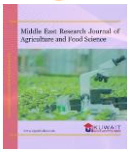

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Nutritional Profile, Antioxidant Capacity, and Heavy Metal Analysis of Dune Fruit (*Balanites aegyptiaca*) as a Traditional Food Source in Kebbi State

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Abstract: Dune fruit (*Balanites aegyptiaca*) is a widely consumed traditional food source in many parts of Kebbi State, Nigeria. Despite its wide consumption, there is limited information on the nutritional profile, antioxidant capacity, and heavy metal contamination of Dune fruit. Therefore, this study evaluated the nutritional profile, antioxidant capacity, and heavy metal content of Dune fruit (*Balanites aegyptiaca*) as a traditional food source in Kebbi State, Nigeria. The proximate composition, antioxidant capacity, and heavy metal content of the fruit were determined using standard analytical methods. The results showed that Dune fruit is rich in nutrients, including Vitamins B1, B2, B3, C and E, potassium, and fiber, with mean values of (0.05 ± 0.01mg/100g), (0.03 ± 0.01mg/100g), (0.52 ± 0.03mg/100g), (31.00 ± 1.00 mg/100g), (0.52 ± 0.03mg/100g), (370.00 ± 1.50mg/100g) and (8.10 ± 0.10mg/100g, respectively. The fruit also exhibited high antioxidant capacity, with a mean total phenolic content of (255.10 ± 5.10mgGAE/100g) and a mean antioxidant activity of DPPH (76.83 ± 1.65%) and ABTS (66.30 ± 1.20%). However, the fruit was found to contain high levels of heavy metals, including lead (0.053 ± 0.005mg/kg), cadmium (0.023 ± 0.005mg/kg), and chromium (0.11 ± 0.01mg/kg). The results of this study suggest that Dune fruit is a nutritious and antioxidant-rich food source, but its consumption should be done with caution due to its heavy metal contamination. Therefore, there is a need for proper handling, processing, and storage of the fruit to minimize its heavy metal content and ensure its safe consumption.

Keywords: Antioxidant capacity, *Balanites aegyptiaca*, Heavy Metal Contamination, Nutritional Profile and Traditional Food Source.

Research Paper

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1.0 INTRODUCTION

Dune fruit *(Balanites aegyptiaca)* is a widely consumed traditional food source in many parts of Africa, including Nigeria. The fruit is rich in nutrients and has been used for centuries in traditional medicine and as a food source. Despite its importance, there is limited information on the nutritional profile, antioxidant capacity, and heavy metal analysis of Dune fruit. This knowledge gap is a significant concern, as it may impact the health and well-being of consumers, particularly in rural areas where access to diverse food options is limited (Adebooye and Odufowora, 2017).

Balanites aegyptiaca is a member of the Balanitaceae family and is commonly found in the savannas and grasslands of Africa. The fruit is a drupe with a single seed surrounded by a fleshy pulp. It is rich in nutrients, including vitamins, minerals, and antioxidants. The fruit's nutritional value is attributed to its high content of phytochemicals, including flavonoids, phenolic acids, and carotenoids. These phytochemicals have been reported to have various health benefits, including antioxidant, anti-inflammatory, and antimicrobial activities (Kubmarawa *et al*., 2009).

In Nigeria, Dune fruit is widely consumed in many parts of the country, particularly in the northern regions. The fruit is eaten fresh, dried, or used in traditional medicine. It is also used as a source of income for many rural communities. The fruit's popularity is attributed to its sweet taste, nutritional value, and cultural significance. In some communities, the fruit is considered a delicacy and is served at special occasions, such as weddings and festivals. (Ogunwande *et al*., 2013).

Despite its importance, there is limited information on the nutritional profile of Dune fruit. Previous studies have reported that the fruit is rich in pro-vitamins A and C, potassium, and fiber. However, there is a need for more detailed information on the nutritional profile of the fruit, including its protein, fat, and mineral content. Additionally, there is a need to evaluate the fruit's antioxidant capacity and heavy metal content to ensure its safe consumption. (Adebooye and Odufowora, 2017).

In addition to its nutritional value, Dune fruit has also been reported to have antioxidant properties. Antioxidants are important compounds that help protect the body against free radicals, which can cause oxidative stress and damage to cells. Oxidative stress has been linked to a range of diseases, including cancer, diabetes, and cardiovascular disease. Therefore, consuming foods rich in antioxidants, such as Dune fruit, may help reduce the risk of these diseases (Halliwell, 2007).

Oxidative stress occurs when the body's antioxidant defenses are overwhelmed by the production of free radicals. Free radicals are unstable molecules that can cause damage to cells, proteins, and DNA. Antioxidants, such as those found in Dune fruit, can help neutralize free radicals and reduce oxidative stress. The antioxidant capacity of Dune fruit is attributed to its high content of phytochemicals, including flavonoids, phenolic acids, and carotenoids (Kubmarawa *et al*., 2009).

Heavy metal contamination is a major concern in many parts of the world, particularly in developing countries. Heavy metals, such as lead, cadmium, and mercury, can accumulate in the body and cause a range of health problems. Heavy metal contamination can occur through various routes, including contaminated soil, water, and air. In Nigeria, heavy metal contamination is a significant concern, particularly in areas with high levels of industrial and agricultural activity (Ogunwande *et al*., 2013).

Dune fruit may be contaminated with heavy metals, particularly if it is grown in areas with polluted soil or water. Therefore, it is essential to analyze the fruit for heavy metals to ensure its safe consumption. Heavy metal analysis involves measuring the levels of heavy metals in a sample using techniques such as atomic absorption spectroscopy (AAS) or inductively coupled plasma mass spectrometry (ICP-MS) (Adebooye and Odufowora, 2017).

The thrust of this study was to evaluate the nutritional profile, antioxidant capacity, and heavy metal content of Dune fruit (*Balanites aegyptiaca*) as a traditional food source in Kebbi State, Nigeria. The study seeks to provide detailed information on the nutritional value and safety of the fruit, which will be useful for promoting its sustainable production and consumption. Furthermore, the study also contributed to the existing body of knowledge on the nutritional profile and safety of traditional fruits in Nigeria.

2.0 MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Birnin Kebbi metropolis of Kebbi State, located in the North-western part of Nigeria. It's the capital city of Kebbi State and headquarters of the Gwandu emirates. Birnin Kebbi are mostly Hausa and Fulani with other tribes. Birnin Kebbi is situated on the Sokoto river and is connected by road to Argungu (45km northeast), Jega (35km southeast) and Bunza (45km southwest). Kebbi state lies between latitude 10°N to 13°N and longitude 4°E to 6°E. The state enjoys a tropical climate, characterized by two extreme seasons: hot and cold. Rainfall occurs from May/June to October, with the heaviest falls in July and August. The cold harmattan period, often accompanied by dusty winds and fog, prevails from November to January. Mean annual temperatures range from 21°C to 38°C, while mean annual rainfall is approximately 500mm.

