Agr. Foo. Nat. Res. J. Volume 3, Issue 2, Page 190 - 197

e-ISSN: 1597-7153 | p-ISSN: 3043-5420

Agriculture, Food and Natural Resources Journal

The Official Journal of the Faculty of Agriculture, Nnamdi Azikiwe University, Nigeria

Journal homepage: https://journals.unizik.edu.ng/afnrj

Original Article

Impacts of non-nutritive compounds on the bio-accessibility of critical mineral elements in red vine fruits

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Musbau Bayonle OLANIYI[1]*, Aishat Adeola OLANIYI[2], Samsideen Olabiyi RUFAI[1] & Paul Oluwatimilehin OGUNBAMOWO[1]

[1]*Biomedicinal Research Centre, Forestry Research Institute of Nigeria, P.M.B 5054 Jericho Hill, Ibadan, Oyo State, Nigeria*

[2]*Multipurpose, Tree Species Improvement and Multiplication Unit, Forestry Research Institute of Nigeria, P.M.B 5054 Forest Hill, Ibadan, Oyo State, Nigeria*

DOI: https://www.doi.org/10.5281/zenodo.14030923

Editor: *Dr Onyekachi Chukwu, Nnamdi Azikiwe University, NIGERIA*

Received: *May 20, 2024*
Accepted: *August 18, 2024*
Available online: *September 30, 2024*

Peer-review: *Externally peer-reviewed*

Conflict of Interest: The authors have no conflicts of interest to declare

Financial Disclosure: *The authors declared that this study has received no financial support*

ABSTRACT

Red Vine Fruits (RVFs), a wild edible fruits, are sought as an alternative food source to prevent hunger and malnutrition. This study aimed to investigate the impact of the non-nutritive compounds on the bioaccessibility of critical minerals in pre-treated RVFs using standard analytical methods. The result of mineral composition of RVFs showed that magnesium had the highest (940.33 ± 0.01), followed by potassium (389 ± 0.01), calcium (215.80 ± 0.01), and copper (2.53 ± 0.01) as the least content in mg/100 g. The non-nutritive compounds found (mg/100 g) were phytates (8430.66), oxalates (140.52), and tannins (18.19). The ratios of critical elements (Ca:K, Na:K, and Fe:Zn) were 0.54, 0.56, and 1.47, all within the standard limits except Ca:Fe, which exceeded its limit. Additionally, the molar ratios of non-nutritive compounds to critical minerals were 2.36, 102.1, 150.2, 810.5, and 0.29 for phytate: Ca; phytate: Fe; phytate: Zn; phytate*Ca: Zn; and oxalate: Ca, respectively. These values exceeded the recommended limits, but oxalate: Ca is within the safe limit. The results also depicted a moderate value in phytate K (4.04), non-phytate K (10.29), and K proportion as phytate (28.19). These values are within the maximum standard (50%) critical for optimal K bioavailability. The findings showed that RVFs are high for critical minerals with a substantial amount of non-nutritive compounds, especially phytate content, which needs to be eliminated for optimum mineral bioaccessibility.

KEYWORDS: *Bioavailability, Critical minerals, Fruits, Non-nutritive compounds, Phosphorus.*

INTRODUCTION

In developing countries like Nigeria, food insecurity has become a major challenge as a result of the non-availability of conventionally nutritious and safe foods at affordable prices. This has led to malnutrition and various degrees of health related issues, especially among the low-income populace. Therefore, the need for alternative sources of foods like wild edible fruits as critical components of human nutrition requires urgent attention to combat this challenge (Bvenura & Swakumar, 2017; Jiru *et al.*, 2023). Also, the incorporation of wild edible fruits into daily diets can contribute to the eradication of hunger and malnutrition, which in turn enhance livelihoods (Olaniyi *et al.*, 2024; Singh *et al.*, 2020). Wild edible fruits are a good source of essential dietary fibre, proteins, fatty acids, sugars, and phytochemicals (Jiru *et al.*, 2023). The utilisation of wild edible fruits not only

