Nutrient composition of formulated diets from tigernut (*Cyperus esculentus*), date fibre (*Phoenix dactylifera*), and coconut (*Cocos nucifera*)

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ABSTRACT

Background: *The nutrient composition of a diet involves analysis of the major nutritional components of the diet. Today, there is a need for a diet that will provide meals that will give attention to nutrient deficiencies and malnutrition in many countries, especially in developing countries where access to balanced and nutrient-rich foods is limited.*

Objective: *This study assessed the nutrient (proximate, vitamin, mineral contents, amino acid profile, and carbohydrate (sugars)) composition of diets formulated with tigernut, date fibre, and coconut meat.*

Methodology: *The diets were formulated with three (3) samples (tigernut, date fibre, and coconut meat) at different ratios into two sample forms (A and B). Six (6) samples were formed. The A sample comprises A1, A2, and A3, while the B sample comprises B1, B2, and B3. The formulated diets were analyzed using standard methods. Data obtained were analysed with one-way analysis of variance and presented as mean ± standard deviation; results were compared using the Tukey HSD.*

Results: *Samples A1 and B2 exhibited significant increase ($p< 0.05$) in fibre and carbohydrate content. The fibre contents were 3.19 ± 5.19 and 2.69 ± 0.00 while those for carbohydrates were 83.94 ± 0.00and 84.49 ± 0.049, respectively. Samples A2 and B1showed significant increases in vitamins and amino acid components. The values of Pyridoxine (1.46 ± 0.02) and glucose (2.083 ± 0.006) of A2 were significantly higher ($p<0.05$) when compared to other samples.*

Conclusion: *Controlled variation in the blending ratios significantly influenced the proximate, vitamin, mineral, and amino acid contents.*

Keywords: Proximate, Mineral, Tigernut, Dates, Coconut

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INTRODUCTION

A formulated diet involves a combination of food ingredients designed to provide complete and balanced nutrition for a target consumer. It is often prepared by combining different natural or processed food materials in specific proportions to supply essential nutrients and overall health [1]. *Cyperus esculentus,* commonly known as tiger nut, is a perennial unbranched plant with fibrous roots, about 1 to 3 ft high. It can reproduce sexually by seeds and asexually via underground stems, rhizomes, and small tubers [2]. This plant was originally native to the Mediterranean region, but its cultivation has now spread to many warm countries [3].

Like other members of the sedge family, the plant is most frequently found inhabiting wet marshes and edges of streams and ponds [4]. Tigernuts have long been recognized for their health benefits as they have a high content of soluble glucose and oleic acid, along with high energy content [4].

Phoenix dactylifera, commonly known as date fruit, is obtained from the date palm, which is an important and one of the oldest trees cultivated by man [5]. The date palm has provided food, ornament, material for shelter, fibre, and fuel in a harsh

environment where relatively few other plants are able to thrive. Thus, date palm cultivation has always blended with the entire social, cultural, religious, and economic development of the people inhabiting the hot, arid regions of the world extending from the Middle East to Northern Africa. Today, date has continued to be the principal crop cultivated in these regions [6].

Cocos nucifera, commonly known as coconut, is native to the coastal areas of Southeast Asia (Malaysia, Indonesia, and the Philippines), and it currently has a wide pantropical distribution [7]. It provides food for millions of people, especially in the tropical and subtropical regions, and it is commonly known as the tree of life because of its many uses. It belongs to the family *Arecaceae* and the subfamily *Cocoideae* [8].

Despite the growing awareness of the importance of balanced nutrition in promoting health and preventing disease, nutrient deficiencies, especially those of proteins, vitamins, and minerals, remain a major public health concern in many developing countries [9]. Tigernut, date, and coconut are underutilized tropical foods known to be rich in essential nutrients, yet their potential in a combined, formulated diet has not be adequately explored; thus, this study investigated the vitamin and mineral content of formulated diet from tigernut, date and coconut, in other to provide scientific evidence to their nutritional value and potential contribution to dietary diversity and involvement for target deficiencies.

Malnutrition and micronutrient deficiencies remain major public health challenges, particularly in developing countries where access to balanced and nutrient-rich foods is limited. Deficiencies in essential nutrients such as proteins, vitamins, minerals, and amino acids contribute to poor growth, weakened immunity, metabolic disorders, and increased susceptibility to diseases. Although many tropical plant foods possess high nutritional potential, several of them remain underutilized in food formulation and dietary interventions.

