Original Research Article

**Nutritional Potential of 15 Local Plant Species in Preventing Mineral Deficiencies in Young Children in Niger**

**Abstract:**

Macroelements and trace elements are essential for the body to function properly. The aim of this study was to determine the mineral composition of the products of 15 local species and their contribution to combating mineral deficiencies. Iron, phosphorus and zinc were determined by UV/visible spectrophotometer. Sodium, calcium, magnesium and potassium were determined by atomic absorption spectrophotometer. The rate of coverage of children's daily mineral requirements was determined according to Canadian government recommendations. The results show that Hyphaene thebaïca pulp contains the highest proportion of potassium (8000mg/100g M); and phosphorus in Arachis hypogaea seeds (662.72mg/100g) and Ziziphus mauritiana kernels (336.71mg/100g). Magnesium levels were highest in Adansonia digitata pulp (283.10mg/100g) and Hyphaene thebaïca (216.27mg/100g), while calcium levels were highest in Adansonia digitata pulp (194.39mg/100g) and Neocarya macrophylla kernel (128.26mg/100g). Sodium levels were highest in Arachis hypogaea seeds (344.91mg/100g). In addition, the highest iron contents were found in the kernel of Anacarduim occidentale (6.40mg/100g) and the seeds of Glycine max (5.80mg/100g) and Pennisetum glaucum (5.80mg/100g). The highest zinc levels were found in almonds, notably Anacarduim occidentale (2.30mg/100g) and Zizyphus mauritiana (2.79mg/100g). More than 80% of the products from the species in this study meet more than 45% of the daily phosphorus requirements of children aged 7 to 12 months. Almonds from Anacarduim occidentale and Neocarya macrophylla provide over 40% of daily iron and zinc requirements for all age groups. These plant products could therefore be used in strategies to combat micronutrient deficiencies and even malnutrition.

**Keywords:** Micronutrients, Malnutrition, mineral elements, local species, Niger /Niamey

**INTRODUCTION**

Micronutrient deficiencies are a major public health problem worldwide, given the serious consequences they have on health (Benazouz et al., 2006). An analysis of data on the number of people suffering from micronutrient deficiencies reveals the scale and severity of the problem. Worldwide, it has been estimated that around three billion people are likely to suffer from “hidden hunger” micronutrient deficiencies (Benazouz et al., 2006). The situation remains worrying, as micronutrient deficiencies are responsible for a number of diseases (Wang, 2019). Indeed, the WHO estimates that more than two billion people suffer from iron-deficiency anemia, and in developing countries, one in two pregnant women and around 40% of preschool children are said to be anemic (Avallone and Bricas, 2021). Consequently, in developing countries, there is an urgent need for additional plant food products to meet nutritional requirements (Sene et al., 2018).

Mineral salts are inorganic substances, unlike vitamins and energetic substances (proteins, carbohydrates and lipids), which are divided into macroelements (Ca, P, K, S, Na, Mg and Cl) and trace elements (I, Fe, Co, Cu, Mn, F, Se, Zn and Al) according to their needs, which determine their classification in one or other of these two groups (Elie, 2022; Paolo, 2021). Trace elements are divided into two families: essential and non-essential. Essential trace elements are trace elements whose deficiency or excess causes major disorders in the body. Non-essential trace elements have no physiological action specifically associated with them, and are not naturally present in the body. (Elie, 2022). Macroelements and trace elements are essential to nutrition, and can act alone, but more often than not act synergistically for the proper functioning of the organism (Abalokoka et al., 2018; Joseph, 1973) . In the living organism, they take the form of mineral salts: these are ions, carrying either a positive (cations) or negative (anions) electrical charge (Élie, 2022). In total, mineral elements account for around 4% of body weight and are involved in numerous functions: mineralization, control of water balance, enzymatic and hormonal systems, muscular, nervous and immune systems (ANSES, 2017). Calcium is involved in the construction and renewal of the skeleton and teeth, and also participates in muscular and cardiac contraction, blood coagulation, cellular exchanges, membrane permeability, hormone release and nerve impulse transmission (Elie, 2022; Sene et al., 2018) . Calcium absorption varies considerably throughout life, being higher during periods of rapid growth and lower in older adults (EFSA, 2017). Magnesium is an essential mineral for enzymatic activity that also plays a role in regulating carbohydrate and lipid metabolism in muscle, heart and nerve tissue, as well as in the body's acid-base balance. (Elie, 2022; Sene et al., 2018). Phosphorus is involved in numerous physiological processes, such as the cellular energy cycle, regulation of the body's acid-base balance, such as the composition of cell structure, in cell regulation and signalling, and in the mineralization of bones and teeth (EFSA, 2015a). As for iron and zinc, they are respectively involved in the production and function of hemoglobin; a protein in red blood cells that transports oxygen from the lungs to cells and in protection against free radicals and those involved in protein synthesis; hence zinc's important role in cell renewal, wound healing and immunity ( Sene et al., 2018) . Dietary iron is made up of haem iron (from animal tissues) and non-haem iron (including ferritin). Foods that contain relatively high concentrations of iron include meat, fish, cereals, beans, nuts, egg yolks, dark green vegetables, potatoes and fortified foods (EFSA, 2017).

