



Evaluation of the Microbiological Quality and Nutritional Potential of Composite Infant Flours Based on Tiger Nut (*Cyperus esculentus*) and Sweet Potato (*Ipomoea batatas*) in Northern Côte d'Ivoire

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Abstract

Childhood malnutrition remains a major public health concern in sub-Saharan Africa, particularly where access to fortified complementary foods is limited. This study evaluated the microbiological quality and micronutrient and phenolic profiles of three composite infant flours formulated from tiger nut (*Cyperus esculentus* L.) and sweet potato (*Ipomoea batatas*) in northern Côte d'Ivoire. Microorganisms were enumerated using the pour-plate method. Minerals were determined by atomic absorption spectrometry, total polyphenols and flavonoids by spectrophotometric methods, β -carotene and vitamin A by spectrophotometry.

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and conversion, and vitamin C by redox titration. Total mesophilic aerobic flora ranged from 77.63 to 88.42 CFU/g, total coliforms from 32.30 to 54.42 CFU/g, and yeasts and moulds from 24.28 to 34.23 CFU/g; faecal coliforms and *Staphylococcus aureus* were not detected. Potassium and magnesium ranged from 1015.28 to 1019.72 mg/100 g and 109.27 to 118.06 mg/100 g, respectively. Vitamin A ranged from 0.35 to 0.96 mg/100 g, while vitamin C ranged from 43.98 to 50.16 mg/100 g. Iron, zinc, calcium, phosphorus, and sodium were comparatively low. Total polyphenols and flavonoids ranged from 0.96 to 1.30 µg GAE/g and 0.46 to 0.54 µg QE/g, respectively. Under the tested conditions, the formulations showed satisfactory microbiological quality and useful nutritional attributes, although fortification with selected minerals would be required to better meet infant nutritional requirements.

Keywords: Childhood malnutrition; complementary feeding; composite infant flour; Tiger nut; *Cyperus esculentus*; sweet potato; *Ipomoea batatas*; microbiological quality; micronutrients; phenolic compounds.

1. Introduction

Childhood malnutrition corresponds to a nutritional imbalance resulting from insufficient, excessive, or inadequate intake of essential nutrients. Its repercussions on child growth and health are considerable, particularly among children under five years of age. Infants aged 6 to 24 months are the most vulnerable, with manifestations such as stunting (22%), wasting (6.7%), and overweight (5.7%). Globally, nearly 340 million children present a micronutrient deficiency (UNICEF, 2021; World Health Organization, n.d.). To address this problem, breastfeeding must be complemented by infant flours fortified with essential nutrients. These formulations provide adequate energy and vitamin intake, thereby contributing to the prevention of common infections (World Health Organization, 2023). Their efficacy is well documented: they have halved the prevalence of iron-deficiency anaemia and improved the nutritional status of nearly 75% of malnourished children (Bhutta *et al.*, 2013; Phuka *et al.*, 2009). Nevertheless, despite these advances, childhood malnutrition persists, particularly in disadvantaged areas where access to such products remains limited and infrastructure remains inadequate (UNICEF, 2021). Faced with these constraints, rural communities are increasingly turning to local resources to develop accessible and effective infant flours. Recent studies of sweet-potato-based complementary foods formulated with locally available ingredients have reported improved nutritional and functional characteristics, supporting the feasibility of such approaches for infant feeding (Alomatu *et al.*, 2025; Nchung *et al.*, 2024). Several initiatives have shown encouraging results: in Niger, a flour based on millet, soybean, and local spirulina enabled the nutritional rehabilitation of 80% of malnourished children; in Benin, a locally formulated multi-ingredient flour based on maize, soybean, sorghum, peanut, baobab pulp, and fish was evaluated during community nutritional rehabilitation of moderately malnourished children (Lalèyè *et al.*, 2023; Razak *et al.*, 2021). Related formulations incorporating orange-fleshed sweet potato, and in some cases tiger nut, further demonstrate that ingredient selection can influence micronutrient composition and overall product quality (Abazidi *et al.*, 2025; Eke *et al.*, 2024). It is within this context that the present study, conducted in the Korhogo department of northern Côte d'Ivoire, is situated. However, the microbiological quality together with the micronutrient and phenolic profiles of infant flours formulated specifically from tiger nut and different sweet potato varieties in northern Côte d'Ivoire remain insufficiently documented. The present study aims to contribute to efforts to address childhood malnutrition through the development of composite flours formulated from tiger nut (*Cyperus esculentus* L.) and sweet potato (*Ipomoea batatas*). More specifically, it evaluates the microbiological quality and the micronutrient and phenolic contents of these formulations to assess their safety and nutritional suitability for infant feeding.

