**Impacts of soaking conditions on proximate composition of finger millet**

**ABSTRACT**

Finger millet (*Eleusine coracana*), a nutrient-dense and drought-tolerant cereal widely cultivated in arid and semi-arid regions of Africa and Asia, holds significant potential for promoting food and nutritional security. Despite its rich content of dietary fiber, essential nutrients, and bioactive compounds, the presence of anti-nutritional factors such as tannins and phytates limits its micronutrient bioavailability. Among various traditional processing methods, soaking is a simple and effective technique for improving the nutritional profile of finger millet at household level by reducing anti-nutrients and enhancing digestibility. The present study was undertaken to assess the effect of soaking on the nutritional composition of finger millet grains at two water-to-grain ratios (1:2 and 1:3) over different soaking durations (0, 12, 14, 16, and 18 hours). The results indicated a progressive increase in crude fiber, total ash, and carbohydrate content with prolonged soaking, while moisture, protein and fat contents showed a decreasing trend. These changes are attributed due to the rate of drying that decreased the moisture content and leaching of soluble proteins and fats, enhanced enzymatic activity, and relative concentration effects results in the decrease of protein and fat concentration. The findings highlight the potential of soaking as a household-level intervention to modify and improve the nutritional quality of finger millet, thereby supporting its utilization in functional and health-promoting food products.

Keywords: Proximate composition, Soaking, Finger millet, Fiber enhancement

**INTRODUCTION**

Finger millet is a highly nutritious, drought-tolerant cereal crop that thrives in arid and semi-arid regions of Africa and Asia. The botanical name of finger millet is *Eleusine coracana* and is a member of the grass family (Poaceae). According to Indian Institute of Millet Research, 2021, In India, the total production of finger millet reached 19.85 lakh metric tonnes during the 2017-2018 period, with Karnataka leading as the highest producer, contributing approximately 12.86 lakh metric tonnes. The kernel of finger millet is primarily composed of three main components: the embryo, endosperm, and seed coat (testa). The seed coat, consisting of five distinct layers, is particularly rich in dietary fiber and antioxidants. This outer layer plays a crucial role in regulating postprandial hyperglycaemia by inhibiting key digestive enzymes such as intestinal pancreatic amylase and α-glucosidase. Finger millet has an excellent nutritive value that is similar to the wheat and these makes finger millet as the potential food crop to achieve food security. Regular consumption of finger millet, either as a staple food or in whole meal-based products, can help maintain optimal blood glucose levels, thereby assisting in the management of various metabolic disorders and promoting overall health (Rathore *et al*., 2019).

Finger millets contain higher amounts of anti-nutrients such as tannins and phytates, which makes some of the micronutrients less bio-accessible. However, these anti-nutrients can be removed by processing techniques such as germination, soaking, roasting, fermentation and dehulling (Nkhata *et al*., 2018). Soaking is a common household process that improves the nutritional quality of millet grain flour and also decreases the levels of anti-nutrients present in cereals. The soaking of grains reduces phytic acid content, which might depend on the species, pH conditions and duration of soaking (Prakash *et al*., 2007). It has been reported that phytate content was significantly reduced during soaking of soybeans (Lestiennem *et al*., 2005). Studies have shown that there are certain nutrient changes that occurs during soaking. However, there is scanty information on the effects of soaking as a pretreatment method on the nutritional properties of finger millet. Hence, the present study has been undertaken with the objective to investigate the changes in chemical composition of finger millet under different soaking conditions.

**MATERIALS AND METHOD**

**Location and period of study**

The present study was carried out during the academic year 2023–2025 in the Department of Food Science and Nutrition at the College of Community Science, Assam Agricultural University, Jorhat, 785013, situated in Jorhat district, Assam, India.

**Sample selection**

The finger millet has low glycaemic index content and high fibre content. The finger millet was collected from KVK, Gossaigaon, Kokrajhar.

**Processing of raw materials**

The samples were processed following the standard protocol described by (Abioye *et al*., 2022), with slight modifications. An amount of 100 g of finger millet was cleaned to remove stones, dirt, shafts, and other foreign bodies that may affect the quality of the final product and it was soaked in water in the ratio of 1:2 and 1:3 for 0 hours (no soaking), 12 hours, 14 hours, 16 hours and 18 hours respectively and dried for 50° C in air tray dryer. The soaking water temperature was maintained to be 30° C with the pH of 6.5 and the soaking water was not changed during the long soaking duration. The grains with soaking during for 0, 12, 14 hours took 30 minutes to dry whereas the grain with soaking duration 16 and 18 hours took 40 minutes to dry. The dried grains were powdered and stored in air tight containers for further analysis of its nutrient composition. The process of developing the different flour has been schematically detailed below in flowchart along with the process elaboration.