In addition, deficiencies in certain nutrients, notably potassium, sodium, magnesium, zinc, phosphorus and nitrogen, lead to stunted growth and tissue repair. In Niger, some authors believe that the high prevalence of malnutrition is associated with severe micronutrient deficiencies (FAO, 2009). There is also a high consumption of imported food supplements in the country. Local supplements account for 18.82%, those from the sub-region 17.68%, those from Asia 8.25% and those from Europe 55.25% (Amadou, 2024).

Faced with this situation, Niger is committed to ensuring optimal nutrition and development for every child, through the commitments mentioned in the National Nutritional Security Policy, notably home food fortification with multi-micronutrient powders, and the consumption of diversified foods, to ensure quantitatively and qualitatively adequate nutrition for children under five and the promotion of micronutrient-rich non-timber forest products and other nutrient-dense foods so that they contribute to reducing nutritional deficiencies in Niger, particularly among vulnerable groups (SCCPNSN,2017). The present study aims to identify local foods with high nutritional potential: the mineral composition of products from 15 local species and their contributions in combating mineral element deficiencies.

**MATERIALS AND METHODS**

**Study area:**

The Niamey region was the field chosen to conduct this study.



**Figure 1:** Presentation of the study area ( Soumana et al., 2024) .

The Niamey region was chosen as the field for this study (**Table I).**

**Table I: Composition and characteristics of plant material**

|  |  |  |  |
| --- | --- | --- | --- |
| **Scientific names** | **Organs 1** | **Forms used** | **Origins** |
|
| ***Adansonia digitata*** | Could | believed | Local market |
| ***Arachis hypogaea*** | Gr | grilled | Local market |
| ***Glycine max*** | Gr | grid | Local market |
| ***Ziziphus mauritiana*** | Am | believed | Local market |
| ***Western Anacarduim*** | Am | grid | Local market |
| ***Borassus aethiopum*** | You | cooked | Local market |
| ***Parkia biglobosa*** | Could | believed | Local market |
| ***Cucurbita SP.*** | Gr | believed | Local market |
| ***Vigna unguiculata*** | Gr | cooked | Local market |
| ***Neocarya macrophylla*** | Could | believed | Local market |
| ***Neocarya macrophylla*** | Am | believed | Local market |
| ***Sesamum indicum*** | Gr | grid | Local market |
| ***Ipomoea batatas*** | You | cooked | Local market |
| ***Sclerocarya birrea*** | Am | grid | Local market |
| ***Pennisetum glaucum*** | Gr | grid | Niamey |
| ***Hyphaene thebaica*** | Could | believed | Local market |
| ***Ziziphus mauritiana*** | Could | believed | Local market |

1: Am = Almond; Pu = Pulp; Gr = Seed; Tu = Tuber.

**Methods**

For each sample, 5g were weighed in two trials and calcined in an oven at 550°C for 2 hours. The ash obtained for each sample was reconstituted in 250 ml of distilled water for experimental analysis.

**Determination of iron, phosphorus and zinc content**

Mineral elements such as iron (Fe), phosphorus (P) and zinc (Zn) were determined using the UV/visible spectrophotometer method.

**Determination of sodium, calcium, magnesium and potassium content**

Mineral elements such as sodium (Na), calcium (Ca), magnesium (Mg) and potassium (K) were determined by the atomic absorption or flame spectrophotometry method, which enables sodium and potassium to be measured under very good conditions, with good accuracy, at very low concentrations (Gueguen and Rombauts , 1961).

**Calculation of daily mineral requirement coverage rates**

The coverage rate of the daily mineral requirements of children aged 0 months to 8 years was determined as the intake of a mineral element in relation to the recommendations (Recommended Dietary Allowances/Appropriate Intakes) of the Canadian government through its institution “Canada Health” (Health Canada, 2023).

**Table II:** Canadian Government Recommended Dietary Intake

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Age groups | Calcium | Magnesium | Phosphorus | Potassium | Sodium | Iron | Zinc |
|  |  | **mg /day** |  |  |  |  |
| 0-6 months | 200 | 30 | 100 | 400 | 110 | 0.27 | 2 |
| 7-12 months | 260 | 75 | 275 | 860 | 370 | 11 | 3 |
| 1-3 years | 500 | 80 | 460 | 2000 | 800 | 7 | 3 |
| 4 - 8 years | 800 | 130 | 500 | 2300 | 1000 | 10 | 5 |

The assessment of the contribution of cereals, pulps, almonds and legumes in elements was made according to age groups (0-6 months; 7-12 months; 1-3 years; 4-8 years). The coverage rate was calculated according to the following formula:$C=\frac{(TX100)}{B}$ ( Parkouda et al., 2007) .