2. Materials and Methods

2.1 Biological Material

The biological material consisted of tiger nut tubers (*Cyperus esculentus*) and three sweet potato (*Ipomoea batatas*) varieties, purchased at the Korhogo market in northern Côte d'Ivoire. The sweet potato varieties selected were white-skinned/white-fleshed, yellow-skinned/orange-fleshed, and purple-skinned/white-fleshed sweet potato. Sweet potato tubers were first washed with distilled water, peeled and then cut into thin slices before being weighed. Tiger nut tubers were carefully sorted to remove impurities and then washed with clean water. After cleaning, each sample was oven-dried at 60 °C for 24 to 48 hours, then individually ground using an electric grinder (RETSCH, type AS 200) to obtain a fine powder, which was stored in labelled containers. These flours were used for the formulations.

2.2 Methods

2.2.1 Formulation of the Composite Infant Flours

The composite infant flours based on sweet potato and tiger nut were formulated using the Pearson square method. This method constitutes a standard manual graphical technique for formulating mixtures from two ingredients (Brah *et al.*, 2016). It consists of placing the target nutrient content at the centre of a square, while the contents of each of the two ingredients are positioned at the left-hand corners. The calculated diagonal differences, expressed as absolute values, determine the respective proportions of each ingredient to be mixed to obtain the desired formulation. These calculations yielded three distinct formulations:

- **F1:** tiger nut flour (55.06 g) and white-skinned/white-fleshed sweet potato flour (44.94 g);
- **F2:** tiger nut flour (53.89 g) and yellow-skinned/orange-fleshed sweet potato flour (46.11 g);
- **F3:** tiger nut flour (53.07 g) and purple-skinned/white-fleshed sweet potato flour (46.93 g).

The resulting flours were used to evaluate microbiological quality, micronutrient content, and phenolic compound content.

2.2.2 Determination of the Mineral Content of the Formulated Flours

The mineral profile of each flour was determined by flame atomic absorption spectrometry (AAS), following the acid solubilisation method described by Williams (1984). Briefly, a 1 g test portion of ash was dissolved in 10 mL of concentrated hydrochloric acid. To prevent chemical interference during the assay (particularly for calcium and magnesium), 10 mL of a lanthanum chloride solution, prepared from 18 g of lanthanum oxide and 250 mL of concentrated HCl, was added to the medium. The mixture was then transferred to a volumetric flask and made up to 100 mL with distilled water. Quantification of the different elements was carried out using an atomic absorption spectrophotometer (Perkin-Elmer, USA) equipped with a burner fed by an air-acetylene mixture. Concentrations were determined at the specific wavelength of each element by extrapolation from the respective calibration curves.

2.3 Microbiological Analyses

2.3.1 Preparation of the Inoculum

Preparation of stock suspensions and decimal dilutions was carried out in accordance with the general food microbiology standard NF ISO 6887-1 (International Organization for Standardization [ISO], 2017). A 10 g test portion of each composite flour was aseptically introduced into a sterile flask containing 90 mL of 0.85% (w/v) buffered physiological water. The mixture was homogenised by vortexing for 2 min to obtain the stock suspension (10^{-1} dilution). From this initial suspension, successive decimal dilutions were prepared up to 10^{-5} in the same sterile diluent. These dilutions were used to enumerate the different target microorganisms. Results for each microorganism were expressed in colony-forming units per gram of sample (CFU/g), in accordance with standard NF ISO 7218 (ISO, 2024), using the following formula:

$$N = \Sigma C / [V \times (n_1 + 0.1 \times n_2) \times d]$$

N: number of microorganisms per gram of sample (CFU/g); *ΣC*: sum of colonies counted on the plates retained at the two successive dilutions; *V*: volume of suspension inoculated per plate (mL); *n*₁: number of plates retained at the first (lower) dilution; *n*₂: number of plates retained at the following (more dilute) dilution; *d*: dilution factor corresponding to the first dilution retained (*n*₁).

