International Journal of Advanced Biochemistry Research 2026; SP-10(1): 369-371

International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(1): 369-371
www.biochemjournal.com
Received: 25-10-2025
Accepted: 29-11-2025

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Effect of malting on proximate composition of major millet-based composite flour

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DOI: https://www.doi.org/10.33545/26174693.2026.v10.i1Se.6953

Abstract
Millets are nutritionally rich, climate-resilient cereals with significant potential to improve food and nutritional security. However, their utilization is often limited due to poor digestibility and the presence of anti-nutritional factors. Malting is a traditional bioprocessing technique known to enhance nutrient availability and functional quality of cereals. The present study aimed to develop composite malt flour from major millets such as pearl millet, sorghum, and finger millet and to evaluate the effect of malting on its proximate composition. The grains were malted through soaking, germination, and drying, followed by milling and blending into composite flour. Based on sensory evaluation, a composite ratio of malted pearl millet, malted sorghum, and malted finger millet in the proportion of 30:20:50 were selected for proximate analysis. Proximate analysis revealed low moisture content (3.78%), moderate protein (11.48%) and fat (4.50%) levels, appreciable ash content (1.79%), and high dietary fibre (6.30%). The findings confirm that malting significantly improves the nutritional quality and shelf stability of millet-based composite flour, supporting its potential application in health-oriented food products.

Keywords: Malting, millets, composite flour, proximate composition, nutritional quality

1. Introduction

Millets are a group of nutritionally rich, climate-resilient cereal grains that play an important role in food and nutritional security, particularly in semi-arid regions. They are good sources of carbohydrates, dietary fibre, proteins, minerals, and bioactive compounds, and their regular consumption has been associated with improved metabolic health and reduced risk of non-communicable diseases (Saleh *et al.*, 2013; Devi *et al.*, 2014) [11, 4]. Compared to refined cereals, millets exhibit a lower glycaemic index and higher micronutrient density, making them suitable for health-oriented diets (Kumar *et al.*, 2018) [7].

Among millets, pearl millet (*Pennisetum glaucum*), sorghum (*Sorghum bicolor*), and finger millet (*Eleusine coracana*) are classified as major millets due to their wide cultivation and consumption. Pearl millet is rich in protein, fat, and energy, sorghum contributes carbohydrates and desirable functional properties, while finger millet is particularly valued for its high dietary fibre and mineral content, especially calcium and iron (Nambiar *et al.*, 2011; Sripriya *et al.*, 1997) [9, 14]. Despite these advantages, the presence of anti-nutritional factors such as phytates and tannins in raw millets limits nutrient bioavailability and digestibility.

Malting is a traditional bioprocessing technique involving soaking, germination, and drying, which improves the nutritional and functional quality of cereals. Germination activates endogenous enzymes, resulting in enhanced protein digestibility, improved mineral bioavailability, and reduction of anti-nutritional factors (Srivastava & Singh, 2012; Adebowale *et al.*, 2019) [15, 1]. Several studies have reported that malting favourably modifies the proximate composition of millets by lowering moisture content, improving protein availability, and increasing dietary fibre, thereby enhancing shelf stability and nutritional value (Mbithi-Mwikya *et al.*, 2000; Saleh *et al.*, 2013) [8, 11].

Although the nutritional benefits of malting individual millets are well documented, limited information is available on the development and proximate evaluation of composite malt flours prepared from a combination of major millets. Therefore, the present study was undertaken to evaluate the effect of malting on the proximate composition of composite flour developed from pearl millet, sorghum, and finger millet.

2. Materials and Methods

2.1 Selection of Raw Materials

Pearl millet, sorghum, and finger millet grains of good quality were procured, cleaned, and used for malt flour development.

2.2 Malting Process

The grains were thoroughly washed and soaked in potable water, followed by germination under controlled conditions to activate enzymatic activity. After germination, the grains were dried to safe moisture levels and milled into fine malted flours. Malting improved the digestibility and functional properties of the grains.

2.3 Development of Composite Malt Flour

Composite malt flour was prepared by blending malted pearl millet, malted sorghum, and malted finger millet in different proportions. Based on sensory evaluation, the composite flour formulated with malted pearl millet, malted sorghum, and malted finger millet in the ratio of 30:20:50, respectively, was found to be most acceptable. This optimized ratio was therefore selected for proximate composition analysis. Malted sorghum was maintained at a constant level to provide desirable functional properties such as binding ability and structural stability.

2.4 Proximate Analysis

The selected composite malt flour was analysed for moisture, crude protein, crude fat, ash, and dietary fibre using standard AOAC methods. All analyses were carried out in triplicate, and results were expressed as mean ± standard deviation.

2.5 Statistical analysis

The data obtained from various analyses were statistically analyzed by using suitable statistics to find out significance of the result (Gupta, 1998) [6].

