Mineral potential in the products of 15 local species and their contributions in the prevention and management of mineral element deficiencies in children aged 6 to 59 months in Niger

**Abstract :**

Macroelements and trace elements are essential for the proper functioning of the body. The objective of this work is to determine the mineral composition of the products of 15 local species and their contributions in the fight against mineral element deficiencies . Thus, iron, phosphorus and zinc were determined by UV / visible spectrophotometer. Sodium, calcium, magnesium and potassium by atomic absorption spectrophotometer. The rate of coverage of children's daily needs in mineral elements was determined according to the recommendations of the Canadian Government. The results show that it is the pulp of *Hyphaene thebaïca* which contains the maximum proportion of potassium (8000mg / 100g DM); and that of phosphorus in the seeds of *Arachis hypogaea* (662.72mg / 100g) and the almond of *Ziziphus mauritiana* (336.71mg / 100g). Furthermore, the highest magnesium contents were obtained in the pulps of *Adansonia digitata* (283.10 mg/100 g) and *Hyphaene thebaïca* (216.27 mg/100 g); calcium in the pulp of *Adansonia digitata* (194.39 mg/100 g) and the almond of *Neocarya macrophylla* (128.26 mg/100 g). The sodium contents were highest in the seeds of *Arachis hypogaea* (344.91 mg/100 g) *.* Furthermore, the highest iron contents were found in the almond of *Anacarduim occidentale* (6.40 mg/100 g) and the seeds of *Glycine max* (5.80 mg/100 g) and *Pennisetum glaucum* (5.80 mg/100 g). The highest zinc contents were observed in almonds, particularly those of *Anacarduim occidentale* (2.30 mg/100 g) and Zizyphus *mauritiana* (2.79 mg/100 g). More than 80% of the products of the species in the present study provide coverage of daily phosphorus requirements of more than 45% in children aged 7 to 12 months. The almonds of *Anacarduim occidentale* and *Neocarya macrophylla* provide more than 40% of the daily iron and zinc requirements for all age groups. Therefore, these plant products could 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 cause on health ( Benazouz et al., 2006) . By analyzing the data on the proposals of people suffering from these deficiencies, we realize the extent of the phenomenon and its degree of seriousness. Worldwide, it was estimated that approximately three billion people are likely to suffer from micronutrient deficiencies "hidden hunger" ( Benazouz et al., 2006) . The situation remains worrying because these are responsible for several 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-aged children are anemic. ( Avallone and Bricas , 2021) . Consequently, in developing countries, there is an urgent need for additional food plant products to meet nutritional needs ( Sene et al., 2018) .

Mineral salts are so-called inorganic substances, unlike vitamins and energy-providing substances (proteins, carbohydrates and fats) 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) depending on their needs determining 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 produces significant disorders in the body. Non-essential trace elements have no physiological action specifically associated with them, and they are not naturally present in the body. (Elie, 2022) . Macroelements and trace elements are essential in nutrition, can intervene alone, but most often act in synergy for the proper functioning of the body ( Abalokoka et al., 2018; Joseph, 1973) . In the living organism, they are in the form of mineral salts: they are ions, carrying an electrical charge either positive (cations) or negative (anions) (Élie, 2022) . In total, mineral elements represent approximately 4% of body weight and are involved in a wide range of 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 muscle and cardiac contraction, blood coagulation, cellular exchanges, membrane permeability, hormone release and the transmission of nerve impulses. (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 enzyme activity that also plays a role in regulating carbohydrate and lipid metabolism in muscle, heart and nerve tissue and the body's acid-base balance. (Elie, 2022; Sene et al., 2018) . Phosphorus is involved in many physiological processes, such as the cellular energy cycle, the regulation of the body's acid-base balance, such as the composition of the cellular structure, in cellular regulation and signaling and in the mineralization of bones and teeth (EFSA, 2015a). As for iron and zinc, they are involved respectively in the production and functioning of hemoglobin; a protein in red blood cells that carries oxygen from the lungs to the cells and in protection against free radicals and those involved in protein synthesis; hence the important role zinc in cell renewal, healing and immunity ( Sene et al., 2018) . Dietary iron is composed of heme iron (from animal tissues) and non-heme 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, including potassium , sodium , magnesium , zinc , phosphorus , and nitrogen , lead to growth arrest 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. In addition , local food supplements represent 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 each child through commitments mentioned in the National Nutritional Security Policy, including the fortification of food at home with multi-micronutrient powders., the consumption of diversified foods, to ensure quantitatively and qualitatively adequate nutrition for children under five years of age and the promotion of non-wood forest products rich in micronutrients and other foods with high nutrient content so that they contribute to reducing nutritional deficiencies in Niger, particularly among vulnerable groups (SCCPNSN, 2017). This study aims to identify local foods with great nutritional potential: the mineral composition of products from 15 local species and their contributions in the fight against mineral 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 study involved 17 samples of 15 species including 8 woody species and 7 non-woody species (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 tests and calcined in an oven at 550°C for 2 hours. The ashes obtained from each sample were reconstituted in 250 ml of distilled water in order to carry out experimental analyses.