2.3.2 Enumeration of Microorganisms in the Composite Infant Flours

Enumeration of microorganisms in each composite flour sample was carried out by the pour-plate method using the decimal dilutions previously prepared. For each dilution, 1 mL was withdrawn and plated in duplicate into sterile Petri dishes. Subsequently, 15 mL of agar medium specific to the target microorganism, previously prepared, was poured into the Petri dishes. After homogenisation by circular movements and complete solidification of the agar, the Petri dishes were incubated, inverted, at the temperature and for the duration appropriate to the target microorganism (Table 1).

Table 1. Microorganisms tested in the composite flours

Target microorganisms	Culture medium	Incubation temperature and duration	Standard
Total mesophilic aerobic flora (TMAF)	PCA	30 °C / 72 h	NF ISO 4833-1
Total coliforms	VRBL	30 °C / 24 h	NF ISO 4832
Fecal coliforms	VRBL	44 °C / 24 h	NF V08-060
Yeasts and molds	Sabouraud + chloramphenicol	25 °C / 4 days	NF ISO 21527-1/2
Staphylococcus aureus	Baird-Parker + RPF	37 °C / 24 h	NF EN ISO 6888-1

PCA: Plate Count Agar; *VRBL*: Violet Red Bile Lactose agar; *RPF*: Rabbit Plasma Fibrinogen; *TMAF*: Total Mesophilic Aerobic Flora; *NF ISO* / *NF EN ISO*: official (French and international) standards defining the analytical method to be followed. The methods in Table 1 correspond to ISO 4833-1 (ISO, 2013a), ISO 4832 (ISO, 2006b), NF V08-060 (Association Française de Normalisation, 2009), ISO 21527-1 and ISO 21527-2 (ISO, 2008a, 2008b), and ISO 6888-1 (ISO, 2021a)

2.4 Determination of the Phenolic Compound Content of the Formulated Flours

2.4.1 Total Polyphenols

The total polyphenol content in each composite flour was determined according to the method described by Kouamé *et al.* (2021). Briefly, 2.5 mL of Folin-Ciocalteu reagent diluted 1/10 was added to 30 µL of flour extract. The resulting mixture was kept in the dark at room temperature for 2 min. Then, 2 mL of a sodium carbonate solution (75 g/L) was added to this mixture. Finally, the resulting solution was incubated at 50 °C for 15 min. After incubation, the absorbance was read spectrophotometrically at 760 nm against a blank. Gallic acid was used as the reference standard for quantification, with the content expressed in milligrams of gallic acid equivalent per gram of flour (mg GAE/g flour).

2.4.2 Flavonoids

The total flavonoid content of the extracts was determined according to the method described by Marinova *et al.* (2005). Briefly, 0.75 mL of 5% sodium nitrite solution and 0.75 mL of 10% aluminium chloride solution were added to 2.5 mL of a 1/500 (w/v) flour solution. After 5 min of incubation, the mixture was combined with 5 mL of 1 M sodium hydroxide solution. The resulting volume was adjusted to 25 mL and vigorously mixed. The absorbance was measured spectrophotometrically at 510 nm against a blank. Quercetin was used as the reference standard for quantification, with the content expressed in milligrams of quercetin equivalent per gram of flour (mg QE/g flour).

2.5 Essential Nutrients

2.5.1 β -Carotene and Vitamin A Content

β -Carotene content of the composite flours was determined by spectrophotometry, following the method of Sass-Kiss *et al.* (2005). A 1 g test portion of each flour was combined with 2.5 mL of 96% ethanol and 0.1 mL of a 20% (w/v) alcoholic hydroquinone solution, used as an antioxidant. After adding 5 mL of hexane, the mixture was homogenised by vortexing and then centrifuged at 3,000 rpm for 20 min. The resulting organic supernatant was collected in tubes wrapped in aluminium foil to limit carotenoid photodegradation. The absorbance of a 4 mL aliquot was read at 450 nm using a UV-Vis spectrophotometer (T80, PG Instruments), with the blank prepared according to the same protocol in the absence of sample. A calibration curve was established from a 10 μ g/mL β -carotene stock solution, enabling the β -carotene concentration of each extract to be determined by extrapolation. Vitamin A content was derived from β -carotene content by applying the standard conversion factor. β -Carotene and vitamin A contents were calculated using the following equations:

$$\beta\text{-Carotene content (mg/100 g)} = (C \times V \times 100) / (Pe \times 1000)$$

$$\text{Vitamin A content (mg/100 g)} = \beta\text{-Carotene content (mg/100 g)} / 6$$

C: β -carotene concentration of the flour (μ g/mL); *V*: total volume of the hexane extract (mL); *Pe*: mass of the test portion (g); 100 and 1000: conversion factors used to express the result in mg/100 g.

