutrition. In an educational setting, this finding can be directly applied in teaching basic nutritional concepts, particularly the classification and functional roles of macronutrients. Using locally available plant materials such as *T. danielli* allows students to relate abstract nutritional theories to real-life biological resources, thereby enhancing conceptual understanding through contextual learning. Protein content was also higher in the leaf extract compared to the root. Proteins are essential for growth, tissue repair, enzyme production, and overall physiological regulation. From an instructional perspective, this result provides a practical example for teaching protein function and analysis in laboratory-based courses. The use of proximate analysis data derived from indigenous plants offers a meaningful platform for demonstrating analytical techniques while simultaneously reinforcing knowledge of nutrition and plant biochemistry (Elemo *et al*., 1999).

Table 1. Comparative proximate composition of ethanol extracts of *Thaumatococcus danielli* leaf and root.

Parameters	Leaf (Mean ± SEM)	Root (Mean ± SEM)
Moisture	5.76 ± 0.26	17.27 ± 0.09
Ash	10.60 ± 0.19	6.20 ± 0.22
Carbohydrate	31.25 ± 0.52	18.75 ± 0.37
Protein	14.88 ± 0.18	7.00 ± 0.12
Fibre	36.61 ± 0.18	48.98 ± 0.32
Lipid	0.90 ± 0.02	1.80 ± 0.06

Values are expressed as mean ± standard error of mean (SEM), n = 3

Ash content, which represents the total mineral composition of plant materials, was found to be higher in the leaf extract. Minerals are critical for numerous biological processes, including bone formation, nerve transmission, and enzymatic activity. In science and biotechnology education, ash content determination is commonly introduced as part of proximate analysis practicals. The data presented in **Table 1** can therefore be utilized as instructional material to help students understand mineral nutrition and the relevance of plant-based mineral sources, particularly in communities where access to fortified foods is limited (Osemeobo, 2005).

In contrast, the root extract exhibited higher moisture content, which may influence its preservation potential and storage stability. High moisture content is often associated with increased susceptibility to microbial growth, which may explain the limited use of roots as food packaging materials. However, from a pedagogical standpoint, this characteristic provides an opportunity to teach students about the relationship between moisture content, food preservation, and microbial activity. Such applications align well with food technology and microbiology curricula, where moisture control is a fundamental concept (Adegunloye *et al*., 2006). Crude fibre content was high in both the leaf and root extracts, with the root showing a comparatively higher level. Dietary fibre plays an important role in digestive health, the regulation of blood glucose levels, and the prevention of certain chronic diseases. In educational practice, fibre content analysis serves as a valuable teaching example for discussing functional foods and health-oriented nutrition. The high fibre values reported in this study can be integrated into nutrition education modules that emphasize the health benefits of plant-based diets and traditional food resources (Shalom *et al*., 2014).

Lipid content was relatively low in both extracts, although slightly higher in the root. Low lipid levels are nutritionally advantageous, particularly in addressing health concerns related to obesity and cardiovascular diseases. The low-fat content of the leaf extract supports its traditional use as a food packaging material, as excessive lipid transfer could compromise food quality. In laboratory instruction, lipid analysis using Soxhlet extraction is a standard practical exercise, and the results obtained from *T. danielli* provide authentic data that can be used to demonstrate lipid determination techniques in food science and biotechnology education.

Beyond the nutritional interpretation, the results summarized in **Table 1** hold clear educational significance. The contrasting proximate compositions of the leaf and root create a comparative framework that is highly suitable for teaching experimental design, data interpretation, and comparative analysis. Students can be guided to analyze why different plant organs exhibit varying nutrient compositions, thereby strengthening their understanding of plant physiology and functional anatomy. Moreover, the integration of indigenous knowledge with scientific analysis enhances the educational relevance of this study. The traditional use of *T. danielli* leaves for food packaging and roots for medicinal purposes provides a culturally grounded context for scientific inquiry. When incorporated into science education, such indigenous practices help bridge the gap between local knowledge systems and formal scientific methodologies, fostering inclusive and culturally responsive education (Ojekale *et al*., 2006). The experimental procedures employed in this study, including ethanol extraction, proximate analysis, and basic statistical treatment of data, are well-suited for instructional laboratories at the tertiary level. These methods are reproducible, cost-effective, and aligned with standard curricula in biotechnology and food science programs. As such, the study serves as a model for laboratory-based learning that emphasizes hands-on experimentation using locally sourced materials.

From a sustainability and educational development perspective, the use of *T. danielli* as a teaching resource promotes environmentally responsible and economically feasible science education. Reliance on indigenous plant materials reduces the need for imported samples and reinforces the importance of biodiversity conservation. This approach supports educational frameworks that advocate for sustainable development and community-based learning (Osemeobo, 2005). Overall, the results demonstrate that *Thaumatococcus danielli* leaf and root possess distinct proximate compositions that justify their traditional nutritional and medicinal uses. More importantly, the findings extend beyond biochemical characterization by providing structured, data-driven content that can be effectively integrated into science, food technology, and biotechnology education. The study illustrates how empirical analysis of indigenous plants can function simultaneously as scientific research and as a pedagogical resource for laboratory-based and contextual learning.

4. CONCLUSION

This study demonstrated that the ethanol extracts of Thaumatococcus danielli leaf and root possess distinct proximate compositions that support their traditional nutritional and medicinal uses. The leaf exhibited relatively higher carbohydrate, protein, and mineral contents with low fat and moisture levels, while the root showed higher fibre and moisture contents, reflecting its medicinal relevance. Beyond biochemical characterization, the findings provide structured empirical data and standardized analytical procedures that can be effectively utilized as contextual learning resources in science, food technology, and biotechnology education. The use of indigenous plant materials in laboratory-based instruction promotes practical skill development, strengthens the integration of local knowledge into formal education, and supports sustainable and cost-effective science education.

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6. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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