**Fig. 1 Schematic diagram of Finger millet flour**

**Nutritive Composition**

The proximate composition of the multi grain composite mixes was determined as per AOAC 2000.

**Statistical analysis**

For present investigation one-way Anova was employed using three replications in SPSS software.

**RESULTS AND DISCUSSIONS**

**Nutrient composition of Finger millet at different soaking hours**

The moisture content tends to increases with the increase in the soaking time (Abioye *et al*., 2022). However, Table 1 depicts that the moisture content of finger millet decreases with an increase in soaking time. This trend may be attributed due to the fact that increase in soaking time results in greater water absorption, thus requires extended drying time to remove the absorbed moisture. During drying, the initial moisture loss occurs rapidly due to the evaporation of surface water. As drying progresses, the remaining bound water within the cellular matrix evaporates more slowly, requiring more time for removal. However, despite the slower rate of moisture loss in later stages, the overall moisture content continues to decline with extended drying until equilibrium is reached (Barbosa-Cánovas, 1996; Bala, B. K. 2016; Thakur *et al*., 2021). Studies have shown contradictory results of moisture content may be due to the grain size, climatic condition, soil type and also the rate of drying of the grain after soaking. However, a similar study conducted by Thakur *et al*., 2021 found significant decrease in moisture content after prolonged soaking which is at par with the present study.

The protein content of finger millet tends to decrease with the increase in the soaking time. This decreasing trend might be attributed due to the leaching of soluble nitrogen and other nutrients into the water. Effect of temperature might also cause protein denaturation resulting in protein loss (Abioye *et al*., 2022). Similarly, Abioye *et al*., 2022 conducted a study and observed that the protein content decreased due to the leaching of soluble nitrogen. Another study conducted by Shobana and Malleshi, 2007 also recorded that the protein content decreased from native stage to decorticated stage ranged from 8.1 ± 0.7% to 6.3 ± 0.6% which is also similar with the present study. A study conducted by Chandra et al., 2016 also revealed that finger millet has a protein content of 7.3% that is at par to the present study.

The fat content also decreased as the soaking time was increased due to the leaching. This may be due to the disruption of cell membranes for prolonged soaking that results in leaching of polar lipids in the water. Moreover, soaking also increases lipase enzyme that initiate lipid hydrolysis resulting in leaching of fat (Abioye *et al*., 2022; Pandey & Awasthi, 2015). Study conducted by Abioye *et al*., 2022 and Pandey & Awasthi, 2015 found decrease in fat content that is similar to the present study. Study conducted by Shobana and Malleshi, 2007 also recorded that the fat content decreased from native stage to decorticated stage ranged from 1.5 ± 0.2% to 0.9 ± 0.2% which is also at par to the present study. Similarly, Chandra *et al*., 2016 also revealed that finger millet has a fat content of 1.3% that is similar to the present study.

Total ash or mineral content of grains tend to increase with prolonged soaking time. Water often contains dissolved minerals that may be absorbed by the grains through their softened outer layers during hydration. Moreover, soaking facilitates breakdown of anti-nutritional factors such as phytates, which typically bind essential minerals within the grain. As phytates are released into the soaking water, the bound minerals become more bioavailable, thereby contributing to an increase in total ash content (Keyata *et al*., 2021). The study conducted by Keyata *et al*., 2021 also showed similar results of increased total ash content with prolonged soaking time. Another study conducted by Hooda and Jood, 2002 revealed that the ash content of raw finger millet was 2.88 ± 0.06% that had increased to 2.92 ± 0.07% after soaking that indicated similarity to the present study. A study conducted by Kaur et al., 2014 also revealed that the finger millet had 2.6% of total ash content that corresponds to the present study. Another study conducted by Oghbaei and Prakash, 2016 also revealed that the total ash content of the whole finger millet flour was 2.21%, corresponding to the present study.

The crude fiber content tends to increase with prolonged soaking time due to softening and partial breakdown of the cell wall structures. This structural modification enhances the accessibility of fiber components and may stimulate enzymatic activities during soaking, which may alter complex carbohydrates into forms that are more readily measured as crude fiber. (Vasishtha & Srivastava, 2011). The study conducted by Vasishtha & Srivastava, 2011 show that fiber content tends to increase with the soaking time that is similar to the present study.

The carbohydrate content tends to increase with prolonged soaking time due to leaching of water-soluble non-carbohydrate components such as proteins and fats into the soaking water that leads to relative increase in the proportion of carbohydrates. Moreover, soaking may activate endogenous enzymes that break down complex polysaccharides into simpler compounds, thus increasing the carbohydrate content (Abioye *et al*., 2022). Similar study conducted by Abioye *et al*., 2022 also showed increase in the carbohydrate content that is similar to the present study. Similarly, another study conducted by Agugo and Onimawo, 2009 revealed that the carbohydrate content of the mung beans increased from raw to boiled stage with the range from 63.38% to 66.57% that is at par to the present study. Another study conducted by El-Adawy, 2002 revealed that the carbohydrate content of the chickpea has increased from 62.34 ± 0.26% to 62.43 ± 0.40% from raw stage to the boiled stage that also shows similarity with the present study.