2.5.2 Vitamin C Content

Vitamin C (ascorbic acid) content of the composite flours was determined by the redox titration AOAC Official Method 967.21 (Latimer, 2023). The principle relies on the reduction of 2,6-dichlorophenolindophenol (2,6-DCPIP) by the ascorbic acid present in the sample. Briefly, 10 g of each flour was dissolved in 40 mL of a 2% (w/v) mixture of metaphosphoric acid and acetic acid. The resulting suspension was centrifuged at 3,000 rpm for 20 min. The supernatant was then collected in a 50 mL volumetric flask, and the volume was adjusted to the mark with distilled water previously boiled and cooled to limit dissolved oxygen. A 10 mL aliquot of this aqueous extract was transferred to an Erlenmeyer flask and titrated with a 0.5 g/L 2,6-DCPIP solution until the appearance of a persistent pink colour lasting at least 15 seconds. Vitamin C content was calculated using the following equation:

$$\text{Vitamin C content (mg/100 g)} = (V \times T \times 100) / Pe$$

V: volume of 2,6-DCPIP solution used to titrate the aliquot (mL); *T*: titre of the 2,6-DCPIP solution, expressed in milligrams of ascorbic acid per millilitre; *Pe*: volume of the titrated aliquot, corresponding to the test portion (mL); 100: factor used to express the result in mg/100 g.

2.6 Statistical Analysis

Experimental data were analysed using SPSS software (version 26). Values are presented as means $\pm$ standard deviations. To assess the significance of the observed differences, analysis of variance (ANOVA) was used, followed by Tukey's multiple comparison test at the 5% significance level.

3. Results and Discussion

3.1 Results

3.1.1 Microbiological Quality of the Composite Infant Flours

Table 2 presents the enumeration of pathogenic microorganisms in the composite infant flours relative to reference standard values. Analysis of the results showed that counts of total mesophilic aerobic flora, total coliforms, and yeasts and moulds ranged from 77.63 to 88.42 CFU/g, 32.30 to 54.42 CFU/g, and 24.28 to 34.23 CFU/g, respectively. These values were significantly below the limit set for the microbiological quality of infant flour. For all microorganisms, the highest values were recorded for formulation F2 and the lowest for F1. Formulation F3 recorded intermediate values, at 85.60 CFU/g for total mesophilic aerobic flora, 44.05 CFU/g for total coliforms, and 28.10 CFU/g for yeasts and moulds. Statistical analysis revealed a significant difference in microbial counts among the formulations ($p < 0.05$). Finally, the formulations contained no faecal coliforms or *Staphylococcus aureus*.

Table 2. Microbiological quality of the composite flours

Target microorganisms	F1	F2	F3	Criteria and standards
TMAF	77.63 $\pm$ 3.02 ^c	88.42 $\pm$ 6.3 ^a	85.60 $\pm$ 1.32 ^b	10 ⁵ CFU/g (ISO 4833-1; ISO 4833-2)
Total coliforms (TC)	32.30 $\pm$ 9.46 ^c	54.42 $\pm$ 3.4 ^a	44.05 $\pm$ 1.2 ^b	10 ³ CFU/g (ISO 4831; ISO 4832)
Fecal coliforms (FC)	0	0	0	10 ³ CFU/g (ISO 4831; ISO 4832)
Yeasts and molds (YM)	24.28 $\pm$ 4.12 ^c	34.23 $\pm$ 6.42 ^a	28.10 $\pm$ 9.6 ^b	10 ³ CFU/g (ISO 21527-1)
<i>Staphylococcus aureus</i> (S.a)	0	0	0	10 CFU/g (ISO 6888-1; ISO 6888-2)

TMAF: Total mesophilic aerobic flora; TC: Total coliforms; FC: Fecal coliforms; YM: Yeasts and molds; S.a: *Staphylococcus aureus*; ISO: International Organization for Standardization. Values followed by the same superscript letter within the same row do not differ significantly ($P > 0.05$). The reference criteria in Table 2 also cite ISO 4833-2 (ISO, 2013b), ISO 4831 (ISO, 2006a), and ISO 6888-2 (ISO, 2021b)