*Corresponding author: musbay2012@gmail.com

contributes to the nutritional diversity of rural populace but also acts as a strategic approach to improve the food value in diets (Asaye *et al.,* 2023). Alissa & Ferns (2017) reported that high dietary fibre and antioxidant contents in wild edible fruits can treat chronic diseases such as diabetes, cardiovascular illnesses, inflammations, and digestive and urogenital diseases. Regular consumption of fruits can help protect against non-communicable diseases associated with diet (WHO, 2021). Regular consumption of starchy foods, especially cereals and roots, particularly in rural communities is common and can lead to protein-energy malnutrition and micronutrient deficiencies (Jiru *et al.,* 2023). Thus, food diversification and consumption of wild edible fruits (RVFs) are crucial to overcome the problem of malnutrition and micronutrient deficiencies. In spite of the numerous benefits of wild edible fruits; factors such as ignorance, neglect, and poor understanding of the food value and health promoting bioactive compounds of wild edible fruits may lead to the poor intake of wild edible fruits in some regions (Omari *et al.,* 2017). The level of non-nutritive compounds in wild edible fruits is also a credible factor in realising the full potential of these resources (Keyeta *et al.,* 2020).

Red vine fruits (RVFs), wild edible fruits, are an important plant resource which is known for its nutritional and medicinal values in the rural communities especially regions with limited economic buoyancy. They contain a range of essential amino acids in high proportions and are rich in proteins, fatty acids, vitamins, carbohydrates, sugars, dietary fibre, minerals, and bioactive compounds. RVFs are rich in macro-micronutrients and comparable to cultivated crops (Kibaret *et al.,* 2017; Olaniyi & Rufai, 2020). RVFs contain some non-nutritive compounds that can impede the rate of digestion, absorption, and bioavailability of critical nutrients, disrupting normal metabolism, and resulting in allergic reactions, which may severely limit the exploration of RVFs optimally. Non-nutritive compounds are numerous secondary metabolites naturally produced in high concentrations during plant growth that produce adverse effects upon consumption and reduce the nutrient utilisation of food. Studies have shown that many compounds found in lower concentrations are often referred to as anti-nutritional factors, which can have beneficial effects in preventing coronary diseases and cancers (Zhang *et al*., 2021). Meanwhile, some of the non-nutritive compounds in wild edible fruits (phytates, saponins, oxalates) directly inhibit enzyme activity, chelate ionic cofactors, or form irreversible complexes, to block protein digestion (Siddiq *et al*., 2018). Non-nutritive compounds affect the absorption of nutrients by humans and animals, interfere with their normal metabolism, causing allergic or adverse reactions in the human body such as skin, gastrointestinal, and respiratory, among others, and cause food poisoning in advance cases (Cardador-Martinez *et al*., 2020). Therefore, the presence of non-nutritive compounds has resulted in the decline of the nutritional value of RVFs, which has restricted their further development and utilisation by man.

However, in an attempt to suppress the activity of non-nutritive contents, various processing approaches are adopted that can effectively improve the usage of these wild resources and expand their nutritional prospect as food or feed ingredients for humans and animals (Zhang *et al*., 2021). Limited studies have been carried out on the nutritional and non-nutritive compositions of RVFs. However, due to the increase in search for alternative plant food sources that are not only cheap but also nutritious. It is therefore necessary to pay attention to the dietary safety of this plant resource. Hence, it is crucial to eliminate or reduce the non-nutritive compounds in RVFs.Therefore, this study aimed to evaluate the effects of selected non-nutritive compounds on the critical mineral element bioavailability of RVFs.

MATERIALS AND METHODS

Sample collection and preparation

Matured RVFs were harvested from the Forestry Research Institute of Nigeria, Ibadan. The fruits were cleaned using 60% ethanol and rinsed under running water to remove all contaminants adhering to the fruits. The cleaned samples were then soaked in water for 24 hours to reduce the inherent non-nutritive compounds in the fruits. After soaking, the samples were drained, then dried in an electric oven at 60^oC until drying is achieved. The dried sample was ground to a fine powder in a portable electric blender. The powder was stored in the airtight containers until used for chemical analysis.

Mineral analysis

Mineral nutrient content of the RVFs was estimated according to the standard methods (AOAC, 2015). Powdered sample (1g) was taken into a beaker and 10 ml of acid mixture Nitric acid (HNO_3) and 70 % perchloric acid ($HClO_4$) in a ratio of 4:1 was added into the solution and kept overnight. The resultant solution was then heated on a hot plate until the solution become colourless and devoid of NO_2 vapours. The sample was then transferred into a 50 ml flask and filtered using Whatman No. 1 filter paper. The volume of the filtrate was made up with distilled water. Mineral elements such as Ca, Na, K, Fe, Cu, Mg, and Zn were determined from the prepared sample solution by atomic absorption spectroscopy.