C: Daily coverage rate in element X (%);

T: Content of this element X in 100g of food;

B: Nutritional Intake recommended by the Canada Health institution.

**Statistical processing and analysis**

Pearson bivariate correlation between different mineral elements and hierarchical classification (dendrogram) were performed with SPSS software version 25.

**RESULTS**

The macro-element mineral composition of pulp, almonds, legumes and one cereal was determined and summarized in Table III. The mineral content (Ca, Mg, Na, K and P) was determined, and potassium content was predominantly high in all 17 samples, including 15 plant species, as in most plant products, with a maximum proportion of 8000mg/100g of dry matter for Hyphaene thebaïca pulp. After potassium come phosphorus levels, the highest of which were found in Arachis hypogaea seeds (662.72mg/100g) and Ziziphus mauritiana kernels (336.71mg/100g). The highest magnesium contents were obtained in the pulps of Adansonia digitata (283.10mg/100g) and Hyphaene thebaïca (216.27mg/100g), the seeds of Cucurbita SPP. (194.40/100g) and Anacarduim occidentale kernel (170.10mg/100g). Adansonia digitata pulp and Neocarya macrophylla kernels are exceptionally rich in calcium, at 194.39mg/100g DM and 128.26mg/100g respectively. Sodium levels in Arachis hypogaea seeds, Neocarya macrophylla pulp and Ipomoea batatas tubers are the highest at 344.91mg/100g MS, 300mg/100g MS and 225mg/100g respectively.

**Table III:** Macroelement contents of main foods

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Species names | Calcium | Magnesium | Sodium | Potassium | Phosphorus |
|  **mg /100g** |
| *Adansonia digitata* | 194.39 | 283.10 | 10.00 | 6000.00 | 124.50 |
| *A. Western* | 20.04 | 170.10 | 15.00 | 399.87 | 274.91 |
| *Arachis hypogaea* | 12.02 | 48.60 | 344.91 | 147.82 | 662.72 |
| *Borassus aethiopum* | 20.04 | 41.31 | 20.00 | 149.98 | 152.48 |
| *Cucurbita SPP.* | 88.18 | 194.40 | 5.00 | 250.00 | 51.00 |
| *Glycine max* | 20.04 | 24.30 | 15.00 | 2500.00 | 129.00 |
| *Hyphaene thebaica* | 50.10 | 216.27 | 100.00 | 8000.00 | 156.00 |
| *Ipomoea batatas* | 20.04 | 38.88 | 225.00 | 2500.00 | 137.00 |
| *NA. macrophylla ( Am)* | 128.26 | 109.35 | 4.99 | 249.33 | 276.75 |
| *N. macrophylla ( Pul )* | 48.10 | 89.91 | 300.00 | 1000.00 | 149.50 |
| *Parkia biglobosa* | 52.10 | 164.03 | 5.00 | 4500.00 | 161.00 |
| *Pennisetum glaucum* | 36.07 | 43.74 | 4.96 | 123.89 | 207.64 |
| *Sclerocarya birrea* | 12.02 | 138.51 | 4.99 | 199.75 | 52.43 |
| *Sesamum indicum* | 28.06 | 145.80 | 4.99 | 74.90 | 56.42 |
| *Vigna unguiculata* | 16.03 | 74.12 | 20.00 | 2500.00 | 154.50 |
| *Z. mauritiana (Am)* | 58.12 | 140.94 | 4.99 | 174.59 | 336.71 |
| *Z. mauritiana ( Pul )* | 72.14 | 148.23 | 5.00 | 4500.00 | 159.00 |

Am= Almond; Pul = Pulp.

Table IV summarizes the trace element content of products from 15 plant species. Indeed, the highest iron contents were found in almonds such as Anacarduim occidentale (6.40 mg/100g), Neocarya macrophylla (5.14 mg/100g); legumes such as Glycine max (5.80 mg/100g), Vigna unguiculata (4.10 mg/100g), Cucurbita SPP. (3.40mg/100g) and millet seeds (Pennisetum glaucum) with a content of 5.80 mg/100g. In addition, zinc levels are mainly low in the products analyzed. However, the highest levels were found in almonds, notably Anacarduim occidentale (2.30mg/100g), Zizyphus mauritiana (2.79mg/100g MS) and Neocarya macrophylla (2.04mg/100g).