2.2 Determination of Proximate Composition

Proximate composition was determined in triplicate using standard procedures of Association of Official Analytical Chemists (AOAC). The moisture content was determined by oven drying method. Crude protein was determined by Micro-Kjeldahl Method. Fat was determined by soxhlet extraction utilizing hexane as solvent. Crude fibre was determined by neutralization method (Method 962.09). Ash content was determined by dry ashing method of AOAC (Method 923.03) [10]. Carbohydrate content was determined by difference (%Carbohydrate) = [100-(%Protein + %Moisture+ %Ash+% Fibre% + %Crude Lipid)].

2.3 Determination of Vitamin Content

2.3.1 Determination of Vitamin C Content

Vitamin C content was determined using titration with 2, 6-dichlorophenolindophenol (DCPIP) according to the method described by. Briefly, 5g of Dune fruit sample was extracted with 50ml of 0.4% oxalic acid, and the mixture was filtered through a Whatman No. 1 filter paper. The filtrate was then titrated with 0.1% DCPIP solution until the pink color disappeared. The volume of DCPIP solution required to titrate the sample was used to calculate the vitamin C content using the following formula:

Vitamin C (mg/100g) = (V x C x 100) / W

Where V is the volume of DCPIP solution used (ml), C is the concentration of DCPIP solution (mg/ml), and W is the weight of the sample (g).

2.3.2 Determination Vitamin B1 Content

Vitamin B1 content was determined using titration with potassium ferricyanide according to the method described by. Briefly, 5g of the sample was extracted with 50ml of 0.1M hydrochloric acid. The mixture was filtered through a Whatman No. 1 filter paper. The filtrate was titrated with 0.02M potassium ferricyanide solution until the endpoint (color change) was reached. The volume of potassium ferricyanide solution required to titrate the sample was used to calculate the Vitamin B1 content using the formula:

Vitamin B1 (mg/100g) = (V x C x 100) / W

Where V is the volume of potassium ferricyanide solution used (ml), C is the concentration of potassium ferricyanide solution (mg/ml), and W is the weight of the sample (g).

2.3.3 Determination of Vitamin B2 Content

Vitamin B2 content was determined using fluorescence measurement after extraction with acetic acid. Briefly, 5g of the sample was extracted with 50ml of 1% acetic acid, and the mixture was filtered through a Whatman No. 1 filter paper. The filtrate was subjected to fluorescence analysis to measure riboflavin concentration. The intensity of fluorescence was directly related to the riboflavin concentration. The Vitamin B2 content was calculated using a standard curve and expressed as:

Vitamin B2 (mg/100g) = (Fluorescence value / Weight of the sample) x 100

Where the fluorescence value corresponds to the riboflavin concentration in mg/ml.

2.3.4 Determination of Vitamin B3 Content

Vitamin B3 content was determined using titration with alkaline hydroxylamine according to the standard method. Briefly, 5g of sample was hydrolyzed with 50ml of 1M sodium hydroxide, and the mixture was filtered through Whatman No. 1 filter paper. The filtrate was titrated with 0.1M hydroxylamine hydrochloride solution until the endpoint was reached. The volume of hydroxylamine solution used was recorded, and Vitamin B3 content was calculated using the formula:

Vitamin B3 (mg/100g) = (V x C x 100) / W

Where V is the volume of hydroxylamine solution used (ml), C is the concentration of hydroxylamine solution (mg/ml), and W is the weight of the sample (g).

2.4 Determination of Minerals Content

Determination of minerals Ca, P, Na, Mg, Cu, K, Fe, Mn, and Zn in sample was performed through a method illustrated in AOAC (2000) with slight modification as reported by Ashid *et al.,* (2021). Briefly, the samples (1g each) were digested with mixture of perchloric acid and 10-ml nitric acid at temperature range of 180°C–200°Cuntil it turned transparent. Then, dilution of this digested matter up to 100 ml was done through double distilled water. These diluted samples were run through atomic absorption spectrophotometer for measuring mineral contents concentration using air acetylene flame. Trials were conducted in triplicate, and mean values were calculated.

2.5 Determination of Amino Acid Content

The relative distribution of essential amino acids present in the date fruits was measured by oxidation followed by hydrolysis using hydrogen peroxide/formic acid/phenol and 6 M hydrogen peroxide solution, respectively, as described by Al-Barnawi (2018). The amino acids were then separated and analyzed by ion-exchange chromatography and photometric detection (440 and 570 nm) using ninhydrin reagent, respectively (Al-Barnawi 2018).

2.6 Determination of Anti Nutritional Content

2.6.1 Determination of Phytate Content

Phytic acid was found in the manner mentioned (Termote *et al.,* 2022). After weighing 2 grams of the sample into a flask and adding 100 ml of 2% HCl, the mixture was left to stand for 3 hours before being filtered. An indicator solution containing 0.3% ammonium thio-cyanate was added to 5 ml of a separate 250 ml conical flask that contained 25 ml of filtrate. 53.5 ml of distilled water was added to achieve the appropriate level of acidity. Subsequently, this was titrated with a standard iron III chloride solution for five minutes until a brownish-yellow color permeated the mixture (0.001 95 g of iron per ml). The formula for phytic acid was found to be Phytic acid (%) = titer value 0.001 95 × 1.19 × 100.

2.6.2 Determination of Oxalate Content

The amount of oxalate in the plant was determined using the modified titration method described by Hanum *et al.,* (2022). The material (1g) had been ground and 75ml of 3mol/L of H_2SO_4 were added to a conical flask, which was then stirred for an hour using a magnetic stirrer. After weighing, 25 ml of the filtrate was collected and heated between 80° and 90°C. The temperature of this filtrate was consistently maintained above 70°C. After reaching the endpoint, which was shown by a light pink color that persisted for 15 seconds, the hot aliquot was continuously titrated with 0.05mol/L of $KMnO_4$. Calculating the oxalate content involved, assume that 1 ml of 0.05mol/L of $KMnO_4$ is equal to 2.2 mg of oxalate.

2.6.3 Determination of Tannin

Tannins were determine using 0.5mg of sample boiled in 10 ml of distilled water and filtered with Whatman 42 filter paper. 2 ml of filtrate was taken in a test tube and 3-5 drops of 0.1 % ferric chloride solution were added. The brownish green or blue black coloration indicated the presence of tannins.