3.1.2 Mineral Content of the Composite Infant Flours

The mineral content (iron, zinc, calcium, potassium, magnesium, sodium, and phosphorus) of the composite flours is presented in Table 3. Iron, zinc, calcium, and potassium contents ranged from 8.24 to 8.47 mg/100 g, 1.35 to 1.87 mg/100 g, 119.22 to 122.18 mg/100 g, and 1015.28 to 1019.72 mg/100 g, respectively. Flours F3 and F2 showed the highest iron contents (8.47 mg/100 g and 8.40 mg/100 g, respectively) and calcium contents (122.18 mg/100 g and 120.55 mg/100 g, respectively), compared with formulation F1 (8.24 mg/100 g for iron and 119.22 mg/100 g for calcium). Regarding zinc, formulation F1 showed the highest concentration (1.87 mg/100 g), followed by F3 (1.65 mg/100 g), while F2 displayed the lowest content (1.35 mg/100 g). Regarding potassium, formulations F1 and F3 showed the lowest contents, at 1015.28 mg/100 g and 1016.38 mg/100 g, respectively, while F2 showed the highest content (1019.72 mg/100 g). Statistical analysis revealed a significant difference among formulations ($p < 0.05$).

Analysis also showed that magnesium, sodium, and phosphorus contents of the composite infant flours ranged from 109.27 to 118.06 mg/100 g, 37.95 to 55.79 mg/100 g, and 137.01 to 138.07 mg/100 g, respectively. For magnesium, formulation F3 showed the highest content (118.06 mg/100 g), followed by F2 (114.12 mg/100 g), while F1 displayed the lowest content (109.27 mg/100 g). For sodium, formulation F2 showed the highest content (55.79 mg/100 g), followed by F3 (40.34 mg/100 g), while F1 showed the lowest concentration (37.95 mg/100 g). Statistical analysis revealed a significant difference among formulations ($p < 0.05$). Finally, no significant difference was observed among the phosphorus contents of the three formulations F1 (137.09 mg/100 g), F2 (138.07 mg/100 g), and F3 (137.01 mg/100 g).

Table 3. Mineral composition of the flours

Parameters (mg/100 g)	F1	F2	F3
Iron (Fe)	8.24 ± 0.01 ^b	8.40 ± 0.51 ^a	8.47 ± 0.65 ^a
Zinc (Zn)	1.87 ± 0.21 ^a	1.35 ± 0.34 ^c	1.65 ± 0.42 ^b
Calcium (Ca)	119.22 ± 0.01 ^b	120.55 ± 0.53 ^a	122.18 ± 0.75 ^a
Potassium (K)	1015.28 ± 0.31 ^b	1019.72 ± 0.36 ^a	1016.38 ± 0.82 ^b
Magnesium (Mg)	109.27 ± 0.41 ^c	114.12 ± 0.42 ^b	118.06 ± 0.86 ^a
Sodium (Na)	37.95 ± 0.31 ^c	55.79 ± 0.45 ^a	40.34 ± 0.53 ^b
Phosphorus (P)	137.09 ± 0.41 ^a	138.07 ± 0.65 ^a	137.01 ± 0.11 ^a

Values followed by the same superscript letter within the same row do not differ significantly ($P > 0.05$).

3.1.3 Phenolic Compound Content of the Composite Infant Flours

Total polyphenols were quantified using the calibration line $Y = 0.6484x - 0.0025$, with a regression coefficient $R^2 = 0.995$. Total flavonoids were determined using the line $Y = 0.6455x - 0.0025$, with a regression coefficient $R^2 = 0.9983$ (Figs. 1 and 2). Analysis of the graphs showed that the composite infant flours contained, respectively, 0.96 µg GAE/g flour of total polyphenols for F2, 1.27 µg GAE/g flour for F1, and 1.30 µg GAE/g flour for F3. In addition, flavonoid content was 0.46 µg QE/g, 0.47 µg QE/g, and 0.54 µg QE/g for F1, F2, and F3, respectively. Examination of these results revealed that total polyphenol and flavonoid contents were generally low across all formulations, but nevertheless showed significant differences among them ($p < 0.05$).

