

The effects of colour and thickness of polyethylene packs on the retention of Fe, P, Ca and Zn in stored plantain flour are described in Table 2. The results show that mineral contents of the stored plantain flour decreases with time. Moreover, flour packed in BHP recorded 1.11, 697.27 and 20.5 mg/kg values of Fe, P and Ca respectively. The calcium and phosphorus retained in flour stored in BHP were significantly higher. Similarly, the Zn retention in the flour stored in TLP polyethylene is significantly higher than Zn contents of flour stored in THP, BLP and BHP. The amount of Zn retained in flour stored in THP, BLP and BHP were 0.92, 0.10 and 0.73 mg/kg respectively.

Table 2 The mineral content of the packaged and stored plantain flour compared with the baseline

Packaging material	Fe (mg/kg)	P (mg/kg)	Ca (mg/kg)	Zn (mg/kg)
Baseline	2.61 ± 0.71a	709.77 ± 28.10d	24.6 ± 0.72e	1.83 ± 0.14d
TLP	0.82 ± 0.00b	571.37 ± 14.47c	10.1 ± 0.14a	1.13 ± 0.00c
THP	0.80 ± 0.00b	470.66 ± 12.06b	17.7 ± 0.14c	0.92 ± 0.00b
BLP	0.63 ± 0.00b	420.30 ± 10.86a	16.1 ± 0.14b	0.10 ± 0.00bc
BHP	1.11 ± 0.00b	697.27 ± 17.49d	20.5 ± 0.14d	0.73 ± 0.00a

Note: Means followed by the same superscript letter within the same column are not significantly different ($P > 0.05$) according to Duncan's multiple range test. TLP: Transparent Low-Density Polyethylene, THP: Transparent High-Density Polyethylene, BLP: Black Low-Density Polyethylene, BHP: Black High-Density Polyethylene

3 Discussion

Polyethylene material is widely used as a mechanical barrier to micro-organisms and macro-organisms causing spoilage to food. Polyethylene also provides a barrier to some abiotic materials such as light, wind, water etc. that are capable of causing spoilage to food. The characteristics of the polyethylene may have direct significant effects on the protective properties of stored food. Luangtana-anan et al. (2017) reported an enhancement of moisture protective properties and stability of pectin via plastic protection. The investigation of the different properties of polyethylene revealed that the properties of the polyethylene have different effects on the retention of the nutritional composition of the stored plantain flour. Vitamin A retention in the plantain flour was favored by transparent low-density polyethylene (TLP). The heat production of TLP might be lower when compared to other polyethylene types considered for storage and this might have contributed to the retention of vitamin A in the flour stored in it. This observation is consistent with the report of Anand et al. (2022), who reported that plant vitamin A, β -carotene are heat-labile therefore its preservation must be in low heat environment. Black high-density polyethylene retains the highest amount of vitamin B6. Plant vitamin B6 (pyridoxine) has been reported to be light sensitive (Gorelova et al., 2022). The black colour of the BHP might have aided the barrier of the plastic to light energy to preserve pyridoxine better than the other types of the polyethylene examined.

Vitamin B9 (folate) is highly water-soluble and is important for DNA synthesis and cell division. The observation of the preservation of folate in the plantain flour packaged in THP (showed the highest folate retention) is slightly contradictory to the report of Liu et al. (2022) who reported that folate is sensitive to photooxidation. Although THP might have favoured folate preservation via heat reduction; owing to the fact that transparent materials could be poor radiator of heat energy (Salimian and Onwukwe, 2023).

Increase in antioxidant activities was also observed in all the polyethylene used (observed through increase in DPPH). High density of the polyethylene could have influenced the production of DPPH positively thereby extending the shelf life of the stored flour. A report by Rojas-Lema et al. (2021) indicated that high density polyethylene favors antioxidant activities in stored food. Although the antioxidant activities were observed to an increase in all plantain flour samples packed in polyethylene, it was also observed that the phenolic content of the flour reduced greatly. The phenol in the flour might have been highly susceptible to degradation forming new products in the period of storage in the polyethylene, this could have resulted in the reduction in its quantity (Rojas-Lema et al., 2021). Similarly, Liang et al. (2023) reported a significant decrease in the phenolic contents of some fermented foods in the process of antioxidant activities in food. The increase in the DPPH could have also