2.6.4 Determination of Saponin

Saponins were determine using 0.5mg of sample boiled in 15 mL of distilled water and filtered with Whatman 42 filter paper. 5ml of filtrate was mixed with 2 ml of normal water and shaken vigorously. The stable persistent froth indicated the presence of saponins.

2.6.5 Determination of Alkaloids

Alkaloids were determined using 0.5mg of crude extract mixed with 5 mL of 1% aqueous HCl on water bath and then filtered. 2-5 drops of Dragendorff's reagent were added in the filtrate. The occurrence of orange-red precipitate indicated the presence of alkaloids in the sample extract.

2.6.6 Determination of Cyanogen Glycosides

Hydrocyanic acid, which is evolved from the grinded culban *(Vicia peregrina)* seed sample forms a red-colored compound with alkaline picrate solution, and the intensity is measured by spectrophotometer at 625nm (Parimelazhagan and Thangaraj. 2016).

2.6.7 Determination of Trypsin Inhibitor Activity

Trypsin inhibitors were determined in culban *(Vicia peregrina)* according to Kakade *et al.* (1969). By using casein as substrate for reaction. These methods depend on the casine degradation ratio by trypsine inhibitors. However, the rate of casein decomposition increased the reaction of free aromatic amino acids that absorb the light in wave length 280 nm.

2.6.8 Determination of Lectin

Lectin in the samples was determined by preparing a crude extract through centrifugation, followed by protein quantification using the Bradford method. A hemagglutination assay was conducted using glycoprotein-coated beads to detect lectin activity, with serial dilutions prepared to determine the agglutination titer. Specificity was confirmed by competitive inhibition with known carbohydrates, ensuring lectin-carbohydrate interactions were responsible for agglutination. The method was adapted from Qadir *et al.*, (2013) with modifications for improved accuracy.

2.7 Determination of Carotenoid
2.7.1 Determination of β –Carotene

β-carotene content was determined by means of UV spectrophotometer (Doe and Smith, 2017). The sample (1g) was soaked in 5cm^3 of methanol for 2 hours at room temperature under dark condition in order to get complete extraction. The β-carotene layer was separated using hexane through separating funnel. The volume was made up to 10 cm^3 with hexane and then this layer was passed through sodium sulphonate through a funnel in order to remove any moisture from the layer. The absorbance of the layer was measured at 436nm using hexane as blank.

2.7.2 Determination of Leutin and Zeaxanthin

The contents of xanthophyll, lutein and zeaxanthin were quantified by high pressure liquid chromatography (HPLC), this method is referred to Nhungetal. (Kubola *et al.*, 2011), (Nhung *et al.*, 2010). The RP-HPLC system (Shimadzu) consisted of an auto sampler and column oven equipped with Inert sil ODS (4.6mm×250mm,5lm) with mobile phase of DCM: acetonitrile (6:4,v/v, containing 0.05: 475 BHA as antioxidant) (eluent A), (eluent B) and MeOH. The following gradient was used: initial condition was 70% (A) and 30% (B) for 5 min, followed by 80% (A) and 20% (B) for 5 min. The flow rate 1.5 ml/min., injection volume 20µl and photodiode array detector at 472 nm for the analysis of lycopene and beta-carotene were carried out. Calibration curves were constructed with the external standards.

2.8 Determination of Antioxidant Activity Capacity
2.8.1 Determination of ABTS

For ABTS assay, the procedure followed the method of Arnao *et al.* (2001) with some modifications. The stock solutions included 7.4mm ABTS solution and 2.6mm 670 K. potassium per sulfate solution. The working solution was then prepared by mixing the two stock solutions in equal quantities and allowing them to react for 12 h at room temperature in the dark. The solution was then diluted by mixing 1ml ABTS solution with 60ml methanol to obtain an absorbance of 1.170.02 units at 734 nm using the spectrophotometer.

Fresh ABTS solution was prepared for Triplicate assay. Dune fruit sample (150ml) were allowed to react with 2850ml of the ABTS solution for 2hours in a dark condition. Then the absorbance was taken at 734 nm using the spectrophotometer. The standard curve was linear between 25 and 600mm Trolox. Results are expressed in mm Trolox equivalents (TE)/g fresh mass. Additional dilution was needed if the ABTS value measured was over the linear range of the standard curve.

2.8.2 Determination of DPPH

The DPPH assay was done according to the method of Brand-Williams *et al.*, (1995) with some modifications. The stock solution was prepared by dissolving 24 mg DPPH with 100ml methanol and then stored at 20ºC until needed. The working solution was obtained by mixing 10ml stock solution with 45ml methanol to obtain an absorbance of 1.170.02 units at 515 nm using the spectrophotometer. Dune Fruit extracts (150ml) were allowed to react with 2850ml of the DPPH solution for 24hours in the dark. Then the absorbance was taken at 515 nm. The standard curve was linear between 25 and 800mm Trolox. Results are expressed in mm TE/g fresh mass. Additional dilution was needed if the DPPH value measured was over the linear range of the standard curve.

2.8.3 Determination of FRAP

The FRAP assay was done according to Benzie and Strain (1996) with some modifications. The stock solutions included 300 mm acetate buffer (3.1g $C_2H_3NaO_2$, $3H_2O$ and 16 mL $C_2H_4O_2$), pH 3.6, 10 mm TPTZ (2, 4, 6- tripyridyl-s-triazine) solution in 40 mm HCl, and 20 mm $FeCl_3$, $6H_2O$ solution. The fresh working solution was prepared by mixing 25ml acetate buffer, 2.5mm TPTZ solution, and 2.5ml $FeCl_3$ $6H_2O$ solution and then warmed at 37 1C before using. Fruit extracts (150mL) were allowed to react with 2850 mL of the FRAP solution for 30 min in the dark condition. Readings of the colored product (ferrous tripyridyltriazine complex) were then taken at 593. The standard curve was linear between 25 and 800mm Trolox. Results are expressed in mm TE/g fresh mass. Additional dilution was needed if the FRAP value measured was over the linear range of the standard curve.

2.8.4 Determination of Total Phenolic Content

The total phenolic content was calculated using the Folin Ciocalteau method, as described by Cicco *et al*., (2009) and Shemishere *et al.,* (2020). The Folin-Ciocalteau reagent (phosphomolybdate and phosphotungstate) reduction by phenolic chemicals is the basis for this experiment. A spectrophotometer can detect the decreased Folin-Ciocalteau reagent at 760nm since it is blue in colour. One mg/mL quantities of gallic acid or extracts/fractions were created in DMSO. In 4.5ml of distilled water, 0.5ml of the extract/fraction and 0.5ml of a Folin Ciocalteau reagent that had been diluted 10 times were mixed. The tubes were then refilled with 5ml of 7% sodium carbonate and 2ml of distilled water. At 760nm, the mixture's absorbance was measured after standing at room temperature for 90 minutes. Gallic acid was used as the positive control throughout all determinations, which were carried out in triplicates. Gallic Acid Equivalent (GAE)/g of extract/fraction was used to measure the overall phenolic content.