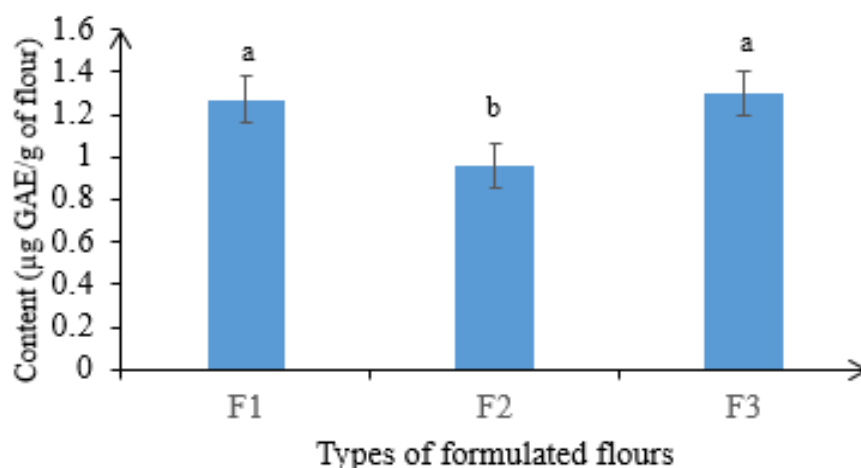


Fig. 1. Total polyphenol contents of the composite flours
Bars bearing the same letter do not differ significantly ($P > 0.05$)

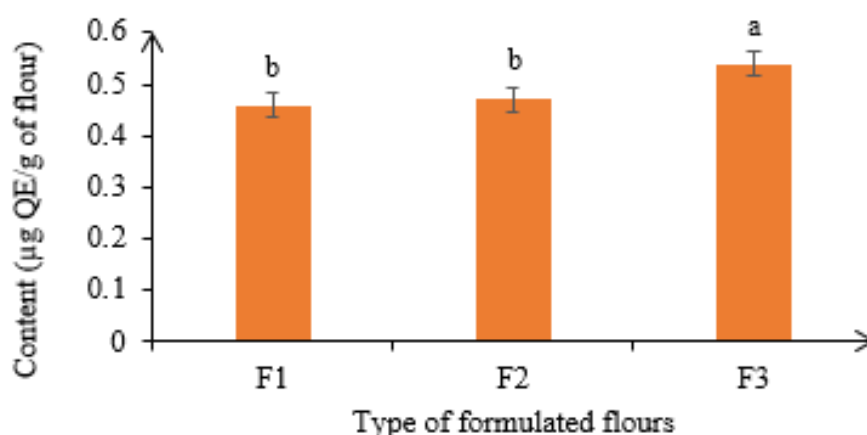


Fig. 2. Flavonoid contents of the composite flours
Bars bearing the same letter do not differ significantly ($P > 0.05$)

3.1.4 Vitamin and Provitamin Content of the Composite Infant Flours

The graph in Fig. 3 presents the vitamin and provitamin contents of the composite flours. Analysis of this graph shows that the different formulations were higher in vitamin C than in vitamin A and β -carotene. For vitamin C, formulations F1 and F3 showed the highest contents, at 50.16 mg/100 g and 47.05 mg/100 g, respectively, with the lowest obtained for F2 (43.98 mg/100 g). Regarding vitamin A, the lowest content was recorded for formulation F3 (0.35 mg/100 g), followed by F1 (0.53 mg/100 g), with the highest for F2 (0.96 mg/100 g). Regarding β -carotene content, the highest content was obtained for F2 (5.77 mg/100 g), followed by F1 (3.10 mg/100 g), with the lowest for F3 (2.21 mg/100 g). Statistical analysis revealed a significant difference among formulations ($p < 0.05$).