**Table IV:** Trace element contents of main foods

|  |  |  |
| --- | --- | --- |
| Species names | Iron | Zinc |
| **mg /100g** |
| *Adansonia digitata* | 1.06 | 0.62 |
| *Western Anacarduim* | 6.40 | 2.30 |
| *Arachis hypogaea* | 1.72 | 1.97 |
| *Borassus aethiopum* | 1.20 | 0.60 |
| *Cucurbita SPP.* | 3.40 | 1.00 |
| *Glycine max* | 5.80 | 0.76 |
| *Hyphaene thebaica* | 0.98 | 0.62 |
| *Ipomoea batatas* | 0.58 | 0.54 |
| *Neocarya macrophylla (Almond)* | 5.14 | 2.04 |
| *Neocarya macrophylla (Pulp)* | 2.25 | 1.90 |
| *Parkia biglobosa* | 0.56 | 0.58 |
| *Pennisetum glaucum* | 5.80 | 1.14 |
| *Sclerocarya birrea* | 1.25 | 0.95 |
| *Sesamum indicum* | 1.40 | 0.95 |
| *Vigna unguiculata* | 4.10 | 0.98 |
| *Ziziphus mauritiana (Almond)* | 2.54 | 2.79 |
| *Ziziphus mauritiana (Pulp)* | 1.68 | 0.70 |

The Pearson correlation, also known as the Pearson correlation coefficient, was measured between the various mineral elements. Thus, moderate and significant positive correlations were observed between magnesium and calcium (r =0.656; p=0.004), potassium and magnesium (r = 0.508 p =0.037), phosphorus and sodium (r = 0.509; P=0.037) and zinc and phosphorus (r = 0.618; p =0.008). In addition, there was a significant moderate negative correlation between zinc and potassium (r = -0.541; p=0.025).

**Table V:** Correlation between the different mineral elements

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  Minerals | That | Fe | Mg | N / A | K | P | Zn |
| That | Pearson correlation | 1 |   |   |   |   |   |   |
| Sig . ( bilateral ) |   |   |   |   |   |   |   |
| Fe | Pearson correlation | -0.073 | 1 |   |   |   |   |   |
| Sig . ( bilateral ) | 0.782 |   |   |   |   |   |   |
| Mg | Pearson correlation | 0.656 \*\* | -0.272 | 1 |   |   |   |   |
| Sig . ( bilateral ) | 0.004 | 0.291 |   |   |   |   |   |
| N / A | Pearson correlation | -0.259 | -0.287 | -0.348 | 1 |   |   |   |
| Sig . ( bilateral ) | 0.316 | 0.263 | 0.171 |   |   |   |   |
| K | Pearson correlation | 0.364 | -0.388 | 0.508 \* | -0.048 | 1 |   |   |
| Sig . ( bilateral ) | 0.151 | 0.124 | 0.037 | 0.853 |   |   |   |
| P | Pearson correlation | -0.128 | 0.125 | -0.270 | 0.509 \* | -0.229 | 1 |   |
| Sig . ( bilateral ) | 0.624 | 0.632 | 0.295 | 0.037 | 0.376 |   |   |
| Zn | Pearson correlation | -0.026 | 0.421 | -0.069 | 0.202 | -0.541 \* | 0.618 \*\* | 1 |
| Sig . ( bilateral ) | 0.922 | 0.092 | 0.791 | 0.438 | 0.025 | 0.008 |   |

\*\*The correlation is significant at the 0.01 level (two-tailed) ;

\*The correlation is significant at the 0.05 level (two-tailed).



**Figure 2:** Hierarchical classification dendrogram

The hierarchical classification of species products according to their mineral content shows three main groups:

-Group 1 includes pulps from Adansonia digitata, Hyphaene thebaïca, Parkia biglobosa and Ziziphus mauritiana ;

- Group 2 includes legumes such as Glycine max, Vigna unguiculata and Ipomoea batatas seeds; Borassus aethiopum hypocotyls

- Group 3 includes seeds from Arachis hypogaea, Cucurbita SP., Pennisetum glaucum and Sesamum indicum; kernels from Anacarduim occidentale, Neocarya macrophylla, Sclerocarya birrea and ziziphus mauritiana; pulp from Neocarya macrophylla.

The daily body requirements of children aged 0 months to 8 years for minerals such as calcium, magnesium, phosphorus, potassium, sodium, iron and zinc are summarized in Tables V, VI, VII and VIII. The results show very satisfactory coverage rates for most mineral elements, depending on the age group. For example, consumption of 100g of Adansonia digitata pulp by a child aged 7 to 12 months provides theoretical calcium coverage of 74.76% and 32.40% of magnesium (Table VI). All the species in this study provide phosphorus coverage of over 45% for children aged 7 to 12 months, with the exception of Cucurbita SP. seeds, Sesamum indicum and Sclerocarya birrea kernels. Potassium coverage rates were relatively high, exceeding 100% in all age groups for species including Adansonia digitata pulp, Glycine max seed, Ipomoea batatas tuber, Hyphaene thebaïca pulp, Parkia biglobosa pulp, Vigna unguiculata seed and Ziziphus mauritiana pulp (Table VII). Sodium coverage rates are practically low for the majority of species in all age groups, below 20% with the exception of Arachis hypogaea, Ipomoea batatas and Neocarya macrophylla pulp (Table VIII). Iron and zinc coverage rates are more than adequate, particularly in almonds from Anacarduim occidentale and Neocarya macrophylla, where rates exceed 40% for all age groups (Table IX).