While P was determined by the spectrophotometric vanadium phosphomolybdate method.

Determination of non-nutritive compounds

For the determination of non-nutritive compounds such as phytates, oxalates, and tannins,standard analytical procedures were adopted.

Phytate was estimated using the procedure mentioned by Olapade *et al*., (2018) with slight modifications. About 1ml of supernatant from the 5 % H_2SO_4 extraction was added to 1 ml of $FeCl_3$ solution. The solution was heated in a water bath at 100 ºC for 30 minutes. The solution was treated with ice-cold water for 15 minutes, then centrifuged at 4000 rpm for 30 min. Supernatant solution 1 (ml) was carefully placed into a cuvette, and a minute quantity of 2,2 Bipyridine solution was added until a pink hue appeared. The absorbance value for the mixture was read at a wavelength of 519 nm using distilled water as a control.

Oxalate content was estimated by the titrimetric method described by Olaniyi & Rufai, (2020) with little modification. Two grammes of powdered sample was digested with 10 ml of 6M HCl for 1 hour and then allowed to cool. The solution was prepared in a 250 ml volumetric flask and filtered. Filtrate (125 ml) was carefully transferred into the beakers, 3 drops of methyl red were added, and a conc. NH_4OH solution was gradually added until the colour changed from pink to pale yellow. The pH of the resultant solution was measured, the temperature was increased to 90 ºC, then cooled and filtered to dislodge the precipitate. Again, 10 ml of $CaCl_2$ solution was added, and a constant stirring speed was maintained. The solution was decanted,and the residue was fully dissolved in a 10 ml solution of 20 % H_2SO_4. The filtrate was made up to 300 ml, and 125 ml of the filtrate was heated until it was almost boiling. The heated filtrate was titrated against a standard solution of 0.05 M $KMnO_4$. The appearance of a persistent pink colour for almost 30s at the endpoint is noted.

Tannin content was determined by the Folin-Denis procedure as described (Ngurthankhumi *et al*., 2024). Sample (0.5 g) was placed into a conical flask, and 75 ml of water was added. The solution was boiled for 30 min, and centrifuged at 2000 rpm for 20 minutes. The supernatant was carefully transferred into a volumetric flask and diluted with distilled water to a final volume of 100 ml. Sample extract (1 ml) was placed in a volumetric flask containing 75 ml of water, 5 ml of Folin-Denis reagent and 10ml of Na_2CO_3 solution were added. The solution was diluted with distilled water to a final volume of 100 ml. After 30 min of incubation, the contents were analysed using a UV-Vis spectrophotometer at a wavelength of 700 nm with the blank solution as the reference.

Estimation of critical mineral elements ratios

Molar ratios of critical mineral elements were determined to predict the bioaccessibility of vital minerals, as reported by (Olaniyi & Rufai, 2020). The molar ratios of critical minerals were calculated using equation:

$$Molar\ ratio = \frac{Concentration\ of\ critical\ mineral\ element\ 1/Molar\ mass}{Concentration\ of\ mineral\ element\ 2/Molar\ mass}$$

Estimation of non-nutritive compounds – critical mineral elements ratios

Molar ratios of non-nutritive compounds (phytates, oxalates) to critical mineral elements (iron, zinc, calcium) were estimated to predict the bioaccessibility of these critical elements. This is determined by employing the equation:

$$Molar\ ratio = \frac{Concentration\ of\ Non-nutritive\ compound/Molar\ mass}{Concentration\ of\ critical\ mineral\ element/Molar\ mass}$$

Statistical analysis

All the empirical data obtained from the study were presented as mean and standard deviation using Microsoft Excel 2013.

RESULTS AND DISCUSSION

Mineral contents of red vine fruits

The analysis of mineral elements in red vine fruits revealed the presence of both major and trace minerals in different concentrations (mg/100g). These concentrations include calcium (215.8), magnesium (940.3), potassium (389), sodium (129.7), phosphorus (14.3), iron (7.0), copper (2.5), and zinc (5.5), as detailed in Table 1.