Similarly, energy value of the grain increased with prolonged soaking, due to the leaching of non-carbohydrate components, resulting in relative increase in the proportion of energy-contributing nutrients, particularly carbohydrates and crude fiber. This shift in nutrient composition, expressed on a dry weight basis, leads to an overall enhancement in calculated energy content (Thakur *et al*., 2021). The study conducted by Thakur *et al*., 2021 also revealed that the energy value increase with the increase in soaking time that is similar to the present study.

**Table 1 Nutritive composition of Finger millet at different soaking hours at different water ratio**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Test sample** | **Energy content****(Kcal/100g)** | **Carbohydrate Content****(g/100g)** | **Crude Protein****(g/100g)** | **Crude Fat****(g/100g)** | **Crude Fiber****(g/100g)** | **Total mineral/Ash****(g/100g)** | **Moisture Content****(g/100g)** |
| **TFM0** (0 hours) | 340.74 ± 4.87 | 74.09 ± 0.83 | 7.17 ± 0.18 | 1.74 ± 0.24 | 1.22 ± 0.20 | 2.09 ± 0.06 | 11.69 ± 0.22 |
| **TFM1** (12 hours) | 340.52 ± 3.99NS | 74.13 ± 1.33NS | 7.12 ± 0.48NS | 1.72 ± 0.18NS | 2.17 ± 0.18S | 2.13 ± 0.30NS | 10.73 ± 0.20NS |
| **TFM1** (14 hours) | 345.06 ± 8.33NS | 75.87 ± 1.55NS | 6.85 ± 0.36NS | 1.57 ± 0.10NS | 2.23 ± 0.26S | 2.16 ± 0.17NS | 9.31 ± 1.79NS |
| **TFM1** (16 hours) | 348.81 ± 14.96NS | 77.31 ± 2.93NS | 6.74 ± 0.74NS | 1.40 ± 0.48NS | 2.38 ± 0.36S | 2.17 ± 0.01NS | 7.99 ± 2.42S |
| **TFM1** (18 hours) | 350.18 ± 4.71NS | 78.57 ± 0.70S | 5.07 ± 0.48S | 1.11 ± 0.09NS | 2.66 ± 0.30S | 2.22 ± 0.02NS | 6.97 ± 1.59S |
| **TFM2** (12 hours) | 334.95 ± 9.40NS | 74.04 ± 2.50NS | 7.26 ± 0.23NS | 1.08 ± 0.09NS | 2.00 ± 0.55NS | 1.85 ± 0.52NS | 11.77 ± 0.94NS |
| **TFM2** (14 hours) | 339.89 ± 3.53NS | 75.49 ± 0.96NS | 7.20 ± 0.36NS | 1.01 ± 0.17S | 2.16 ± 0.28S | 1.92 ± 0.11NS | 10.22 ± 0.79NS |
| **TFM2** (16 hours) | 342.98 ± 6.28NS | 76.99 ± 1.71NS | 6.85 ± 0.36NS | 0.85 ± 0.30S | 2.27 ± 0.14S | 2.13 ± 0.13NS | 8.91 ± 1.00NS |
| **TFM2** (18 hours) | 344.12 ± 2.31NS | 77.41 ± 0.97NS | 6.97 ± 0.18NS | 0.75 ± 0.27S | 2.48 ± 0.55S | 2.16 ± 0.12NS | 8.25 ± 0.65S |
| **CD** | **11.22** | **3.38** | **0.70** | **0.70** | **0.82** | **0.35** | **3.28** |

TFM0: No-soaking, TFM1: Soaking in water at 1:2 ratio, TFM2: Soaking in water at 1:3 ratio

Values are mean ± SD of 3 replications (n=3)

S - Significant at p ≤ 0.05

NS - Non significant

**CONCLUSION**

The study revealed that soaking significantly influenced the nutritional composition of the sample. It was observed that crude fibre, total ash, energy, and total carbohydrate levels showed an increasing trend with the increase in the soaking time. In contrast, a notable decrease was recorded in moisture content, crude protein and crude fat content, indicating a potential leaching or degradation effect during the soaking process. However, it is important to note that varying the water-to-sample ratio (1:2 and 1:3) has no significant differences in the nutritional parameters assessed. This suggests that the soaking water ratio does not have an impact on the nutritional quality of the sample but the increase in soaking time results in potential change in nutritional composition of finger millets. Therefore, the study depicts that optimum water ratio that is 1:2 is suitable for soaking of finger millet.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, manuscript) has been used to write the manuscripted.