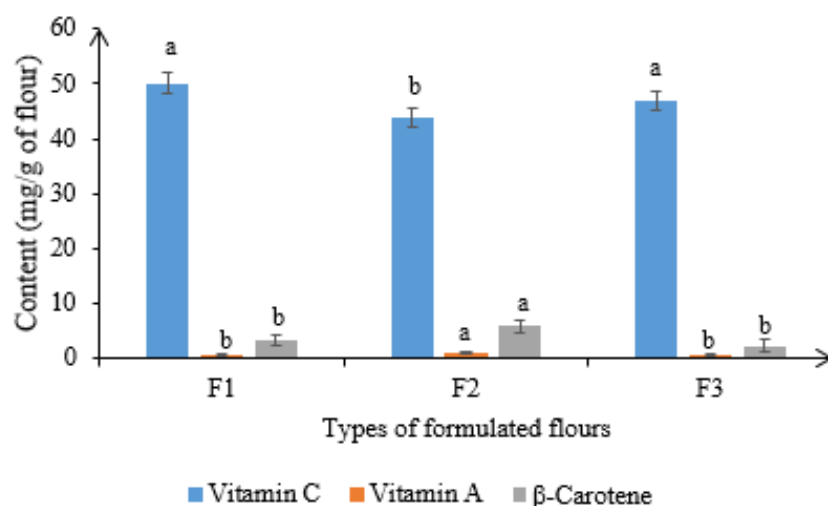


Fig. 3. Vitamin and provitamin content of the formulated composite flours
Bars bearing the same letter do not differ significantly ($P > 0.05$)

3.2 Discussion

To evaluate the quality and nutritional value of the tiger nut and sweet potato infant flours, microbiological, mineral, vitamin, and phenolic analyses were performed. Microbial enumeration results showed that the three formulations largely complied with the thresholds set by ISO standards, with values ranging between 77.63 and 88.42 CFU/g for total mesophilic aerobic flora, between 32.30 and 54.42 CFU/g for total coliforms, and between 24.28 and 34.23 CFU/g for yeasts and moulds. Moreover, the total absence of faecal coliforms and *Staphylococcus aureus* confirms the good hygienic quality of the flours. This quality could be explained, on the one hand, by drying at 60 °C for 24 to 48 hours, which markedly reduced water content and inhibited microbial growth (Chen *et al.*, 2025; Karuppuchamy *et al.*, 2024). On the other hand, it could be attributed to the antibacterial properties of tiger nut, whose flavonoids inhibit the growth of *Staphylococcus aureus*, as well as adherence to good hygiene practices during formulation (Liu *et al.*, 2026; Sylla *et al.*, 2026). Similar results have been reported in Burkina Faso and Guinea for local infant flours, with total

mesophilic aerobic flora counts of 2.4×10^2 to 1.1×10^4 CFU/g and 674 CFU/g, respectively, associated with a total absence of *Staphylococcus aureus* and coliforms (Bougma et al., 2022; Sankhon et al., 2024).

Furthermore, the mineral profile of the three composite flours revealed high potassium (1015.28 to 1019.72 mg/100 g) and magnesium (109.27 to 118.06 mg/100 g) contents, largely meeting the recommended requirements for infant flours (Mouquet et al., 1998). This mineral richness could be explained by the intrinsic composition of tiger nut and sweet potato. Indeed, tiger nut has potassium contents of 418.73 to 944.60 mg/100 g and magnesium contents of 895.79 to 1344.98 mg/100 g, while sweet potato is known for its high potassium content (> 300 mg/100 g) (Krochmal-Marczak et al., 2014; Semdé et al., 2019). Studies conducted in Côte d'Ivoire and Cameroon on local composite flours have also reported similar contents (Gbogouri et al., 2019; Sika et al., 2019). These two minerals play essential physiological roles in infants. Indeed, potassium ensures fluid–electrolyte balance, nerve transmission, and muscle contraction, while magnesium is involved in bone mineralization, growth, and neuromuscular development.

However, the contents of iron (8.24 to 8.47 mg/100 g), calcium (119.22 to 122.18 mg/100 g), phosphorus (137.01 to 138.07 mg/100 g), zinc (1.35 to 1.87 mg/100 g), and sodium (37.95 to 55.79 mg/100 g) remain below the recommended thresholds for infant flour (Mouquet et al., 1998). This deficiency could be attributed to the intrinsic biochemical composition of tiger nut and sweet potato, which are rich in carbohydrates but relatively poor in certain micronutrients. These results are consistent with those of Olorode et al. (2022), who also observed low contents of these minerals in composite flours based on orange-fleshed sweet potato, roasted African yam bean, and tiger nut. To improve mineral quality, fortification with micronutrient-rich ingredients such as moringa and sesame would be advisable. Moringa is known for its high iron and zinc content, while sesame stands out for its high calcium, iron, and zinc content (Glover-Amengor et al., 2017; Sène et al., 2018). Indeed, a deficiency in these minerals could promote iron-deficiency anaemia, stunted growth, bone fragility, and reduced immunity (Lassi et al., 2020).