**Table VI:** Ratesdaily calcium and magnesium coverage of species

|  |  |  |
| --- | --- | --- |
| Species | **Calcium** | **Magnesium** |
| (0-6) 1  | (7-12) 1 | (1-3) 2 | (4 – 8) 2 | (0-6) 1 | (7-12) 1 | (1-3) 2 | (4 - 8) 2 |
| *A. digitata*  | 97.19 | 74.76 | 38.88 | 24.3 0 | 81 | 32.4 0 | 30.37 | 18.69 |
| *A. Western* | 10.02 | 7.71 | 4.01 | 2.51 | 8.35 | 3.34 | 3.13 | 1.93 |
| *A. hypogaea* | 6.01 | 4.62 | 2.4 | 1.5 0 | 5.01 | 2.00​ | 1.88 | 1.16 |
| *B. aethiopum* | 10.02 | 7.71 | 4.01 | 2.51 | 8.35 | 3.34 | 3.13 | 1.93 |
| *Cucurbita SP.* | 44.09 | 33.91 | 17.64 | 11.02 0 | 36.74 | 14.7 0 | 13.78 | 8.48 |
| *G. max* | 10.02 | 7.71 | 4.01 | 2.51 | 8.35 | 3.34 | 3.13 | 1.93 |
| *H. thebaica* | 25.05 | 19.27 | 10.02 | 6.26 | 20.88 | 8.35 | 7.83 | 4.82 |
| *I. potatoes* | 10.02 | 7.71 | 4.01 | 2.51 | 8.35 | 3.34 | 3.13 | 1.93 |
| *N. macrophylla* \* | 64.13 | 49.33 | 25.65 | 16.03 | 53.44 | 21.38 | 20.04 | 12.33 |
| *N. macrophylla \** \* | 24.05 | 18.5 | 9.62 | 6.01 | 20.04 | 8.02 | 7.52 | 4.62 |
| *P. biglobosa* | 26.05 | 20.04 | 10.42 | 6.51 | 21.71 | 8.68 | 8.14 | 5.01 |
| *P. glaucum* | 18.04 | 13.87 | 7.21 | 4.51 | 15.03 | 6.01 | 5.64 | 3.47 |
| *S. birrea* | 6.01 | 4.62 | 2.4 0 | 1.5 0 | 5.01 | 2.00​ | 1.88 | 1.16 |
| *S. indicum* | 14.03 | 10.79 | 5.61 | 3.51 | 11.69 | 4.68 | 4.38 | 2.7 0 |
| *V. unguiculata*  | 8.02 | 6.17 | 3.21 | 2.00​ | 6.68 | 2.67 | 2.51 | 1.54 |
| *Z. mauritiana* \* | 29.06 | 22.35 | 11.62 | 7.26 | 24.22 | 9.69 | 9.08 | 5.59 |
| *Z. mauritiana \** \* | 36.07 | 27.75 | 14.43 | 9.02 | 30.06 | 12.02 | 11.27 | 6.94 |

\*Almond; \*\*Pulp; 1=month; 2=year.

**Table VII:** Daily phosphorus and potassium coverage rates of species

|  |  |  |
| --- | --- | --- |
| **Species** | **Phosphorus** | **Potassium** |
| (0-6) 1 | (7-12) 1 | (1-3) 2 | (4 - 8) 2 | (0-6) 1 | (7-12) 1 | (1-3) 2 | (4 - 8) 2 |
| *A. digitata*  | 124.50 | 45.27 | 27.07 | 24.90 | 1500.00 | 697.67 | 300 | 260.87 |
| *A.western*  | 274.91 | 99.97 | 59.76 | 54.98 | 99.97 | 46.50 | 19.99 | 17.39 |
| *A. hypogaea* | 662.72 | 240.99 | 144.07 | 132.54 | 36.95 | 17.19 | 7.39 | 6.43 |
| *B. aethiopum* | 152.48 | 55.45 | 33.15 | 30.50 | 37.49 | 17.44 | 7.50 | 6.52 |
| *Cucurbita SP.* | 51.00 | 18.55 | 11.09 | 10.20 | 62.50 | 29.07 | 12.50 | 10.87 |
| *G. max* | 129.00 | 46.91 | 28.04 | 25.80 | 625.00 | 290.70 | 125 | 108.7 |
| *H. thebaica* | 156.00 | 56.73 | 33.91 | 31.20 | 2000.00 | 930.23 | 400 | 347.83 |
| *I. potatoes* | 137.00 | 49.82 | 29.78 | 27.40 | 625.00 | 290.70 | 125 | 108.70 |
| *N. macrophylla \** | 276.75 | 100.64 | 60.16 | 55.35 | 62.33 | 28.99 | 12.47 | 10.84 |
| *N. macrophylla \*\** | 149.50 | 54.36 | 32.50 | 29.90 | 250.00 | 116.28 | 50 | 43.48 |
| *P. biglobosa* | 161.00 | 58.55 | 35.00 | 32.20 | 1125 | 523.26 | 225 | 195.65 |
| *P. glaucum* | 207.64 | 75.51 | 45.14 | 41.53 | 30.97 | 14.41 | 6.19 | 5.39 |
| *S. birrea* | 52.43 | 19.07 | 11.40 | 10.49 | 49.94 | 23.23 | 9.99 | 8.68 |
| *S. indicum* | 56.42 | 20.52 | 12.27 | 11.28 | 18.72 | 8.71 | 3.74 | 3.26 |
| *V. unguiculata* | 154.50 | 56.18 | 33.59 | 30.90 | 625.00 | 290.70 | 125 | 108.70 |
| *Z. mauritiana\**  | 336.71 | 122.44 | 73.20 | 67.34 | 43.65 | 20.30 | 8.73 | 7.59 |
| *Z. mauritiana\*\** | 159.00 | 57.82 | 34.57 | 31.80 | 1125.00 | 523.26 | 225 | 195.65 |