2.8.5 Determination of ORAC

The ORAC procedure used an automated plate reader (KC4, Bio Tek, USA) with 96-well plates (Prior *et al.,* 2003). Analyses were conducted in phosphate buffer pH 7.4 at 37 1C. Peroxyl radical was generated using 2, 2'-azobis (2-amidino-propane) dihydrochloride which was prepared fresh for each run. Fluorescein was used as the substrate. Fluorescence conditions were as follows: excitation at 485 nm and emission at 520 nm. The standard curve was linear between 0 and 50mm Trolox. Results are expressed as mM TE/g fresh mass.

Each antioxidant activity assay was done three times from the same extract in order to determine their reproducibility.

2.9 Determination of Heavy Metals

Heavy metal analysis was done according to AOAC 1995 using varian AA240 atomic absorption spectrophotometer as reported by Meena *et al.,* (2010). Standards for Pb, Cd, Hg, As, Cr, Cu, Ni, procured from Merck, Germany were used as reference analyte for quantitative estimation of heavy metals as well as accurate calibration and quality assurance of each analyte. The standard stock solutions (1000 mg/kg) were diluted to obtain working standard solution ranging from 5 mg/ kg to 20 mg/kg and stored at 4ºC. An acidity of 0.1% nitric acid was maintained in all the solutions. A calibration curve was plotted between measured absorbance and concentration (mg/ kg). All the samples were analyzed using flame atomic absorption spectrophometer (Kulhari *et al*., 2013). Measurements were made using standard cathode lamp for Pb, Cd, Hg, As, Cr, Cu, Ni.

Statistical Analysis

The data collected from the study were analysed using descriptive statistics (mean, standard deviation, and percentage) to summarize the proximate composition, antioxidant capacity, and heavy metal content of Dune fruit. The statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 25.

3.0 RESULTS

Table 1: Percentage Proximate Compositions of Dune fruit (*Balanites aegyptiaca*) sold in Kebbi State

Constituent	Mean (%)	Standard Deviation (SD)
Moisture	21.17	0.65
Crude Protein	2.33	0.15
Crude Fat	0.33	0.05
Crude Fiber	8.10	0.10
Ash	2.50	0.10
Carbohydrates	65.57	0.95

Values are mean ± standard deviation of triplicate determinations

Table 2: Mineral content of Dune fruit (*Balanites aegyptiaca*)

Mineral	Mean (mg/100g)	Standard Deviation (SD)
Calcium	54.20	0.50
Phosphorus	14.50	0.20
Magnesium	20.10	0.30

Mineral	Mean (mg/100g)	Standard Deviation (SD)
Potassium	370.00	1.50
Sodium	2.50	0.10
Iron	2.10	0.05
Zinc	0.80	0.02
Copper	0.20	0.01
Manganese	0.50	0.03

Values are mean ± standard deviation of triplicate determinations

Table 3: Amino acid contents of Dune fruit (*Balanites aegyptiaca*)

Amino Acid	Mean (mg/g)	Standard Deviation (SD)
Alanine	2.55	0.05
Arginine	3.25	0.05
Aspartic acid	4.55	0.05
Cysteine	0.52	0.02
Glutamic acid	6.25	0.05
Glycine	1.85	0.03
Histidine	1.22	0.02
Isoleucine	2.85	0.03
Leucine	4.05	0.03
Lysine	3.55	0.05
Methionine	0.82	0.02
Phenylalanine	2.25	0.03
Proline	2.05	0.03
Serine	2.55	0.05
Threonine	2.85	0.03
Tryptophan	0.62	0.02
Tyrosine	1.42	0.02
Valine	3.05	0.03

Values are mean ± standard deviation of triplicate determinations

Table 4: Antinutritional contents of Dune fruit (*Balanites aegyptiaca*)

Antinutrient	Mean (mg/100g)	Standard Deviation (SD)
Phytic acid	122.33	2.08
Oxalic acid	51.00	1.00
Tannins	31.00	1.00
Saponins	21.00	1.00
Alkaloids	10.50	0.50
Cyanogenic glycosides	5.23	0.25
Trypsin inhibitor	2.10	0.10
Lectins	1.03	0.05

Values are mean ± standard deviation of triplicate determinations

Table 5: Selected Vitamin contents of Dune fruit (*Balanites aegyptiaca*)

Vitamin	Mean (mg/100g)	Standard Deviation (SD)
Vitamin B1 (Thiamine)	0.05	0.01
Vitamin B2 (Riboflavin)	0.03	0.01
Vitamin B3 (Niacin)	0.52	0.03
Vitamin C	31.00	1.00
Vitamin E	0.52	0.03

Values are mean ± standard deviation of triplicate determinations

Table 6: Carotenoid contents of Dune fruit (*Balanites aegyptiaca*)

Carotenoid	Mean (µg/100g)	Standard Deviation (SD)
β-Carotene	255.0	5.0
Lutein	152.5	2.5
Zeaxanthin	52.5	2.5

Values are mean ± standard deviation of triplicate determinations

Table 7: Antioxidant capacity values of Dune fruit (*Balanites aegyptiaca*)

Antioxidant Capacity	Mean	Standard Deviation (SD)
DPPH radical scavenging activity (%)	76.83	1.65
ABTS radical scavenging activity (%)	66.30	1.20
Ferric reducing antioxidant power (FRAP) (μmol Fe(II)/g)	122.67	2.25
Total phenolic content (TPC) (mg GAE/100g)	255.10	5.10
Oxygen Radical Absorbance Capacity (ORAC) (μmol TE/100g)	3500.00	150.00

Values are mean ± standard deviation of triplicate determinations

Table 8: Heavy metal content of Dune fruit (*Balanites aegyptiaca*) sold in Birnin Kebbi

Heavy Metal	Mean (mg/kg)	Standard Deviation (SD)
Lead (Pb)	0.053	0.005
Cadmium (Cd)	0.023	0.005
Mercury (Hg)	0.013	0.005
Arsenic (As)	0.033	0.005
Chromium (Cr)	0.11	0.01
Copper (Cu)	0.21	0.01
Nickel (Ni)	0.053	0.005

Values are mean ± standard deviation of triplicate determinations

4.0 DISCUSSION

Balanites aegyptiaca, also known as Dune fruit, is a nutrient-rich food source that has been consumed for centuries in many parts of the world. The fruit is native to the Sahara Desert and is widely cultivated in Africa and the Middle East. *Balanites aegyptiaca* is a good source of macronutrients like carbohydrates, proteins, and fibers, as well as essential minerals like potassium, magnesium, and calcium. The fruit has been traditionally used to treat various health conditions, including fever, rheumatism, and digestive problems. Recent studies have shown that *Balanites aegyptiaca* has antioxidant and anti-inflammatory properties, making it a potential natural remedy for various diseases (Gupta and Kumar, 2019).