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

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 contents**

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

**Calculation of the coverage rates for daily mineral element requirements**

The rate of coverage of the daily needs of children from 0 months to 8 years in mineral elements was determined as being the intake of a mineral element in relation to the recommendations (Recommended Nutritional Intake/Adequate Intake) 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 mineral composition in macroelements of pulps, almonds, legumes and a cereal was determined and grouped in Table III. Thus, the mineral contents ( Ca , Mg, Na, K and P) were measured and the potassium content is mainly 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 the pulp of *Hyphaene thebaïca* . After potassium, come the phosphorus contents , the highest of which were found in the seeds of *Arachis hypogaea* (662.72mg/100g of DM) and the almond of *Ziziphus mauritiana* (336.71mg/100g DM) . 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 the kernel of *Anacarduim occidentale* (170.10mg/100g DM ) . The pulp of *Adansonia digitata* and the kernel of *Neocarya* macrophylla are exceptionally rich in calcium respectively.194.39mg/100g DM, 128.26mg/100g DM . As for the sodium contents in the seeds of *Arachis hypogaea* , the pulp of *Neocarya macrophylla* and the tubers of *Ipomoea batatas,* they represent the highest respectively 344.91mg/100g, 300mg/100g DM and 225mg/100g DM.

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

Pearson correlation, also known as Pearson correlation coefficient, was measured between the different 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, a moderate and significant negative correlation was observed 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 element contents shows three main groups:

-Group 1 contains the pulps of *Adansonia digitata, Hyphaene thebaïca, Parkia biglobosa and Ziziphus mauritiana* ;

- Group 2 concerns legumes such as the seeds of *Glycine max, Vigna unguiculata* and the tuber of *Ipomoea batatas* ; hypocotyl of *Borassus aethiopum*

- Group 3 includes the seeds of *Arachis hypogaea, Cucurbita SP., Pennisetum glaucum* and *Sesamum indicum; almonds of Anacarduimouest, Neocarya macrophylla, Sclerocarya birrea* and *ziziphus mauritiana; the pulp of Neocarya macrophylla* .