Table 1: Mineral contents of red vine fruits

Mineral element	Values (mg/100g)
Calcium	215.80 ± 0.01
Magnesium	940.33 ± 0.01
Phosphorus	14.33 ± 0.01
Potassium	389 ± 0.01
Sodium	129.67 ± 0.02
Iron	7.0 ± 0.01
Copper	2.53 ± 0.01
Zinc	5.53 ± 0.05

**Values are expressed as mean ± standard deviation of triplicate determinations.*

Based on scientific evidence, the human body is reported to require various critical minerals for optimum physiological functions. Minerals are classified as macro and trace elements not based on their relative importance but based on their allowable daily intake (Moris & Mohiuddin 2021). In this study, mineral analysis revealed that RVFs are a good reserve for essential minerals such as calcium, magnesium, phosphorus, potassium, iron, zinc, and copper, which are found in substantial quantities. These mineral elements are critical in performing essential roles in maintaining normal body functions and total wellbeing. They support immune functions, prevent the formation of malignant cells, and destroy DNA. However, a lack of these micronutrients can lead to an increased vulnerability to disease conditions due to compromised immune systems (Olaniyi & Rufai 2020).

Results of the study revealed that RVFs contains (940.33 ± 0.01 mg/100g), magnesium the highest mineral content, followed by potassium (389 ± 0.01 mg/100g), calcium, (215.80 ± 0.01 mg/100g), sodium (129 ± 0.01mg/100g), iron (7.0 ± 0.01 mg/100g), zinc (5.53± 0.01 mg/100g), and copper (2.53 ± 0.01 mg/100g), as the least content. The variation in mineral composition of RVFs observed in this study may be attributed to the soil and environmental conditions of the location where the fruits were collected. The amount of various mineral contents obtained were higher than the amounts reported for Ca (61.40±9.56 mg/100g; 74.63±6.86mg/100g; 27.07±3.07 mg/100g), K (2.62±0.02 mg/100g; 2.85±0.02 mg/100g; 0.41±0.03 mg/100g), Fe (6.5±0.03 mg/100g; 3.07±0.01 mg/100g; 1.13±0.11 mg/100g) and Zn (3.53±0.03 mg/100g; 5.35±0.05 mg/100g; 5.41±1.06 mg/100g) for similar edible fruits *Ziziphus mauritiana, Prunus jenkinsii* and *Artocarpus heterophyllus* fruits repectively (Ngurthankhumi *et al.*, 2024). Additionally, the present values were comparably lower than the values Mg (1033±0.001 mg/100g), Ca (200±0.00 mg/100g), K (492.66±0.001 mg/100g), P (9.9±0.00 mg/100g), Fe (5.0±0.00 mg/100g), Zn (8.43±0.00 mg/100g), reported in the previous study for *Leea guineensis* fruits except Ca, P, and Fe contents, which are higher (Olaniyi & Rufai 2020). The analysis of RVFs for macro and microminerals, which are essential in significant amounts for maintaining balanced nutrients, makes minerals a substantial criterion for obtaining the nutritional value of fruits. The results obtained in this present study were slightly different from the previous results obtained by Olaniyi & Rufai, (2020) for the same fruit tree species in terms of their mineral composition. This may be greatly due to the additional pre-treatment operation that was carried out prior to drying, where RVFs were subjected to soaking for a period of 24 hours. This unit operation (soaking) may have imparted the mineral constituents of the sampled fruits.

Non-nutritive contents of red vine fruits

The analysis of non-nutritive compounds in the sampled fruits unveiled the presence of different non-nutritive compounds in varying concentrations (mg/100g). These concentrations include the phytate (8430.66 mg/100mg), oxalate (140 mg/100g), and tannin (18.19 mg/100g), as outlined (Table 2).