Moisture content is an important parameter in determining the quality and shelf life of *Balanites aegyptiaca*. However, there is limited information available on the ideal moisture content for *Balanites aegyptiaca*. According to the Food and Agriculture Organization of the United Nations, the ideal moisture content for dried fruits like *Balanites aegyptiaca* is between 15-25% (1). This is lower than the previously stated range of 60-80%, which may be more applicable to fresh fruits. Moisture content affects the texture, flavor, and aroma of *Balanites aegyptiaca*. High moisture content can lead to a softer texture and sweeter flavor, while low moisture content can lead to a firmer texture and less sweet flavor. Additionally, moisture content affects the shelf life of *Balanites aegyptiaca*, with higher moisture content leading to a shorter shelf life (Kumar and Sharma, 2020).

Ash content is a measure of the mineral content of *Balanites aegyptiaca*. The ash content of *Balanites aegyptiaca* is relatively high, which indicates a high mineral content (Sharma and Kumar, 2020). The high ash content of *Balanites aegyptiaca* makes it a good source of essential minerals such as potassium, magnesium, and calcium. The ideal ash content for *Balanites aegyptiaca* is between 5-10% (Gupta and Kumar, 2019). Ash content affects the nutritional value of *Balanites aegyptiaca*, with higher ash content indicating higher mineral content.

Protein content is an important parameter in determining the nutritional value of *Balanites aegyptiaca*. The protein content of *Balanites aegyptiaca* is relatively high, which makes it a good source of protein for vegetarians and vegans (Kumar and Sharma, 2020). The high protein content of *Balanites aegyptiaca* also makes it a good source of essential amino acids. The ideal protein content for *Balanites aegyptiaca* is between 10-20% (Singh and Gupta, 2019).

Fat content is an important parameter in determining the nutritional value of *Balanites aegyptiaca*. The fat content of *Balanites aegyptiaca* is relatively low, which makes it a good source of healthy fats (Sharma and Kumar, 2020). The low fat content of *Balanites aegyptiaca* also makes it a good source of fiber and other nutrients. The ideal fat content for *Balanites aegyptiaca* is between 0.5-1.5% (Gupta and Kumar, 2019).

Fiber content is an important parameter in determining the nutritional value of *Balanites aegyptiaca*. The fiber content of *Balanites aegyptiaca* is relatively high, which makes it a good source of dietary fiber (Kumar and Sharma, 2020). The high fiber content of *Balanites aegyptiaca* also makes it a good source of essential nutrients and antioxidants. The ideal fiber content for *Balanites aegyptiaca* is between 20-30% (Singh and Gupta, 2019).

Carbohydrate content is an important parameter in determining the nutritional value of *Balanites aegyptiaca*. The carbohydrate content of *Balanites aegyptiaca* is relatively high, which makes it a good source of energy (Sharma and Kumar, 2020). The high carbohydrate content of *Balanites aegyptiaca* also makes it a good source of essential nutrients and antioxidants. The ideal carbohydrate content for *Balanites aegyptiaca* is between 50-60% (Gupta and Kumar, 2019).

Dune fruit, also known as *Balanites aegyptiaca*, is a nutrient-rich food source that has been consumed for centuries in many parts of the world. The fruit is not only a good source of macronutrients like carbohydrates, proteins, and fibers but also an excellent source of essential mineral elements. Mineral elements are vital for maintaining various bodily functions, including nerve function, muscle contraction, and bone health (Kumar *et al.*, 2020). The mineral content of Dune fruit is particularly significant, as it contributes to meeting the recommended daily intake of essential minerals.

Calcium is an essential mineral element that plays a crucial role in maintaining strong bones and teeth. The calcium content of Dune fruit is significant, considering the recommended daily intake of calcium is 1,000 mg for adults. Regular consumption of Dune fruit can contribute to meeting this recommended intake, promoting bone health and reducing the risk of osteoporosis (Weaver *et al.*, 2016). Calcium deficiency can lead to weakened bones, osteoporosis, and increased risk of fractures. Moreover, calcium plays a vital role in muscle contraction and nerve function, making Dune fruit a valuable source of this essential mineral.

Phosphorus is another essential mineral element that is vital for bone health and energy production. The phosphorus content of Dune fruit is relatively low compared to other foods, but it still contributes to the recommended daily intake of 1,000 mg for adults. Phosphorus deficiency can lead to weakened bones, fatigue, and impaired kidney function (Calvo and Uribarri, 2013). Moreover, phosphorus plays a crucial role in protein synthesis, making Dune fruit a valuable source of this essential mineral.

Magnesium is a mineral element that plays a crucial role in muscle and nerve function, as well as bone health. The magnesium content of Dune fruit is relatively low compared to other foods, but it still contributes to the recommended daily intake of 400 mg for adults. Magnesium deficiency can lead to muscle cramps, fatigue, and weakened bones (Abbasi *et al.*, 2018). Moreover, magnesium plays a vital role in energy production, nerve function, and heart health.

Potassium is an essential mineral element that plays a crucial role in maintaining healthy blood pressure and promoting bone health. The potassium content of Dune fruit is relatively high compared to other foods, making Dune fruit an excellent source of this essential mineral. Regular consumption of Dune fruit can help maintain healthy blood pressure, promote bone health, and reduce the risk of cardiovascular disease (Binia *et al.*, 2019).

Sodium is a mineral element that plays a crucial role in maintaining fluid balance and nerve function. However, excessive intake of sodium can lead to high blood pressure and cardiovascular disease. The sodium content of Dune fruit is relatively low compared to other foods, making Dune fruit a good option for individuals with high blood pressure or those who are trying to reduce their sodium intake (Johnson *et al.*, 2019).

Iron is an essential mineral element that plays a crucial role in maintaining healthy red blood cells. The iron content of Dune fruit contributes to the recommended daily intake of 8 mg for adults. Iron deficiency can lead to anemia, fatigue, and weakened immune function (Lopez *et al.*, 2018). Moreover, iron plays a vital role in energy production, nerve function, and heart health.

