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Improving the quality of pearl millet and wheat flour composite bread by optimizing process parameters

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Abstract

Bread is traditionally made from wheat flour. However, there are challenges in using wheat for bread development such as low yield, unable to resist drought, and low pest resistance in developing countries. Millets which are underutilized cereals on the other hand can overcome the above-mentioned challenges and hence can be used to make bread by mixing with wheat. However, using millet for bread development has some issues due to the presence of anti-nutritional factors (phytate and tannin). The overall process includes cleaning, washing the millet, germination (malting), drying, grinding, and dough preparation for making bread. The germination effect on the anti-nutritional contents was investigated by varying the germination time (1, 2, and 3 days) and germination temperature (25, 30, and 35°C). After the germination conditions were optimized, the effect of flour size (150, 250, and 350µm) and mixing ratio of millet flour with wheat (0, 10, 30, and, 50%) on antinutritional components and quality of bread were analyzed. The phytate and tannin content of raw pearl millet was 689.6 mg/100g and 834.72mg/100g respectively. The lowest phytate and tannin content for pearl millet was 95.5483 mg/100g and 105.2 mg/100g respectively at 30 oC for 3 days of germination. This result shows that both temperature and time during the germinating process have a significant impact on both phytate and tannin content reduction. The optimum mixing ratio (millet to wheat) and particle size were 10:90 and 150 micrometers respectively for pearl millet with wheat flour composite bread, which shows mixing ratio and particle size have a significant effect on the reduction of phytate, and tannin content and enhanced the quality of bread from pearl millet, and wheat composite bread.

Germination time, temperature, mixing ratio, and particle size appeared to be promising food processing parameters for improving the nutrient and energy densities of pearl millet, and wheat composite flour bread which enables to introduction of the utilization of underutilized and environmental shock-resilient cereals like pearl millet and this could be a means to alleviate the hidden hunger in developing countries including the global south.

Keywords: Bread, Phytate, Tannin, Germination, Pearl millet, Mixing

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Introduction

Bread is an ancient and widely consumed food product, considered one of the oldest known technologies [1]. Wheat is the most common cereal used for bread making. However, the use of wheat for breadmaking presents challenges such as low yield, vulnerability to drought, and limited pest resistance, particularly in developing countries [2]. Millets, on the other hand, are a diverse category of small-seed crops cultivated globally, especially in India, Africa, and China. They can offer a promising alternative to wheat due to their higher resistance to diseases and pests, adaptability to a wide range of climate conditions (including higher temperatures, arid, and semiarid conditions), and productivity under drought conditions [3,4]. Moreover, millets are affordable and offer nutritional benefits, being rich in protein, fiber, vitamins, and minerals such as zinc, iron, potassium, magnesium, and calcium [5]. Millets come in different species, such as pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), proso millet (*Panicum miliaceum*), and foxtail millet (*Setaria italica*) [6].
Pearl millet (PM) is a prevalent cereal crop grown in tropical dry and semi-dry regions, particularly in Africa and Asia. Pearl millet holds significant socio-economic, food/feed, health, and environmental implications for disadvantaged populations in Africa [4]. It is rich in zinc, fiber, antioxidants, energy, and iron, contributing to overall health and well-being [5]. However, it contains anti-nutrients such as phytic acid and tannins, which hinder the bioaccessibility and bioavailability of minerals, protein, and starch [7]. These anti-nutrients bind to proteins, carbohydrates, and minerals, reducing their digestibility in the human digestive system.

In Ethiopia, wheat production poses challenge due to increases in price and availability. Besides, in the 2015 Seqota Declaration, Ethiopia's government declared a high-level, 15-year commitment to eliminate stunting among children under the age of two by 2030 [8]. In contrast, pearl millet is an affordable cereal crop in some areas of Ethiopia, and it offers gluten-free and fiber-rich food stuffs [9]. Substituting wheat with pearl millet for bread preparation could be important to address protein malnutrition and mineral differences which are a main cause for children stunting under age five by using in different processed food forms at commercial and household level including bread making. The research presented focuses on optimizing the bread development process using a composite flour of pearl millet and wheat.

Material and Methods

Pearl millet (Kola-1; accession number: ICMV221) was obtained from the Seka Dryland Agricultural Research Center in Ethiopia. Initially, the proximate values of both germinated (at 25°C for 3 days) and un germinated pearl millet were analyzed. Subsequently, germination time (1, 2, and 3 days) and germination temperature (25, 30, and 35°C) were optimized using a central composite design (CCD) and response surface methodology (Design Expert 11), with phytic acid and tannins as the response variables.

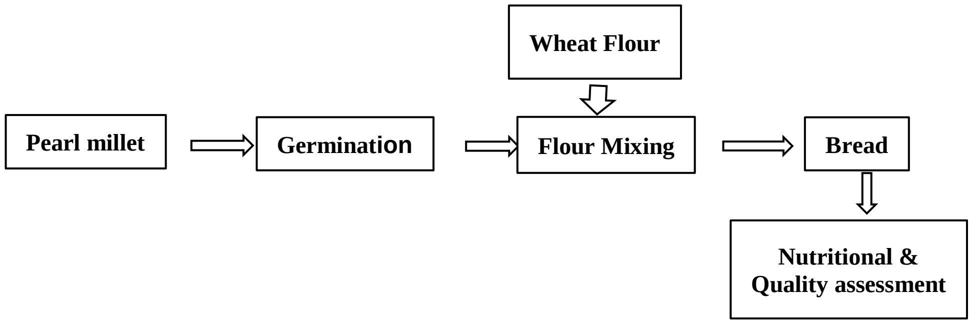


Fig. 1. Schematic diagram of bread development from wheat, germinated pearl millet and quality parameter analysis