Furthermore, the low vitamin A content observed could be explained by the degradation of β -carotene, the vitamin A precursor present in sweet potato, during processing (Pénicaud et al., 2011). This thermolabile compound is sensitive to oxidation and light, and its prolonged exposure to heat during drying, as well as the mechanical stress of grinding, promotes auto-oxidation reactions, thereby reducing its bioavailability (Pénicaud et al., 2011). This would explain the low β -carotene contents of the composite flours compared with those of fresh sweet potato (11 to 28 mg/100 g) (Failla et al., 2009). In contrast, the high vitamin C content could be explained by the intrinsic richness of tiger nut and sweet potato. Indeed, tiger nut contains approximately 22.9 mg/100 g of vitamin C (Abano et al., 2021), while a Mozambican sweet potato genotype contains approximately 23.89 mg/100 g (Selemane et al., 2024). Although vitamin C is water-soluble and heat-sensitive, its degradation during processing generally remains more limited than that of β -carotene (Selemane et al., 2024). The vitamin A and C contents of the three composite flours thus exceed the thresholds set by Codex Alimentarius Standard CXS 74-1981 (Codex Alimentarius Commission, 2023). These flours could therefore contribute to preventing vitamin A and C deficiencies in infants, reducing the risk of xerophthalmia, scurvy, and iron-deficiency anaemia (Castro-Pachón et al., 2025; Rani et al., 2024; Seng et al., 2024).

Finally, the composite flours based on tiger nut and sweet potato showed low phenolic compound contents, with 0.96 to 1.30 μ g GAE/g for total polyphenols and 0.46 to 0.54 μ g QE/g for flavonoids. This low secondary metabolite content may be explained by the intrinsic nature of tiger nut and sweet potato as well as by the processing steps (peeling, drying, grinding), which remove some of the phenolic compounds (Kim et al., 2019; Yuan et al., 2021). The values obtained are markedly lower than those reported by Soro et al. (2013) for fermented yam/soybean composite flours (585 to 1250 μ g GAE/g). However, this low content could constitute a nutritional advantage, as certain phenolic compounds, particularly tannins, are reported to have antinutritional properties by reducing protein digestibility and inhibiting the absorption of zinc, iron, and copper (Chung et al., 1998). Thus, these formulated flours would favour better bioavailability of essential micronutrients and proteins for infants.

4. Conclusion

The three composite infant flours formulated from tiger nut and sweet potato showed low microbial counts under the analytical conditions, with no detected faecal coliforms or *Staphylococcus aureus*. Across the formulations, potassium and magnesium were the most abundant measured minerals, whereas iron, zinc, calcium, phosphorus, and sodium remained below the stated reference requirements. Vitamin C ranged from 43.98 to 50.16 mg/100 g, vitamin A from 0.35 to 0.96 mg/100 g, and β -carotene from 2.21 to 5.77 mg/100 g. Total polyphenol and flavonoid contents were low, ranging from 0.96 to 1.30 μ g GAE/g and 0.46 to 0.54 μ g QE/g, respectively. These findings indicate that the tiger nut–sweet potato combinations have potential as locally formulated complementary flours with satisfactory microbiological quality and contributions from selected vitamins and minerals. However, mineral fortification, particularly for iron, zinc, calcium, and phosphorus, should be considered before the formulations are expected to meet broader infant nutritional requirements. Further validation across production batches would help establish the consistency of these microbiological and nutritional characteristics.

5. Limitation

The study was limited to three formulations prepared from tiger nut and three sweet potato varieties sourced from the Korhogo market. Consequently, the findings primarily characterise these raw materials and the specified drying, milling, and formulation conditions. The laboratory measurements describe microbiological quality and selected mineral, vitamin, and phenolic components but do not establish nutritional outcomes in infants. Broader validation across additional raw-material sources and production batches would strengthen the generalisability of the findings.

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Declaration of AI Use

This manuscript was prepared through the intellectual contributions of the author(s) to the study design, data analysis, interpretation of results, and scholarly content. Grammarly and ChatGPT were used solely to assist with grammatical refinement and reference formatting during manuscript revision. The author(s) accept full responsibility for the accuracy, integrity, and final content of the manuscript.

Competing Interests

Authors have declared that no competing interests exist.

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