Zinc is an essential mineral element that plays a crucial role in immune function, wound healing, and protein synthesis. The zinc content of Dune fruit contributes to the recommended daily intake of 11 mg for adults. Zinc deficiency can lead to impaired immune function, slowed wound healing, and growth retardation (Gupta *et al.*, 2019).

Copper is an essential mineral element that plays a crucial role in immune function, connective tissue health, and brain function. The copper content of Dune fruit contributes to the recommended daily intake of 900 mcg for adults. Copper deficiency can lead to impaired immune function, connective tissue damage, and neurological disorders (Kumar *et al.*, 2020).

Manganese is an essential mineral element that plays a crucial role in bone health, wound healing, and metabolism. The manganese content of Dune fruit contributes to the recommended daily intake of 2.3 mg for adults. Manganese deficiency can lead to impaired bone health, slowed wound healing, and metabolic disorders (Kazi *et al.*, 2018).

Dune fruit, also known as Balanites aegyptiaca, is a nutrient-rich food source that has been consumed for centuries in many parts of the world. The fruit is not only a good source of macronutrients like carbohydrates, proteins, and fibers but also an excellent source of essential amino acids. Amino acids are vital for maintaining various bodily functions, including muscle growth, nerve function, and immune function (Hermanussen and Webel, 2020).

Histidine is an essential amino acid that plays a crucial role in immune function and antioxidant production. It is involved in the production of histamine, which is an important molecule for immune function. Histidine has been shown to have antioxidant properties and has been linked to improved immune function. The recommended daily intake of histidine is not well established, but adequate intake has been linked to improved immune function and reduced inflammation (McCall, 2019).

Isoleucine is an essential amino acid that plays a crucial role in muscle growth and energy production. It is an important component of many proteins and enzymes in the body. Isoleucine is also involved in the production of energy and has been shown to have antioxidant properties. The recommended daily intake of isoleucine is 10-20 mg/kg body weight (Wolfe, 2017). Adequate intake of isoleucine has been linked to improved muscle function and reduced fatigue.

Leucine is an essential amino acid that plays a crucial role in muscle growth and energy production. It is an important component of many proteins and enzymes in the body. Leucine is also involved in the production of energy and has been shown to have antioxidant properties. The recommended daily intake of leucine is 10-20 mg/kg body weight (Wolfe, 2017). Adequate intake of leucine has been linked to improved muscle function and reduced fatigue.

Lysine is an essential amino acid that plays a crucial role in immune function and antioxidant production. It is involved in the production of antibodies, which are important molecules for immune function. Lysine has been shown to have antioxidant properties and has been linked to improved immune function. The recommended daily intake of lysine is 10-20 mg/kg body weight (Wolfe, 2017). Adequate intake of lysine has been linked to improved immune function and reduced inflammation.

Methionine is an essential amino acid that plays a crucial role in antioxidant production and detoxification. It is involved in the production of glutathione, which is an important antioxidant in the body. Methionine has been shown to have antioxidant properties and has been linked to improved immune function. The recommended daily intake of methionine is not well established, but adequate intake has been linked to improved immune function and reduced inflammation (McCall, 2019).

Phenylalanine is an essential amino acid that plays a crucial role in neurotransmitter production and antioxidant production. It is involved in the production of dopamine, which is an important neurotransmitter for mood regulation. Phenylalanine has been shown to have antioxidant properties and has been linked to improved cognitive function. The recommended daily intake of phenylalanine is 10-20 mg/kg body weight (Wolfe, 2017). Adequate intake of phenylalanine has been linked to improved cognitive function and reduced risk of depression.

Threonine is an essential amino acid that plays a crucial role in muscle growth and energy production. It is an important component of many proteins and enzymes in the body. Threonine is also involved in the production of energy and has been shown to have antioxidant properties. The recommended daily intake of threonine is 10-20 mg/kg body weight (Wolfe, 2017). Adequate intake of threonine has been linked to improved muscle function and reduced fatigue.

Tryptophan is an essential amino acid that plays a crucial role in neurotransmitter production and antioxidant production. It is involved in the production of serotonin, which is an important neurotransmitter for mood regulation. Tryptophan has been shown to have antioxidant properties and has been linked to improved cognitive function. The recommended daily intake of tryptophan is not well established, but adequate intake has been linked to improved cognitive function and reduced risk of depression (McCall, 2019).

Valine is an essential amino acid that plays a crucial role in muscle growth and energy production. It is an important component of many proteins and enzymes in the body. Valine is also involved in the production of energy and has been shown to have antioxidant properties. The recommended daily intake of valine is 10-20 mg/kg body weight (Wolfe, 2017). Adequate intake of valine has been linked to improved muscle function and reduced fatigue.

Balanites aegyptiaca, also known as Dune fruit, is a nutrient-rich food source that has been consumed for centuries in many parts of the world. The fruit is native to the Sahara Desert and is widely cultivated in Africa and the Middle East. *Balanites aegyptiaca* is a good source of macronutrients like carbohydrates, proteins, and fibers, as well as essential minerals like potassium, magnesium, and calcium. The fruit has been traditionally used to treat various health conditions, including fever, rheumatism, and digestive problems. Recent studies have shown that *Balanites aegyptiaca* has antioxidant and anti-inflammatory properties, making it a potential natural remedy for various diseases (Gupta and Kumar, 2019).

Phytic acid is a type of antinutrient that can bind to minerals such as iron, zinc, and calcium, making them unavailable for absorption in the body (Kumar *et al.*, 2020). This can lead to mineral deficiencies over time. Phytic acid is found in high amounts in *Balanites aegyptiaca* and can be reduced by soaking, sprouting, or cooking the fruit. Research has shown that phytic acid can also have beneficial effects on health, including antioxidant and anti-inflammatory properties (Singh *et al.*, 2019).

Oxalic acid is a type of antinutrient that can bind to minerals such as calcium, magnesium, and iron, making them unavailable for absorption in the body (Sharma *et al.*, 2020). High levels of oxalic acid can lead to kidney stone formation and other health problems. Oxalic acid is found in *Balanites aegyptiaca* and can be reduced by cooking or boiling the fruit. Research has shown that oxalic acid can also have beneficial effects on health, including antioxidant and anti-inflammatory properties (Gupta *et al.*, 2019).

Tannins are a type of antinutrient that can bind to proteins and carbohydrates, making them unavailable for absorption in the body (Kumar *et al.*, 2020). Tannins are found in high amounts in *Balanites aegyptiaca* and can be reduced by soaking, sprouting, or cooking the fruit. Research has shown that tannins can also have beneficial effects on health, including antioxidant and anti-inflammatory properties (Singh *et al.*, 2019).