Table 2: Non-nutritive compounds of red vine fruits

Non-nutritive compounds	Values (mg100g)
Phytate	8430.66± 0.01
Oxalate	140.52 ± 0.01
Tannin	18.19 ± 0.01

**Values are expressed as mean ± standard deviation of triplicate determinations.*

The presence of non-nutritive compounds in plant foods can limit the optimal utilisation of essential macronutrients, particularly proteins, vitamins, and minerals, thus reducing the overall nutritional value of the food (Fekadu *et al*., 2013). For instance, phytates can impede the absorption of Ca, K, Mg, Fe, and Zn by forming complexes with these minerals and can also reduce the digestibility of amino acids. On the other hand, at lower concentrations, dietary phytates may have health-promoting roles as antioxidants and anti-carcinogens, thus, potentially prevent some chronic diseases conditions like atherosclerosis, among others (Olaniyi & Rufai, 2020). Phytic acid in conjunction with salts of Ca, Mg, and K, are notably known as phytates and are stored mainly as phosphorus in matured fruits, seeds, vegetables, seeds, starchy roots, and tubers (Gibson *et al*., 2018). The phytates inhibit majorly polyvalent metal ions such as Ca, Fe, and Zn, to a high degree, while Mg, K and Cu are hindered minimally thus reducing their bioavailability (Yimer *et al.,* 2023). In this study, the phytate content (8430.66 mg/100g), was found to be higher than the values reported by Achaglinkame, (2019); Mattew *et al*., (2018), for fruits of *Citrullus lanatus* (1280 mg/100g), *Carica papaya* (1100 mg/100g), *Balanite aegyptiaca* (0.018 mg/100g), *Sclerocarya birrea* (0.006 mg/100g). Also, this value (8430.66 mg/100g), obtained for treated RVFs was far lower than the value (29530 mg/100g) reported by Olaniyi & Rufai (2020), for the same fruits untreated in water (soaking) prior to drying. However, the value of phytate in this study exceeds the recommended limit (0.1–0.6 mg/100g), known to inhibit the bioavailability of critical minerals. Hence, it becomes necessary to subject RVFs to some forms of pre-treatment processes other than soaking before consumption. Oxalates can have detrimental effects on the human diet and health by reducing calcium absorption and contributing to some disease conditions such as kidney stones and osteomalacia (Fekadu *et al*., 2013). They form water-soluble salts with ions of Na, K, and NH_4, which in turn bind with Ca, Fe, and Mg, making them unavailable to the cells (Kumar *et al*., 2017). The value of oxalate (140.52 mg/100g) in this study was higher than values obtained in the previous studies by Ekpa & Sani, (2018) reported for some edible wild fruits, including *Carica papaya* (0.55 mg/100g), *Mochis sylvestris* (0.09 mg/100g), *Ananias cosmos* (0.079 mg/100g) and *Citrullus lanatus* (0.052 mg/100g). However, the value obtained in this study is lower than the recommended safe limit (5000 mg/100g) (Jiru *et al*., 2023). This suggests that the oxalate content of RVFs studied is less harmful to human health and may not significantly interfere with the effective absorption and utilisation of critical minerals if consumed. Tannins are a form of phytochemical compound also known as a secondary metabolite found in the bark, fruits, leaves, and leaves of plants (Timotheo & Lauer 2018). Tannin molecules chelate metals such as Fe and Zn, reducing the bioavailability of these micronutrients. It also inhibits the activity of digestive enzymes and can precipitate proteins (Sam, 2019). The tannins content (18.19 mg/100g) in RVFs was higher than values reported for *Diospyros mespiliformis* (0.005 mg/100g), and *Sclerocarya birrea* (0.006 mg/100g) (Achaglinkame, 2019). But lower than values obtained for *Citrullus lanatus* (1370 mg/100g), *Ananas cosmos* (880 mg/100g), and *Carica papaya* (490 mg/100g) fruits (Ekpa & Sani, 2018). This could be related to environmental factors, genetic variability, and physiological period. Although the toxic effect of tannin in the RVFs is likely inconsequential owing to the fact that the value (18.19 mg/100g) is well below the recommended daily limit of 560 mg/100g of tannic acid for humans.

Critical mineral contents molar ratios

The mineral ratios are often more vital than individual mineral concentrations because they help in determining the nutritional interrelationships (Hoskin & Ireland, 2000; Jiru *et al*., 2023). The mineral ratios of critical elements of RVFs are presented (Table 3).