Cyperus esculentus, *Phoenix dactylifera, and Cocos* nucifera are natural food materials known to contain important nutrients including dietary fibre, carbohydrates, healthy lipids, vitamins, minerals, and bioactive compounds. However, despite their individual nutritional importance, there is limited scientific information on the nutritional composition of diets formulated from combinations of these food materials. There is inadequate data on how changes in formulation proportions influence the nutritional composition of such composite diets.

This study provides scientific data on the nutritional quality of formulated diets produced from these food materials. The findings will help determine how different formulation ratios influence nutrient composition and identify blends with improved nutritional properties. [Also] contribute to the development of functional foods that may support dietary management, nutritional supplementation, and health promotion.

MATERIALS AND METHODS

Sample Collection and Preparation

Tigernut, dates, and coconut were obtained from Mile 3 Market, Port Harcourt, Rivers State. The samples were cleaned to remove impurities and kept in a bowl. The date fibres were cut into two halves. The coconut meat was removed from the shell and diced. They were all oven dried at30°Cand ground into fine powder using a high-speed blender. The diets were formulated with three (3) samples (tigernut, date fiber, and coconut meat) at different ratios into two sample forms (A and B). The A sample comprises A1, A2, and A3, while the B sample comprises B1, B2, and B3. The A samples were formulated in the ratios of 40:30:30 (A1), 30:30:40 (A2), and 30:40:30 (A3). The B samples were in the ratios of 70:20:10 (B1), 10:70:20(B2), and 20:70:10 (B3). The formulated diets were analyzed using standard methods

Proximate Analysis

Moisture Content Determination

Moisture content was determined using the oven-drying method. A clean petri dish was washed, dried, and weighed. Approximately 1–2 g of the sample was placed in the petri dish, and the combined weight of the dish and sample was recorded. The sample was then dried in an oven at 105°C for 2 hours, cooled, and weighed. Drying was continued for additional periods of 1 hour until a constant weight was obtained. The percentage moisture content was calculated from the loss in weight during drying using the formula:

$$\% \text{ Moisture Content} = \frac{W_1 - W_2}{\text{Weight of Sample}} \times 100$$

where W_1 is the weight of the petri dish and sample before drying, and W_2 is the weight of the petri dish and sample after drying.

Carbohydrate Determination

The carbohydrate content of the samples was determined by difference. This method involved subtracting the sum of the percentages of moisture, protein, ash, crude fat, and crude fibre from 100. The carbohydrate content was calculated using the formula:

$$\% \quad \text{Carbohydrate} \quad = \quad 100 - (\% \, Protein + \% \, Moisture + \% \, Ash + \% \, Fat + \% \, Fibre)$$

Ash Content Determination

Ash content was determined by incineration in a muffle furnace. A clean and dry platinum crucible was weighed, and approximately 1–2 g of the sample was placed into it. The crucible containing the sample was heated in a muffle furnace at 550°C for 3 hours to completely burn off the organic matter, leaving only the inorganic residue (ash). After ashing, the crucible was cooled in a desiccator and reweighed [10]. The percentage ash content was calculated using the formula:

$$\% \text{ Ash Content} = \frac{W_3 - W_1}{W_2 - W_1} \times 100$$

where W_1 is the weight of the empty crucible, W_2 is the weight of the crucible and sample before ashing, and W_3 is the weight of the crucible and ash after ashing.

Crude Fibre Determination

Crude fibre content was determined by sequential acid and alkaline digestion. Two grams of the sample were first defatted with petroleum ether. The defatted sample was boiled under reflux for 30 minutes with 200 mL of 1.25% sulphuric acid solution and filtered through linen cloth. The residue was washed thoroughly with boiling water until it became free of acid. The residue was then boiled for another 30 minutes with 200 mL of 1.25% sodium hydroxide solution, filtered through a Gooch crucible containing washed and ignited asbestos, dried in an electric oven, and weighed. The dried residue was subsequently incinerated, cooled, and reweighed. The loss in weight after incineration represented the crude fibre content and was calculated as a percentage of the original sample weight [10].