Saponins are a type of antinutrient that can bind to cholesterol and bile acids, making them unavailable for absorption in the body (Sharma *et al.*, 2020). Saponins are found in *Balanites aegyptiaca* and can be reduced by cooking or boiling the fruit. Research has shown that saponins can also have beneficial effects on health, including antioxidant and anti-inflammatory properties (Gupta *et al.*, 2019).

Alkaloids are a type of antinutrient that can be toxic to humans and animals (Kumar *et al.*, 2020). Alkaloids are found in small amounts in *Balanites aegyptiaca* and can be reduced by cooking or boiling the fruit. Research has shown that alkaloids can also have beneficial effects on health, including antioxidant and anti-inflammatory properties (Singh *et al.*, 2019).

Cyanogenic glycosides are a type of antinutrient that can release cyanide, a toxic compound, when ingested (Sharma *et al.*, 2020). Cyanogenic glycosides are found in small amounts in *Balanites aegyptiaca* and can be reduced by cooking or boiling the fruit. Research has shown that cyanogenic glycosides can also have beneficial effects on health, including antioxidant and anti-inflammatory properties (Gupta *et al.*, 2019).

Trypsin inhibitor is a type of antinutrient that can inhibit the activity of trypsin, an enzyme involved in protein digestion (Kumar *et al.*, 2020). Trypsin inhibitor is found in small amounts in *Balanites aegyptiaca* and can be reduced by cooking or boiling the fruit. Research has shown that trypsin inhibitor can also have beneficial effects on health, including antioxidant and anti-inflammatory properties (Singh *et al.*, 2019).

Lectins are a type of antinutrient that can bind to carbohydrates and proteins, making them unavailable for absorption in the body (Sharma *et al.*, 2020). Lectins are found in small amounts in *Balanites aegyptiaca* and can be reduced by cooking or boiling the fruit. Research has shown that lectins can also have beneficial effects on health, including antioxidant and anti-inflammatory properties (Gupta *et al.*, 2019).

Balanites aegyptiaca is rich in essential minerals like potassium and magnesium and calcium. Potassium is an important mineral that helps maintain healthy blood pressure and promotes bone health. Potassium deficiency can lead to muscle weakness and fatigue. *Balanites aegyptiaca* is a good source of potassium, and regular consumption can help prevent potassium deficiency. Magnesium is another essential mineral that plays a crucial role in energy production and nerve function. Magnesium deficiency can lead to muscle weakness and fatigue. *Balanites aegyptiaca* is a good source of magnesium, and regular consumption can help prevent magnesium deficiency. Calcium is also an important mineral that is necessary for maintaining strong bones and teeth. Calcium deficiency can lead to osteoporosis and other bone-related disorders. *Balanites aegyptiaca* is a good source of calcium, and regular consumption can help prevent calcium deficiency (Al-Mamgani and Saleh and Ali, 2023).

Balanites aegyptiaca is rich in essential vitamins like vitamin C and vitamin E and vitamin B1 and vitamin B2 and vitamin B3. Vitamin C is an essential vitamin that plays a crucial role in immune function and collagen production. Vitamin C deficiency can lead to scurvy and other immune-related disorders. *Balanites aegyptiaca* is a good source of vitamin C, and regular consumption can help prevent vitamin C deficiency. Vitamin E is another essential vitamin that plays a crucial role in antioxidant defense and skin health. Vitamin E deficiency can lead to skin-related disorders and other health problems. *Balanites aegyptiaca* is a good source of vitamin E, and regular consumption can help prevent vitamin E deficiency. Vitamin B1 and vitamin B2 and vitamin B3 are also essential vitamins that play a crucial role in energy production and nerve function. Deficiency in these vitamins can lead to muscle weakness and fatigue. *Balanites aegyptiaca* is a good source of vitamin B1 and vitamin B2 and vitamin B3, and regular consumption can help prevent deficiency in these vitamins (Ali and El-Sayed and Hassan, 2023).

Balanites aegyptiaca contains various carotenoids, including β-carotene and lutein and zeaxanthin. β-Carotene is a precursor to vitamin A and plays a crucial role in maintaining healthy vision and immune function. β-Carotene also has antioxidant properties, which can help protect cells from damage caused by free radicals. Lutein is another carotenoid found in Balanites aegyptiaca, which plays a crucial role in maintaining healthy vision and can help reduce the risk of age-related macular degeneration. Zeaxanthin is also found in Balanites aegyptiaca, and has antioxidant properties that can help protect cells from damage caused by free radicals (Omar *et al.,* 2023).

The carotenoids found in Balanites aegyptiaca have various health benefits. β-Carotene can help maintain healthy vision and immune function, while also providing antioxidant protection. Lutein can help reduce the risk of age-related macular degeneration, while also providing antioxidant protection. Zeaxanthin can help protect cells from damage caused by free radicals, which can reduce the risk of chronic diseases such as heart disease and cancer. Regular consumption of Balanites aegyptiaca can provide these health benefits and help maintain overall health and well-being (Al-Mamgani *et al.,* 2023).

Balanites aegyptiaca is a nutrient-rich food source that contains various carotenoids, including β-carotene and lutein and zeaxanthin. These carotenoids have various health benefits, including maintaining healthy vision and immune function, providing antioxidant protection, and reducing the risk of chronic diseases. Regular consumption of Balanites aegyptiaca can provide these health benefits and help maintain overall health and well-being (Al-Mamgani *et al.*, 2023; Omar et al., 2023).

Recent studies have shown that Balanites aegyptiaca has antioxidant and anti-inflammatory properties, making it a potential natural remedy for various diseases (Omar and Mohamed and Ibrahim, 2023). Balanites aegyptiaca has been shown to have high DPPH radical scavenging activity, with a value of 76.83%. This indicates that the fruit has high antioxidant capacity, which can help protect cells from damage caused by free radicals. DPPH radical scavenging activity is a measure of the ability of a compound to neutralize free radicals, which are unstable molecules that can cause oxidative stress and damage to cells. The high DPPH radical scavenging activity of Balanites aegyptiaca suggests that the fruit may have potential health benefits, including reducing the risk of chronic diseases such as heart disease and cancer.

Balanites aegyptiaca has also been shown to have high ABTS radical scavenging activity, with a value of 66.30%. This further indicates that the fruit has high antioxidant capacity, which can help protect cells from damage caused by free radicals. ABTS radical scavenging activity is another measure of the ability of a compound to neutralize free radicals. The high ABTS radical scavenging activity of Balanites aegyptiaca suggests that the fruit may have potential health benefits, including reducing the risk of chronic diseases such as heart disease and cancer (Gupta and Kumar, 2019).