Arithmetic Mean

Mean values were calculated using the formula:

$$A = S/N$$

A= average (or arithmetic mean)
N= the number of terms (e.g., the number of items or numbers being averaged)
S= The sum of the numbers in the set of interest (e.g., the sum of the numbers being averaged)

Standard deviation

The standard deviation was calculated by using the formula

$$S.D. = \frac{\sqrt{\Sigma(x-\mu)2}}{N}$$

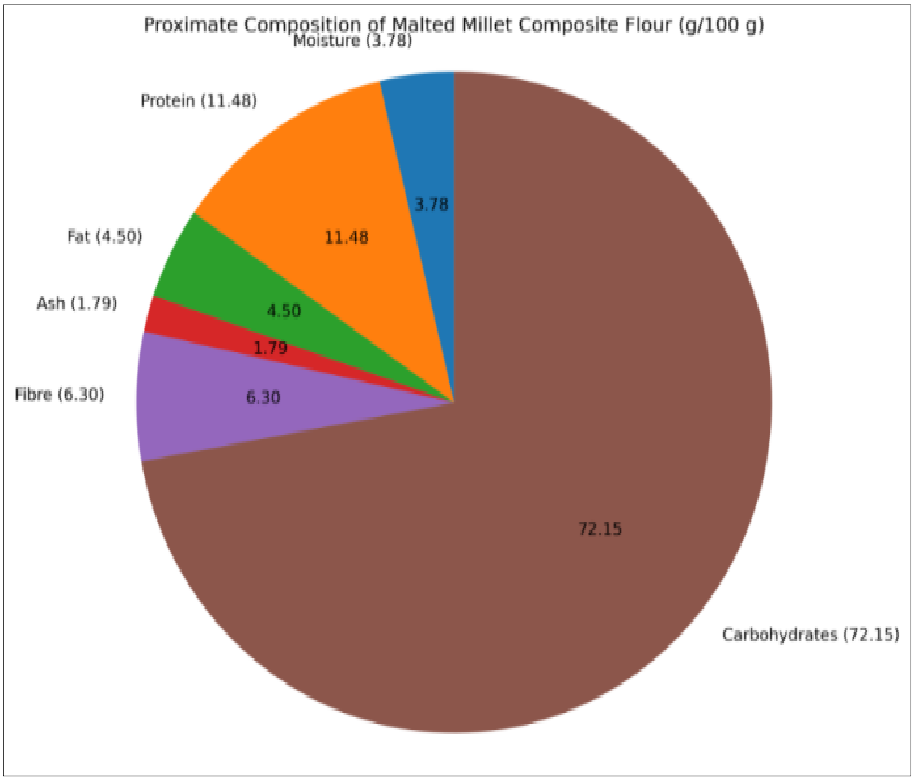
Where,
σ = Standard Deviation
x = each value in the sample
μ = The mean value of the sample
∑= the summation
N = Number of values in the sample

3. Results and Discussion

3.1 Proximate Composition of Composite Malt Flour

Table 1: Proximate Composition of Composite Malt Flour Prepared from Major Millets

S. No.	Nutrients	Mean±SD
1.	Moisture	03.78± 0.26
2.	Protein	11.48±0.04
3.	Fat	04.5±0.04
4.	Ash	01.79±0.01
5.	Fibre	06.30±0.02
6.	Carbohydrates	72.15±0.27
7.	Energy	375.02±1.15



The moisture content of the composite malt flour was low (3.78%), indicating effective drying during malting and milling. Low moisture levels are desirable for improved shelf stability and reduced microbial spoilage. Shahidi and Chandrasekara (2013) [13, 3] reported moisture contents ranging from 4.0 to 8.0% in malted millet flours, while Patekar and Hashmi (2017) [10] observed moisture values of approximately 5.2-7.6% in processed sorghum and millet flours, supporting the low moisture content observed in the present study.

The crude protein content of the composite malt flour was 11.48%, which is higher than that commonly reported for refined cereal flours. Germination activates proteolytic enzymes that partially hydrolyze storage proteins into simpler and more digestible forms, thereby improving protein availability (Dykes & Rooney, 2007) [5]. Chandrasekara and Shahidi (2011) [3] reported protein contents ranging between 9.5 and 12.8% in malted millet flours, while Alane *et al*. (2021) [2] observed protein values of around 10.2-12.4% in malted sorghum-based products, which are comparable to the findings of the present study.

The fat content of the composite malt flour was moderate (4.50%), largely influenced by the inherent lipid content of pearl millet. Previous studies suggest that malting causes minimal changes in total lipid content, though enzymatic activity during germination may slightly modify lipid fractions (Taylor & Emmambux, 2008) [16]. Taylor and Emmambux (2008) [16] reported fat contents ranging from 3.5 to 5.8% in malted pearl millet products, which aligns closely with the present observation.

Ash content (1.79%) reflected appreciable mineral presence in the composite malt flour. Malting enhances mineral bioavailability by reducing phytate content, which otherwise binds minerals and limits absorption (Shahidi & Ambigaipalan, 2015) [12]. Shahidi and Ambigaipalan (2015) [12] reported ash values ranging from 1.5 to 2.6% in malted and whole millet flours. The inclusion of finger millet, known for its high mineral density, further contributed to the ash content observed in this study.

Dietary fibre content was notably high (6.30%), reinforcing the potential role of the composite malt flour in promoting gut health and reducing the risk of chronic diseases. Dykes and Rooney (2007) [5] reported dietary fibre values between 5.0 and 8.5% in whole and malted millets, while Chandrasekara and Shahidi (2011) [3] observed fibre contents of approximately 6.0-9.0%, supporting the results of the present investigation.

Overall, the proximate analysis confirmed that malting significantly enhanced the nutritional quality and storage stability of the millet-based composite flour compared to conventional refined flours.

Conclusion

The present study demonstrated that malting is an effective processing technique for improving the proximate nutritional composition of major millets. The composite malt flour prepared from malted pearl millet, malted sorghum, and malted finger millet in the optimized ratio of 30:20:50, selected based on sensory evaluation, exhibited low moisture content, moderate protein and fat levels, appreciable mineral content, and high dietary fibre. These characteristics indicate enhanced nutritional quality and improved shelf stability. The findings support the potential utilization of malted composite millet flours in the development of health-oriented food products and promote the wider incorporation of millets into daily diets

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