$$\% \text{ Crude Fibre} = \frac{\text{Weight of Fibre}}{\text{Weight of Sample}} \times 100$$

Crude Fat Determination

Crude fat content was determined using the Soxhlet extraction method with petroleum ether as the extraction solvent. Clean boiling flasks were dried in an oven at 105–110°C, cooled in a desiccator, and weighed. Approximately 300 mL of petroleum ether (boiling point 40–60°C) was added to the flask, and the sample was placed in an extraction thimble plugged with cotton wool. The Soxhlet apparatus was assembled and allowed to reflux continuously for about 6 hours to extract the fat. After extraction, the solvent was recovered, and the flask containing the extracted fat was dried in an oven at 105–110°C for 1 hour. The flask was cooled in a desiccator and weighed [10]. The crude fat content was calculated as follows:

$$\% \text{ Fat} = \frac{\text{Weight of Flask + Oil} - \text{Weight of Empty Flask}}{\text{Weight of Sample}} \times 100$$

Crude Protein Determination

Crude protein content was determined using the Kjeldahl method. Approximately 0.5 g of the sample was weighed into a Kjeldahl flask, and 0.5 g of Kjeldahl catalyst mixture was added. The mixture was digested with concentrated sulphuric acid until a clear solution was obtained, indicating complete digestion of organic matter. The digest was allowed to cool and diluted to 100 mL with distilled water. A 5 mL aliquot of the digest was transferred into a Kjeldahl distillation apparatus, followed by the addition of 5 mL of 40% sodium hydroxide solution. The liberated ammonia was distilled into a receiver flask containing 5 mL of 2% boric acid solution and mixed indicator. Distillation continued until approximately 50 mL of distillate was collected. The distillate was then titrated with 0.01 N hydrochloric acid until a pink endpoint was reached. The percentage nitrogen was calculated from the titre value, and the crude protein content was obtained by multiplying the nitrogen content by a conversion factor of 6.25 [10].

$$\% \, Nitrogen = Titre \, Value \times 0.01 \times 14 \times 4$$

$$\% \, Protein = \% \, Nitrogen \times 6.25.$$

Vitamin Analysis

Determination of Vitamin Content: Vitamin B Complex Analysis

The vitamin B complex (thiamine, riboflavin, niacin, pyridoxine, and cobalamin) was determined using High-Performance Liquid Chromatography (HPLC). Two grams of the sample were mixed with 25 mL of 0.1 N sulphuric acid and incubated at 121°C for 30 minutes. After cooling, the pH was adjusted to 4.5 using 2.5 M sodium acetate, and 50 mg of Taka diastase enzyme was added. The mixture was incubated overnight at 35°C to facilitate enzymatic digestion. The resulting solution was filtered through Whatman No. 4 filter paper, diluted with 50 mL of distilled water, and further filtered through a 0.45 µm membrane filter. An aliquot (20 µL) of the filtrate was injected into an HPLC system equipped with an Agilent ZORBAX Eclipse Plus C18 reversed-phase column (250 × 4.6 mm, 5 µm). Separation was achieved using an isocratic mobile phase consisting of methanol and 0.023 M phosphoric acid (33:67, v/v; pH 3.54) at a flow rate of 0.5 mL/min. Detection was performed at 270 nm using a UV detector. Quantification of the vitamins was achieved by comparing

sample peak areas with those obtained from prepared vitamin B standard solutions.

Vitamin C (Ascorbic Acid) Analysis

Vitamin C content was determined using HPLC following extraction with metaphosphoric acid and acetic acid solution. Ten grams of the sample were homogenized in an extracting solution containing 0.3 M metaphosphoric acid and 1.4 M acetic acid and agitated at 10,000 rpm for 15 minutes. The mixture was filtered through Whatman No. 4 filter paper, and the extraction was performed in triplicate. A standard solution of L-ascorbic acid was prepared at a concentration of 0.1 mg/mL for calibration. Chromatographic analysis was carried out using an Agilent HPLC system fitted with a reversed-phase column. Separation was achieved using an isocratic mobile phase consisting of 0.1 M potassium acetate (pH 4.9) and acetonitrile-water (50:50, v/v) in a ratio of 33:67 at a flow rate of 1.0 mL/min. Detection was performed at 254 nm, and quantification was based on calibration curves generated from standard solutions.