\*Almond; \*\*Pulp; 1=month; 2=year **.**

**Table VIII:** Coverage ratedaily sodium intake of species

|  |  |
| --- | --- |
| Species | Sodium |
| **(0-6 months)** | **(7-12 months)** | **(1-3 years)** | **(4-8 years)** |
| A. digitata | 9.09 | 2.70 | 1.25 | 1.00 |
| A. Western | 13.63 | 4.05 | 1.87 | 1.5 |
| A. hypogaea | 313.55 | 93.22 | 43.11 | 34.49 |
| B. aethiopum | 18.18 | 5.40 | 2.50 | 2.00 |
| Cucurbita SP. | 4.55 | 1.35 | 0.63 | 0.5 |
| G. max | 13.64 | 4.05 | 1.88 | 1.5 |
| H. thebaica | 90.91 | 27.03 | 12.50 | 10.00 |
| I. potatoes | 204.55 | 60.81 | 28.13 | 22.5 |
| N. macrophylla \* | 4.53 | 1.35 | 0.62 | 0.50 |
| N. macrophylla \*\* | 272.73 | 81.08 | 37.50 | 30.00 |
| P. biglobosa | 4.55 | 1.35 | 0.63 | 0.50 |
| P. glaucum | 4.51 | 1.34 | 0.62 | 0.50 |
| S. birrea | 4.54 | 1.35 | 0.62 | 0.50 |
| S. indicum | 4.54 | 1.35 | 0.62 | 0.50 |
| V. unguiculata | 18.18 | 5.41 | 2.50 | 2.00 |
| Z. mauritiana \*  | 4.53 | 1.35 | 0.62 | 0.50 |
| Z. mauritiana \*\* | 4.55 | 1.35 | 0.63 | 0.50 |

\*Almond; \*\*Pulp

**Table IX:** Coverage ratedaily iron and zinc species

|  |  |  |
| --- | --- | --- |
| **Species names** | **Iron** | **Zinc** |
| (0-6) 1 | (7-12) 1 | (1-3) 2 | (4 - 8) 2 | (0-6) 1 | (7-12) | (1-3) | (4 - 8) |
| *A. digitata*  | 392.59 | 9.64 | 15.14 | 10.60 | 31.00 | 20.67 | 20.67 | 12.40 |
| *A.western*  | 2369.61 | 58.16 | 91.40 | 63.98 | 114.96 | 76.64 | 76.64 | 45.99 |
| *A.hypogaea* | 638.72 | 15.68 | 24.64 | 17.25 | 98.55 | 65.70 | 65.70 | 39.42 |
| *B. aethiopum* | 444.37 | 10.91 | 17.14 | 12.00 | 30.00 | 20.00 | 20.00 | 12.00 |
| *Cucurbita SP.* | 1259.26 | 30.91 | 48.57 | 34.00 | 50.00 | 33.33 | 33.33 | 20.00 |
| *G. max* | 2148.15 | 52.73 | 82.86 | 58.00 | 38.00 | 25.33 | 25.33 | 15.20 |
| *H. thebaica* | 362.96 | 8.91 | 14.00 | 9.80 | 31.00 | 20.67 | 20.67 | 12.40 |
| *I. batatas*  | 214.81 | 5.27 | 8.29 | 5.80 | 27.00 | 18.00 | 18.00 | 10.80 |
| *N. macrophylla \** | 1902.27 | 46.69 | 73.37 | 51.36 | 102.22 | 68.15 | 68.15 | 40.89 |
| *N. macrophylla \*\** | 833.33 | 20.45 | 32.14 | 22.50 | 95.00 | 63.33 | 63.33 | 38.00 |
| *P. biglobosa* | 207.41 | 5.09 | 8.00 | 5.60 | 29.00 | 19.33 | 19.33 | 11.60 |
| *P. glaucum* | 2147.47 | 52.71 | 82.83 | 57.98 | 56.99 | 37.99 | 37.99 | 22.80 |
| *S. birrea* | 462.38 | 11.35 | 17.83 | 12.48 | 47.44 | 31.63 | 31.63 | 18.98 |
| *S. indicum* | 517.82 | 12.71 | 19.97 | 13.98 | 47.44 | 31.62 | 31.62 | 18.97 |
| *V. unguiculata*  | 1518.52 | 37.27 | 58.57 | 41.00 | 49.00 | 32.67 | 32.67 | 19.60 |
| *Z. mauritiana\** | 942.22 | 23.13 | 36.34 | 25.44 | 139.67 | 93.11 | 93.11 | 55.87 |
| *Z.mauritiana \** | 622.22 | 15.27 | 24.00 | 16.80 | 35.00 | 23.33 | 23.33 | 14.00 |