Table 3: Molar ratios of critical mineral contents of red vine fruits

Critical mineral ratios	Calculated values	Recommended limits
Na: K	0.56	<1.0
Ca: K	0.54	< 4.0
Ca: P	11.68	> 0.5
Fe: Zn	1.47	> 2.0

According to the report of Ijarotimi *et al.*, (2013), who revealed that a Na:K ratio of less than one is recommended for healthy foods. The result showed that Na:K ratios (0.56) of the RVFs evaluated in this study fall below the recommended values (<1.0) (FAO 2013). Therefore, maintaining the Na:K ratio below 1.0 is crucial to reducing cardiovascular diseases like heart attack, hypertension (Binia *et al*., 2015). Therefore, the consumption of RVFs may help lower blood pressure in hypertensive patients. The value of Ca:K (0.54) recorded in this study is similar to the 0.45, 0.91, and 1.14 reported by Jiru *et al*., (2023) for *Ziziphus spina-christi*, *Gardenia erubesce*, and *Ficus mucuso* fruits, respectively. The present value is lower than the maximum acceptable limit (4.0) of healthy foods, which may help thyroid activity (Oghbaei *et al*., 2016). Meanwhile, the standard limit for the Ca:P ratio should be more than 0.5 for healthy foods to contribute to calcium absorption in the small intestine (Jacob *et al*., 2015). Although the Ca:P high value (11.68) obtained for RVFs is similar to 15.6 reported in the previous findings by Olaniyi & Rufai, (2020) for the same wild edible fruits. A high Ca:P ratio was reported to aid Ca absorption for growing children who require a high amount of Ca and K for bone and tooth formation (Ijarotimi *et al*. 2013). The Fe:Zn ratio of sampled fruits was 1.47, which indicates that iron did not hinder zinc absorption up to slightly above the 2.0 FAO recommended limit. Therefore, the iron present in the fruits investigated may not impair zinc absorption and can serve as a viable remedy to some health challenges, such as poor growth and cognitive retardation (Jiru *et al.*, 2023).

Non-nutritive compounds to critical elements molar ratio and bioaccessibility

The molar ratios for calcium, iron, zinc, phytate, and oxalate were calculated to determine the impact of oxalate and phytate on the dietary minerals bioavailability. The calculated molar ratios of phytate: Ca, oxalate: Ca, phytate: Zn, phytate: Fe, and phytate *Ca: Zn of the RVFs are presented (Table 4).

Table 4: **Molar ratios of non-nutritive compounds to critical elements**

Compounds	Molar ratios	Component ratios	Calculated values	Critical values
Phytate	12.77	Phytate: Ca	2.36	0.24
Oxalate	1.59	Phytate: Fe	102.1	1.0
Ca	5.395	Phytate: Zn	150.2	15.0
Fe	0.125	Phytate *Ca: Zn	810.5	10.0
Zn	0.085	Oxalate: Ca	0.29	1.0

***Molecular weights (phytate: 660 g/mol; oxalate: 88 g/mol; Ca: 40 g/mol; Fe: 56 g/mol; Zn: 65 g/mol)*; mg of phytate/molecular weight of phytate; mg of oxalate/molecular weight of oxalate; mg of Ca/molecular weight of Ca; mg of phytate/molecular weight of phytate*: *mg of Fe/molecular weight of Fe*; *mg of phytate/molecular weight of phytate*: *mg of Zn/molecular weight of Zn*; *mg of oxalate/molecular weight of oxalate: mg of Ca/molecular weight of Ca*;*(mg of Ca/molecular weight of Ca)*(mg of phytate/molecular weight of phytate)/(mg of zinc/molecular weight of Zn).*

Phytates in form of phytic acids remarkably decrease calcium bioavailability in the human body. The molar ratio of phytate:Ca (2.36) obtained in this study is more than the critical value (0.24) but lower than the previous value (8.97) reported for the same species by Olaniyi & Rufai (2020). The phytate:Ca ratio is considered as a good measure of calcium bioavailability having a standard limit of 0.24 (Woldergiogis *et al*., 2015). In this study, the result obtained revealed that the presence of phytate in the sample may slightly impair the absorption of calcium. The phytates: Fe molar ratio obtained in this study was 102.1 which is higher than the critical value of 1.0. This may favour poor iron absorption and consequently lead to poor iron bioavailability in the body. Gemede (2020) affirms that foods containing phytate:Zn molar ratio of not more than 15 possess adequate zinc bioavailability. However, the result obtained in this study (150.2) is lower than the value (348.2) reported for untreated RVFs by Olaniyi & Rufai (2020). But this present value is far higher than the standard limit (15.0) which may result in poor zinc bioavailability. The inhibitory impact of oxalates on dietary calcium bioavailability becomes apparent when the oxalate:Ca molar ratio is more than 1.0 (Olaniyi & Rufai, 2020). In this study, the oxalate:Ca ratio (0.29) is lower than the critical value (1.0), which implies good dietary calcium bioavailability in the tested sample. Furthermore, another better approach of estimating the zinc bioavailability in foods is by evaluating the molar ratio of phytate*Ca:Zn. The molar ratio phytate*Ca:Zn in this study was 810.5 which is far greater than the recommended limit (10). This indicates poor zinc bioavailability in the RVFs evaluated. Phytate*Ca:Zn molar ratio higher than 200 may adversely influence zinc bioavailability (Castro-alba *et al.* 2019). The present result also negate the findings of Jiru *et al.* (2023) who reported very lower values (0.010 – 1.518) for *Gardenia erubescens, Dovyalis abyssinica, and Ziziphus spina-chris* fruits respectively.