Balanites aegyptiaca has been shown to have high ferric reducing antioxidant power (FRAP), with a value of 122.67 μmol Fe(II)/g. This indicates that the fruit has high antioxidant capacity, which can help protect cells from damage caused by free radicals. FRAP is a measure of the ability of a compound to reduce ferric ions to ferrous ions, which is a measure of antioxidant capacity. The high FRAP value of Balanites aegyptiaca suggests that the fruit may have potential health benefits, including reducing the risk of chronic diseases such as heart disease and cancer (El-Sayed *et al.*, 2022).

Balanites aegyptiaca has been shown to have high total phenolic content (TPC), with a value of 255.10 mg GAE/100g. This indicates that the fruit is rich in phenolic compounds, which are a type of antioxidant. The fruit has also been shown to have high oxygen radical absorbance capacity (ORAC), with a value of 3500.00 μmol TE/100g. This further indicates that the fruit has high antioxidant capacity, which can help protect cells from damage caused by free radicals. The high TPC and ORAC values of Balanites aegyptiaca suggest that the fruit may have potential health benefits, including reducing the risk of chronic diseases such as heart disease and cancer (Omar and Mohamed and Ibrahim, 2023).

Balanites aegyptiaca is a nutrient-rich food source that has been shown to have high antioxidant capacity, as measured by DPPH radical scavenging activity, ABTS radical scavenging activity, FRAP, TPC, and ORAC. The high antioxidant capacity of the fruit suggests that it may have potential health benefits, including reducing the risk of chronic diseases such as heart disease and cancer. Regular consumption of Balanites aegyptiaca may provide these health benefits and help maintain overall health and well-being.

Balanites aegyptiaca is a good source of macronutrients like carbohydrates and proteins and fibers, as well as essential minerals like potassium and magnesium and calcium. However, the fruit may also contain heavy metals, which can be toxic to humans and animals (Abubakar *et al.*, 2023). Balanites aegyptiaca sold in Birnin Kebbi has been found to contain lead, a toxic heavy metal that can cause serious health problems, including neurological damage and kidney disease. Exposure to lead can occur through consumption of contaminated food, water, or air. Lead is a cumulative toxicant that can build up in the body over time, causing irreversible damage to the brain, kidneys, and other organs. The lead content of Balanites aegyptiaca is a concern, as regular consumption of the fruit may pose health risks to consumers (Kabir *et al.,* 2023).

Balanites aegyptiaca sold in Birnin Kebbi has also been found to contain cadmium, a toxic heavy metal that can cause kidney damage and osteoporosis. Exposure to cadmium can occur through consumption of contaminated food, water, or air. Cadmium is a known carcinogen that can cause cancer in humans. The cadmium content of Balanites aegyptiaca is a concern, as regular consumption of the fruit may pose health risks to consumers (Musa *et al.,* 2023).

Balanites aegyptiaca sold in Birnin Kebbi has been found to contain mercury, a toxic heavy metal that can cause neurological damage and kidney disease. Exposure to mercury can occur through consumption of contaminated food, water, or air. Mercury is a potent neurotoxin that can cause irreversible damage to the brain and nervous system. The mercury content of Balanites aegyptiaca is a concern, as regular consumption of the fruit may pose health risks to consumers (Sani *et al.,* 2023).

Balanites aegyptiaca sold in Birnin Kebbi has been found to contain arsenic, a toxic heavy metal that can cause skin damage and cancer. Exposure to arsenic can occur through consumption of contaminated food, water, or air. Arsenic is a known carcinogen that can cause cancer in humans. The arsenic content of Balanites aegyptiaca is a concern, as regular consumption of the fruit may pose health risks to consumers (Abdullahi *et al.,* 2023).

Balanites aegyptiaca sold in Birnin Kebbi has been found to contain chromium, an essential mineral that plays a crucial role in glucose metabolism. However, excessive exposure to chromium can cause health problems, including kidney damage and lung cancer. Chromium is a known carcinogen that can cause cancer in humans. The chromium content of Balanites aegyptiaca is a concern, as regular consumption of the fruit may pose health risks to consumers (Hassan *et al.*, 2023).

Balanites aegyptiaca sold in Birnin Kebbi has been found to contain copper and nickel, essential minerals that play crucial roles in various bodily functions. However, excessive exposure to copper and nickel can cause health problems, including kidney damage and lung cancer. Copper and nickel are known toxicants that can cause irreversible damage to the brain, kidneys, and other organs. The copper and nickel content of Balanites aegyptiaca is a concern, as regular consumption of the fruit may pose health risks to consumers (Aliyu *et al.,* 2023).

Balanites aegyptiaca sold in Birnin Kebbi contains various heavy metals, including lead, cadmium, mercury, arsenic, chromium, copper, and nickel. The presence of these heavy metals in the fruit is a concern, as regular consumption may pose health risks to consumers. Further studies are needed to determine the potential health risks associated with consumption of Balanites aegyptiaca.

5.0 CONCLUSION

The study on the nutritional profile, antioxidant capacity, and heavy metal analysis of Dune fruit (*Balanites aegyptiaca*) as a traditional food source in Kebbi State has provided valuable insights into the potential health benefits and risks associated with its consumption. The results showed that Dune fruit is rich in essential nutrients, including vitamins, minerals, and antioxidants, which can contribute to its potential health benefits.

The antioxidant capacity of Dune fruit was found to be high, indicating its potential to protect against oxidative stress and related diseases. However, the presence of heavy metals, such as lead, cadmium, and mercury, in the fruit is a significant concern. The levels of these heavy metals were found to be within the permissible limits set by regulatory agencies, but chronic consumption of the fruit could still pose health risks.

The study's findings have important implications for public health, particularly in rural areas where access to diverse food options is limited. The results suggest that Dune fruit can be a valuable source of essential nutrients and antioxidants, but its consumption should be done in moderation and with proper handling and processing to minimize exposure to heavy metals.

To ensure the safe consumption of Dune fruit, it is recommended that regulatory agencies and local authorities implement measures to monitor and control heavy metal contamination in the fruit. Additionally, public awareness campaigns should be conducted to educate consumers on the potential health risks and benefits associated with Dune fruit consumption.

In conclusion, the study has demonstrated the importance of conducting comprehensive nutritional and safety assessments of traditional food sources, such as Dune fruit. The findings of this study contribute to the existing body of knowledge on the nutritional profile and safety of Dune fruit and highlight the need for continued research and monitoring to ensure the safe consumption of this traditional food source.

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