**REFERENCE**

Abioye, V. F., Olatunde, S. J., Ogunlakin, G. O., & Abioye, O. A. (2022). Effect of soaking conditions on chemical composition, antioxidant activity, total phenols, flavonoids and antinutritional contents of finger millet. *African Journal of Food, Agriculture, Nutrition and Development*, *22*(7), 20942-20956.

Agugo, U. A., & Onimawo, I. A. (2009). HEAT TREATMENT ON THE NUTIRITIONAL VALUE OF MUNGBEAN. *Electronic Journal of Environmental, Agricultural & Food Chemistry*, *8*(10).

AOAC (2000). Association of Official Analytical Chemists. Official Methods of Analysis (Vol. II 17th edition) of AOAC International. Washington, DC, USA. Method Nos: 920.39, 920.87, 923.03, 925.10, 962.09, 974.24, 985.35 and 965.17

Bala, B. K. (2016). *Drying and storage of cereal grains*. John Wiley & Sons.

Barbosa-Cánovas, G. V., & Vega-Mercado, H. (1996). *Dehydration of foods*. Springer Science & Business Media.

Chandra, D., Chandra, S., & Sharma, A. K. (2016). Review of Finger millet (Eleusine coracana (L.) Gaertn): A power house of health benefiting nutrients. *Food Science and Human Wellness*, *5*(3), 149-155.

El-Adawy, T. A. (2002). Nutritional composition and antinutritional factors of chickpeas (Cicer arietinum L.) undergoing different cooking methods and germination. *Plant foods for human nutrition*, *57*, 83-97.

Hooda, S., & Jood, S. (2003). Effect of soaking and germination on nutrient and antinutrient contents of fenugreek (Trigonella foenum graecum L.). *Journal of Food Biochemistry*, *27*(2), 165-176.

ICAR-Indian Institute of Millets Research, <https://www.milletstats.com/finger-millet-ragi/>

Kaur, K. D., Jha, A., Sabikhi, L., & Singh, A. K. (2014). Significance of coarse cereals in health and nutrition: a review. *Journal of food science and technology*, *51*, 1429-1441.

Keyata, E. O., Tola, Y. B., Bultosa, G., & Forsido, S. F. (2021). Premilling treatments effects on nutritional composition, antinutritional factors, and in vitro mineral bioavailability of the improved Assosa I sorghum variety (Sorghum bicolor L.). *Food Science & Nutrition*, *9*(4), 1929-1938.

Lestiennem I, Mouquet-Rivier C, Icard-Verniere C, Rochette I and S Treche The effects of soaking of whole, dehulled and ground millet and soybean seeds on phytate degradation and Phy: Fe and Phy: Zn molar ratios. International Journal of Food Science. 2005; 40(4): 391-399.

Nkhata S.G, Ayua E, Kamau EH and J Shingiro Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. Food Science and Nutrition. 2018; 6(8): 2446–2458.

Oghbaei, M., & Prakash, J. (2016). Effect of primary processing of cereals and legumes on its nutritional quality: A comprehensive review. *Cogent Food & Agriculture*, *2*(1), 1136015.

Pandey, H., & Awasthi, P. (2015). Effect of processing techniques on nutritional composition and antioxidant activity of fenugreek (Trigonella foenum-graecum) seed flour. *Journal of food science and technology*, *52*, 1054-1060.

Prakash D, Suri S, Upadhyay G and BN Singh Total phenol, antioxidant and free radical scavenging activities of some medicinal plants. International Journal of Food Science and Nutrition. 2007; 58(1):18-28.

Rathod, J. M., Sarojini, J. K., & Hemalatha, S. (2019). Formulation of high fiber multigrain composite flour and its storage quality. *International Journal of Chemical Studies*, *7*(3), 1513-1516.

Shobana, S., & Malleshi, N. G. (2007). Preparation and functional properties of decorticated finger millet (Eleusine coracana). *Journal of Food Engineering*, *79*(2), 529-538.

Thakur, P., Kumar, K., Ahmed, N., Chauhan, D., Rizvi, Q. U. E. H., Jan, S., ... & Dhaliwal, H. S. (2021). Effect of soaking and germination treatments on nutritional, anti-nutritional, and bioactive properties of amaranth (Amaranthus hypochondriacus L.), quinoa (Chenopodium quinoa L.), and buckwheat (Fagopyrum esculentum L.). *Current Research in Food Science*, *4*, 917-925.

Vasishtha, H., & Srivastava, R. P. (2013). Effect of soaking and cooking on dietary fibre components of different type of chickpea genotypes. *Journal of Food Science and Technology*, *50*, 579-584.