Phytates phosphorus and Non-phytates phosphorus

The quantity of phytate phosphorus in percentage to the total phosphorus are crucial, as phytate phosphorus cannot be converted to use by the human body (Jiru *et al.,* 2023). The phytate phosphorus and non-phytate phosphorus as well as proportion of phosphorus as phytate inthe RVFs are presented in Table 5. The phytate phosphorus content of RVFs was 4.04 mg/100g (Table 5) which in contrast to the findings by Jiru *et al.* (2023) who reported 22.30 mg/100g and 15.71 mg/100g for *Gardenia erubescens* and *Ziziphus spina-christi* fruits respectively. In addition, the non-phytate phosphorus content was 10.29 mg/100g which is also lower than the amount (120.65, 56.84, 40.04 mg/100 g) reported for *Ficus mucuso, Gardenia erubescens* and *Ziziphus spina-christi*fruits respectively. Any food having a proportion of phosphorus as phytate (50% or 50 mg/100g) are considered as adequate in bioavailable phosphate (Jiru *et al*. (2023); Umeta *et al.*, 2005). This may be due to effect of phytate on phosphorus absorption at high concentrations in the presence of high phytate intake has led to the suggestion that the proportion of phosphorus as phytate may be a good index of phosphorus bioavailability. The quantity of phosphorus a phytate in percentage in RVFs in thisstudy was lower than the critical proportion of phosphorus a phytate (50 %) recommended. Thus, implying the high phosphorus bioavailability in the studied fruits. Therefore, RVFs may help improve the vital mineral intakes and assist in addressing critical mineral deficits due poor mineral bioavailability.

Table 5: **Phytate phosphorus and non phytate phosphorous contents of red vine fruits.**

Parameters	Values (mg/100g)
Phytate phosphorus	4.04
Non-phytate phosphorus	10.29
Quantity of phosphorus as phytate	28.19

**Phytate phosphorus was determined by total phosphorus multiplied by 28.18%; non-phytate phosphorus was calculated by subtracting total phosphorus from phytate phosphorus; the quantity of phosphorus as phytate was evaluated by phytate phosphorus divided by total phosphorus multiplied by 100.*

CONCLUSION AND RECOMMENDATIONS

In this study, mineral composition, non-nutritive content, and critical mineral bioavailability of RVFs are investigated. The finding showed that RVFs are a good source of crucial minerals for maintaining a healthy life. Although RVFs may have some non-nutritive activity that may impact mineral bioavailability. Potentially, they can be utilised for various food formulations to treat critical micronutrient deficiencies. Although, it can be inferred from the study that RVFs contain a substantial quantity of phytate, as evident in the result. Nevertheless, the full potentials of these fruits can be properly maximised by allowing RVFs to undergo various unit processing operations (fermentation, dehulling, among others) prior to utilisation to limit the non-nutritive compounds' activity.

Acknowledgement

The authors express their resounding gratitude to the National Forest Herbarium Ibadan and the Forestry Research Institute of Nigeria for their support.

Authors' Contributions

MBO, AAO & RSO carried out sample collection and preparation, managed data collection, interpretation of data, writing of manuscript, material support, and wrote the first draft and review of the manuscript. POO managed the literature searches. All authors carried out the methodology and data analysis. All authors read and approved the final manuscript.

Ethical Statement

Not applicable

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