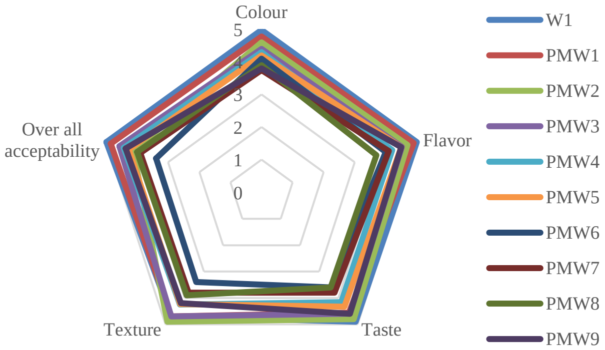
In the second optimization step, the effects of flour sieve size (150, 250, and 350 µm) and the mixing ratio of pearl millet flour with wheat (0, 10, 30, and 50%) were optimized, considering antinutritional components and bread quality as responses for pearl millet germinated for 3 days at 30°C. Finally, for the optimized sample, the proximate composition, antinutrients, functional properties, and sensory values of the developed bread were analyzed using standard procedures (as shown on **Fig 1**).

Results and Discussion

The protein content of raw and germinated pearl millet was found to be 11.4% and 13.9%, respectively. The increase in protein content in the germinated pearl millet could be attributed to enhanced bioavailability of proteins during germination which could be the biological synthesis of new amino acids and a corresponding decrease in carbohydrates [10]. Germination reduced the lipid content, which might be due to hydrolysis and the utilization of fats as an energy source for biochemical reactions. Germination enhances the fiber content of pearl millet, due to the degradation of dry matter through enzymatic hydrolysis of starch and microbial breakdown of carbohydrates, proteins, and fats and formation of cellulose, lignin, and hemicellulose from crude fiber, and synthesis of various cellular components in plant cells [11]. Germination improves the functional values of flour samples and sensory values of bread (**Figure 3**). The bulk density of the composite flour was within the range of 0.65 g/ml to 0.75 g/ml. The water absorption capacity (WAC) of flour samples ranged from 0.4 ml/g to 1.3 ml/g. WAC is significantly affected by the blending ratio. The highest WAC was observed in the 50:50 ratio of pearl millet to wheat flour with a flour particle size of 150µm (PMW7). WAC is an important factor in food products as it influences both economic viability and quality as it reflects the ability of proteins and fibers to absorb and retain water by providing hydrophilic components such as polar and charged side chains [12]. Antinutrients are substances that can interfere with the absorption or utilization of nutrients, including minerals and proteins. The initial phytate content of raw pearl millet (PM) was measured at 689.6 mg/100g while lowest recorded phytic acid content was 95.55 mg/100g, achieved after three days of germination at a temperature of 30°C. and the lowest tannin content observed in the PM and wheat flour composite bread was 2.649 mg CE/100g after pearl millet germination.

a b c d

Fig. 2. Pearl millet (PM) processing steps; a-PM grain, b- germinated PM, c- flour and d- bread from PM and wheat flour



Where: W1=wheat at 150 µm sieve size, W2=wheat at 250 µm , W3=wheat at 350 µm, PMW1=pearl millet to wheat 10:90 at 150µm, PMW2=pearl millet to wheat 10:90 at 250µm, PMW3=pearl millet to wheat 10:90 at 350µm, PMW4= pearl millet to wheat 30:70 at 150µm, PMW5=pearl millet to wheat 30:70 at 250µm, PMW6= pearl millet to wheat 30:70 at 350µm, PMW7= pearl millet to wheat 50:50 at 150µm, PMW8= pearl millet to wheat 50:50 at 250µm, PMW9= pearl millet to wheat 50:50 at 350µ ; WAC-Water Absorption index; OAC- oil absorption index

Fig. 3. Mean scores of the sensory evaluation of pm-wheat composite bread

The optimized composite flour bread, consisting of pearl millet (PM) and wheat flour, as shown in Table 4 exhibited a protein content of 11.32%, ash content of 2.81%, fat content of 3.58%, fiber content of 2.92%, carbohydrate content of 67.61%.

Conclusions and Outlook

Pearl millet has comparable nutritional content and could be a valuable ingredient in preparing more nutrient-rich bread. However, certain antinutrients, such as phytates and tannins, can bind to these nutrients, making them unavailable for absorption in the digestive system. Despite the presence of antinutritional components, simple processing methods like germination can effectively reduce these antinutrients to manageable levels. The optimal germination time and temperature for maximum output have not been extensively studied. The optimal germination time and temperature were (3 days and 30°C). Optimum mixing ratio (1 pearl millet: 9 wheat flour) and particle size of flour were 150µm. Germination reduces the phytate (by 86.1%) and tannin content (by 74.6%). Antinutrients reduction expected to enhance bioaccessibility of minerals in digestion process. WAC and oil absorption content (OAC) increased with an increasing pearl millet flour while bulk density decreased. Overall acceptability of bread samples was above 3.39 on seven hedonic scale. Therefore, Pearl millet has a potential to alleviate the hidden hunger in developing countries.

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