The coverage rates of the daily needs of the organism of children aged 0 months to 8 years in mineral elements 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 of needs for most mineral elements according to age groups . For example, the consumption of 100g of the pulp of *Adansonia digitata* by a child aged 7 to 12 months gives him a theoretical coverage of calcium of 74.76% and 32.40% of magnesium (Table VI). All the species in the present study allow a phosphorus coverage of more than 45% in children aged 7 to 12 months with the exception of the seeds of *Cucurbita SP., Sesamum indicum* and the almond of *Sclerocarya birrea .* Potassium coverage rates are relatively high with rates that are greater than 100% in all age groups for species, notably the pulp of *Adansonia digitata* , the seed of *Glycine max* , the tuber *Ipomoea batatas* , the pulp of *Hyphaene thebaïca* , the pulp of *Parkia biglobosa* , the seed of *Vigna unguiculata and* the pulp *of Ziziphus mauritiana* (Table VII). Sodium coverage rates are practically low for the majority of species in all age groups combined and are less than 20% with the exception of *Arachis hypogaea* , *Ipomoea batatas* and the pulp of *Neocarya macrophylla* (Table VIII). Iron and zinc coverage rates are largely sufficient, particularly in the almonds of *Anacarduim occidentale* and *Neocarya macrophylla, for* which these rates are greater than 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) . A breastfed child after six months needs more vitamins, minerals, proteins and carbohydrates than breast milk generally provides (Amadou, 2023). Any food or nutritious liquid other than breast milk that is given to the young child during this period falls under the category of complementary foods, and complementary feeding is the process of introducing these foods (Amadou, 2023). In addition, sociodemographic 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 assessment of local food products from domesticated and wild species accessible at low cost must be subject to a specific nutritional assessment. This is how the objective of this study was achieved in which the mineral composition of 17 samples from 15 local species composed of almonds, pulps, legumes and a cereal and their contributions in 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, hence the deficiencies or excess of essential trace elements which produce significant disorders in the organism. (Elie, 2022) . Finally, macroelements such as calcium (Ca), phosphorus (P), sodium (Na) and potassium (K) intervene in the body by strengthening 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 are very rich in macroelements but poor in trace elements with many variations from one species to another but also between the pulp and the almond of the same species. Thus, among the macroelements determined, the potassium contents are mainly the highest in all the samples of 15 plant species with a maximum proportion of 8000mg/100g DM for the pulp of *Hyphaene thebaïca* . 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 the almond of *Anacarduim occidentale* (170.10mg/100g DM). Comparing the results of *Adansonia digitata* in magnesium with previous data in the literature, some authors in Ivory Coast and Burkina Faso (Kouassi, 2018; Parkouda et al., 2007) found lower results in magnesium respectively 44.62 mg/100g and 192.27 mg/100g. The observed difference could be due to the nature and richness of the soils, fluctuation and climate changes as well as the technique and the duration between the collection of samples and their analysis in the laboratory. (Halidou et al., 2022) . As for phosphorus contents, the seeds of *Arachis hypogaea* and the almond of *Ziziphus mauritiana* presented the highest values respectively 662.72mg/100g DM and 336.71mg/100g DM. As for the phosphorus content of peanut ( *Arachis hypogaea* ), it is a lower content (359mg/100g) which was mentioned in the West African food composition table (Barbara et al., 2012) . The pulp of *Adansonia digitata* and the almond of *Neocarya macrophylla* are exceptionally rich in calcium respectively 194.39mg/100g DM and 128.26 mg/100 g DM. For the pulp of *Adansonia digitata* , the value is higher than that reported in the previous study from the Ivory Coast , the content of which reaches 310.12 mg/100 g. (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 element of the skeleton (EFSA, 2017) because approximately 99% of total body calcium is found in bones and teeth as calcium hydroxyapatite, where it plays a structural role (EFSA, 2015b). Low calcium intake also appears to be a risk factor for the development of overweight and obesity. ( Nessaibia And Khelaltia , 2016) . Sodium levels are relatively low for most products. However, the seeds of *Arachis hypogaea* , the pulp of *Neocarya macrophylla* and the tubers of *Ipomoea batatas* are the richest in sodium respectively 344.91mg/100g DM, 300mg/100g DM and 225mg/100g DM. This sodium content of *Ipomoea batatas* is significantly higher than that reported in the food composition table in West Africa for several varieties of this species (Barbara et al., 2012). In association with sodium and chlorine (sodium chloride NaCl ), they intervene in the osmotic pressure of extracellular fluids. Sodium deficiency leads to neurasthenia, fatigue, dehydration (Elie, 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 DM), *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.

**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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