\*Almond; \*\*Pulp; 1=month; 2=year.

**DISCUSSION**

Optimal infant and young child feeding practices are among the specific interventions implemented during the first 1,000 days to prevent malnutrition (Chaibou et al., 2024). Breastfed children after six months need more vitamins, minerals, proteins and carbohydrates than breast milk generally provides (Amadou, 2023). Any nutritious food or liquid other than breast milk that is given to the young child during this period falls into the category of complementary foods, and complementary feeding is the process of introducing these foods (Amadou, 2023). In addition, socio-demographic and lifestyle factors are associated with food choices (Asgari et al., 2024). Thus, in Niger, a Sahelian country where the majority of the population lives in poverty, the nutritional evaluation of local food products from domesticated and wild species accessible at lower cost must be the subject of a particular nutritional assessment. This was the aim of this study, in which the mineral composition of 17 samples from 15 local species (almonds, pulps, legumes and a cereal) and their contribution to meeting the daily mineral requirements of young children were determined. The mineral composition of food products is one of the criteria for consumer choice (Cissé, 2012). These selection criteria play a crucial role in living beings, which is why deficiencies or excesses of essential trace elements can lead to major disorders in the body (Elie, 2022). Finally, macroelements such as calcium (Ca), phosphorus (P), sodium (Na) and potassium (K) are involved in the body by fortifying bones and playing the role of bio-activators and osmotic balance in cellular metabolism (Abalokoka et al., 2018).

The results of the present study showed that the samples were very rich in macroelements but poor in trace elements, with many variations from one species to another, but also between the pulp and the kernel of the same species. Thus, among the macroelements determined, potassium levels are predominantly the highest in all samples of 15 plant species, with a maximum of 8000mg/100g for Hyphaene thebaïca pulp. The high values of this mineral in the samples are confirmed by some authors, for whom “in most plant products, the most predominant mineral compound is potassium” (Cissé et al., 2009). The highest magnesium contents were obtained in the pulps of Adansonia digitata (283.10mg/100g DM) and Hyphaene thebaïca (216.27mg/100g), the seeds of Cucurbita SPP. (194.40/100g DM) and Anacarduim occidentale kernel (170.10mg/100g). Comparing the magnesium results of Adansonia digitata with previous literature data, some authors in Côte d'Ivoire and Burkina Faso (Kouassi, 2018; Parkouda et al., 2007) found inferior magnesium results of 44.62 mg/100g and 192.27 mg/100g respectively. The difference observed could be due to the nature and richness of the soils, climate fluctuation and change, as well as the technique and duration between sample collection and laboratory analysis (Halidou et al., 2022). As for phosphorus content, Arachis hypogaea seeds and Ziziphus mauritiana kernels presented the highest values, respectively 662.72mg/100g and 336.71mg/100g. As for the phosphorus content of groundnuts (Arachis hypogaea), a lower level (359mg/100g) was reported in the West African food composition table (Barbara et al., 2012). Adansonia digitata pulp and Neocarya macrophylla kernel are exceptionally rich in calcium, at 194.39mg/100g and 128.26mg/100g respectively. In the case of Adansonia digitata pulp, the value is higher than that reported in the previous Côte d'Ivoire study, where the content was as high as 310.12mg/100g (Kouassi, 2018). On the other hand, the calcium content in this study is higher than that obtained in another study which found 107 mg/100g (Diaby et al., 2016). Calcium is an essential skeletal element (EFSA, 2017) as around 99% of total body calcium is found in bones and teeth in the form of calcium hydroxyapatite, where it plays a structural role (EFSA, 2015b). Low calcium intake also appears to be a risk factor in the development of overweight and obesity (Nessaibia and Khelaltia, 2016). Sodium levels are relatively low for most products. Nevertheless, Arachis hypogaea seeds, Neocarya macrophylla pulp and Ipomoea batatas tubers are the richest in sodium respectively 344.91mg/100g ,300mg/100g and 225mg/100g. This sodium content of Ipomoea batatas is significantly higher than that reported in the West African food composition table for several varieties of this species (Barbara et al., 2012). In association, sodium and chlorine (sodium chloride NaCl) are involved in the osmotic pressure of extracellular fluids. Sodium deficiency leads to neurasthenia, fatigue and dehydration (Élie, 2022).

