

been as a result of some of the products from the breakdown of phenolic compounds involvement in the scavenging activities of free radicals that could cause spoilage of the stored flour (Ali et al., 2022).

Iron, calcium, zinc, and phosphorus are vital minerals essential for human health. Iron is crucial for oxygen transport in the blood and energy metabolism. Calcium supports strong bones and teeth, muscle function, and nerve signaling (Soetan et al., 2010). Zinc plays a key role in immune function, wound healing, and enzyme activity. Phosphorus is important for bone mineralization, energy production through ATP, and cell membrane integrity. Adequate intake of these minerals through food is necessary to prevent deficiencies, support growth, maintain physiological functions, and promote overall well-being (Serna and Bergwitz, 2020). The preservation of iron, calcium and phosphorus in plantain flour was observed to be better in BHP, this might be as a result of the black colour of the BHP reducing photo-oxidation of these elements as earlier reported (Wang et al., 2022).

4 Conclusion

The colour and thickness of polyethylene packaging materials significantly influence the retention of minerals, vitamins, and antioxidant properties of stored plantain flour. Across all treatments, storage resulted in measurable nutrient losses compared with baseline values; however, the extent of degradation varied with packaging characteristics. Transparent low-density polyethylene (TLP) favoured the retention of vitamin A and zinc and exhibited the highest DPPH antioxidant activity, suggesting enhanced radical scavenging potential under this packaging condition. In contrast, black high-density polyethylene (BHP) provided superior protection for vitamin B6 and key minerals such as iron, calcium, and phosphorus, highlighting the role of increased thickness and reduced light permeability in limiting nutrient degradation. Vitamin B9 was best preserved in transparent high-density polyethylene (THP), indicating that both density and optical properties interact to affect nutrient stability. Although antioxidant activity increased during storage, a concurrent decline in total phenolic content suggests phenolic degradation or transformation into other antioxidant compounds over time. Overall, the findings confirm that no single packaging material optimally preserves all nutrients; rather, packaging choice should be guided by the target nutritional components of interest. The study underscores the importance of selecting appropriate polyethylene colour and thickness to enhance shelf life, maintain nutritional quality, and support food security in plantain flour processing and storage systems, particularly in low-resource settings.

5 Materials and Methods

The unripe French plantain (*Musa paradisiaca*) fruits used for this research were of the same species and sourced from a local farm at Ikere, Ekiti State, Nigeria. The French plantain is called “Ogede agbagba” in Yoruba language. It is characterized by a complete, dense bunch carrying many hands and numerous smaller fingers, topped with a large, persistent male bud at maturity (Orluchukwu and Ogburia, 2014). The fruits were carefully sorted so that those used for the experiment were devoid of visible phytopathogenic defects and of length 20 ± 5 cm. The fruits were manually de-skinned, and the remaining pulp matrices were systematically sliced into small pieces to accelerate sun drying. The pulp slices were subjected to conventional open-air solar drying until they reached constant weight equilibrium and were subsequently pulverized using a heavy-duty 750-watt Solitaire Mixer Grinder. The powder was allowed to be thermally stable to ambient temperature. The resulting flour was passed through a standard 250 μ m sieve to remove extraneous particulate matter, fibrous fractions, and oversized plantain particles.

5.1 Experimental design and storage conditions

The packaging bags used for this experiment were of polythene materials and measured 15 cm by 15 cm. The bags were categorized into four distinct groups based on pigment profile (transparent and black) and thickness {0.03 mm (low-density polyethylene) and 0.15 mm (high-density polyethylene)}. The bags were divided into four groups: transparent low-density polyethylene (TLP), transparent high-density polyethylene (THP), black low-density polyethylene (BLP) and black high-density polyethylene (BHP). Aliquots of 50 g of the processed plantain flour were measured using electronic scale weighing balance (LCD type) and transferred into each type of polythene bag in triplicates, making a total of 12 bags of 50 g plantain flour. Samples of the flour were analyzed for minerals (Fe, Ca, Zn and P), vitamins (A, B6 and B9) and antioxidant properties (total phenolic