The iron and zinc contents are practically low for the majority of the products studied. Nevertheless, these contents are appreciable because the recommended nutritional intake of iron is 0.27 at 11mg/day and those in zinc from 2 to 5mg/day in children from 0 months to 8 years. The highest iron contents were found in almonds such as *Anacarduim occidentale* (6.40 mg/100g), *Neocarya macrophylla* (5.14 mg/100 DM); legumes such as *Glycine max* (5.80 mg/100g DM), *Vigna unguiculata* (4.10 mg/100g DM) and *Cucurbita SPP.* (3.40mg/100g DM) and millet seeds (*Pennisetum glaucum* ) with a content of 5.80 mg/100g DM. For the almond of *Anacarduim occidentale* , Abalokoka et al. ( 2018 ) found a relatively close iron content varying depending on the localities from 7.05 to 7.76 mg/100 g. But, Sudik et al., ( 2023 ) in a research in Nigeria, found an iron content of *Glycine max* more important, varying slightly from 40.23 mg/100g to 43.38 mg/100g depending on the source. This variability of results could be justified by environmental conditions . Therefore, the presence of anemia and any infant morbidity were found to be significant determinants of malnutrition . ( Patra et al., 2024) . Similarly, zinc levels are mainly low in the majority of these plant species products. However, the highest levels were observed in almonds, particularly *Anacarduim occidentale* (2.30 mg/100 g DM), *Zizyphus mauritiana* (2.79 mg/100 g DM) and *Neocarya macrophylla* (2.04 mg/100 g). In the case of the *Anacarduim occidentale almond* , other studies have found levels slightly higher than those of the present study, which levels varied depending on the source from 4.39 to 6.99 mg/100 g. ( Abalokoka et al., 2018) .

Humans need a minimum amount of minerals for their metabolism to function properly. (Paolo, 2021) . Tables VI to IX show a good capacity to cover the daily requirements of macroelements and trace elements of infants and young children by foods for this present study . The rates of coverage of the mineral element requirements of all these species in the latter based on the recommended nutritional intakes are reported here for the first time to our knowledge. These intakes indicate the quantity of a nutrient that must be consumed regularly to maintain health in a healthy individual or population (EFSA, 2017). In the event of insufficient, but also excessive, intake, there is the risk of undesirable consequences, even toxic effects (Paolo, 2021) . It should be noted that the 6 to 11 month period also corresponds to the introduction of complementary feeding (Kanguaye, 2020). Thus, the most widespread deficiencies in the world are iron, vitamin A, iodine and zinc deficiencies ( Bricas et al., 2021) . Nevertheless, daily iron and zinc coverage rates are largely sufficient, particularly in the almonds of *Anacarduim occidentale* and *Neocarya macrophylla* for which these rates are higher than 40% for all age groups (Table VIII). In addition, the fight against micronutrient deficiencies involves, in particular, the diversification of diets ( Bricas et al., 2021) . In this sense, the consumption of products from wild and domesticated species such as legumes, cereals, pulps and almonds , in view of the results of this study, could contribute to improving diets and combating mineral deficiencies. All this allows us to say that today , particularly in rural areas, these consumed plants are of great interest for the food security of populations (almost daily consumption of these products ( Kouame et al., 2015) . Finally, these results in mineral elements show that certain micronutrient deficiencies could be avoided or could be corrected by the consumption of wild fruits ( Parkouda et al., 2007) .

**CONCLUSION**

This present study on almonds and pulps of fruits, legumes, tubers and a cereal made it possible to determine the mineral composition of these species and their contribution in the fight against mineral deficiencies in young children aged 0 months to 8 years. Thus, the results show that the highest potassium content was found in the pulp of *Hyphaene thebaïca* (8000mg/100g DM), that of phosphorus in the seeds of *Arachis hypogaea* (662.72mg/100g). As for the magnesium and calcium contents, the first one is found to be higher in the pulps of *Adansonia digitata* (283.10mg/100g) and *Hyphaene thebaïca* (216.27mg/100) and the second one in the pulp of *Adansonia digitata* (194.39mg/100g) and the almond of *Neocarya macrophylla* (128.26mg/100g). The seeds of *Arachis hypogaea* presented the highest content (344.91mg/100g) of sodium. In addition, the highest iron content was found in the almond of *Anacarduim occidentale* (6.40mg/100g). The highest zinc contents were observed in the almonds of *Anacarduim occidentale* (2.30mg/100g) and Zizyphus *mauritiana* (2.79mg/100g). More than 80% of the products of the species in this study provide more than 45% of daily phosphorus requirements for children aged 7 to 12 months. The almonds of *Anacarduim occidentale* and *Neocarya macrophylla* provide more than 40% of daily iron and zinc requirements for all age groups. Finally, the results show that these plant products could be used in strategies to combat micronutrient deficiencies and even malnutrition. It would be important to determine the vitamin composition.

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Authors have declared that no competing interests exist

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