Determination of Fat-Soluble Vitamins (A, D, E, K and β-Carotene)

Fat-soluble vitamins were determined using reversed-phase HPLC. Ten grams of the sample were mixed with 1 g pyrogallic acid, 70 mL ethanol, and 30 mL of 50% potassium hydroxide solution. The mixture was refluxed in a water bath for 40 minutes. The vitamins were extracted successively with 50 mL, 30 mL, and 20 mL portions of ether. The extract was washed with distilled water until neutral, dried over anhydrous sodium sulphate, concentrated to approximately 5 mL using a water bath, diluted to 10 mL with methanol, and filtered through a 0.45 µm membrane filter. HPLC analysis was carried out using an Agilent 1100 Series system equipped with a diode array detector. β-Carotene was separated using an Agilent TC-C18 column (250 × 4.6 mm, 5 µm) with an acetonitrile:methanol:ethyl acetate (88:10:2) mobile phase and detected at 453 nm. Vitamins A, D, E, and K were separated on an Agilent Eclipse XDB-C18 column (150 × 4.6 mm, 5 µm) using methanol as the mobile phase and detected at wavelengths of 325 nm, 265 nm, 290 nm, and 244 nm, respectively. Identification and quantification were achieved by comparison with authentic standards prepared at concentrations ranging from 0.1 to 10 mg/L. All procedures were performed under subdued light conditions to prevent degradation of the vitamins.

Determination of Mineral Content

Mineral analysis was carried out using the American Public Health Association (APHA, 1995) method with an Agilent FS240AA Atomic Absorption Spectrophotometer (AAS). Approximately 2 g of the dried sample was weighed into a digestion flask and digested with 20 mL of an acid mixture containing concentrated nitric acid, perchloric acid, and concentrated sulphuric acid in the ratio of 650:80:20 (v/v/v). The mixture was heated until a clear digest was obtained, indicating complete digestion of the sample. After cooling, the digest was diluted to 100 mL with distilled water and analyzed using the Atomic Absorption Spectrophotometer for the determination of mineral elements.

Amino Acid Analysis

Amino acid composition was determined using Gas Chromatography (GC) following acid hydrolysis and derivatization. A 0.1 g lyophilized sample was hydrolysed with 15 mL of 6 N hydrochloric acid in a nitrogen-flushed screw-cap tube and heated at 110°C for 24 hours. Following hydrolysis, the solution was filtered, and the filtrate was diluted to 25 mL with pyridine. An aliquot was further filtered through a 0.50 µm membrane filter. Derivatization was performed by drying measured volumes of standard or sample solution under vacuum at 65°C. The residue was treated with methanol-water-phenylisothiocyanate solution, dried again, and subsequently reacted with a derivatizing reagent consisting of methanol-water-triethylamine-phenylisothiocyanate (7:1:1:1, v/v). After standing at room temperature for 20 minutes, solvents were removed under nitrogen, and the derivatized samples were dissolved in a diluent containing 5 mM sodium phosphate and 5% acetonitrile. Chromatographic separation was performed using an Agilent 6890 Gas Chromatography system equipped with a Flame Ionization Detector (FID) and a Spherisorb C18 column (250 × 4.6 mm, 5 µm). Elution was achieved using a gradient system comprising sodium acetate buffer with triethylamine (Eluent A) and acetonitrile-water (60:40, v/v) (Eluent B) at a constant column temperature of 30°C. Amino acids were identified and quantified by comparison with standard amino acid solutions.

Carbohydrate Analysis by HPLC

Carbohydrate composition was determined by HPLC following acid hydrolysis and derivatization. Ten milligrams of the lyophilized sample were hydrolysed with 1 mL of 3 M trifluoroacetic acid in a sealed ampoule at 130°C for 2 hours. After cooling, the hydrolysate was centrifuged at 2000 rpm for 5 minutes and evaporated to dryness under

reduced pressure to remove residual trifluoroacetic acid. The dried hydrolysate was reconstituted in 1 mL of distilled water. Derivatization was carried out by adding 30 µL of 0.3 M sodium hydroxide, followed by the addition of fucose as an internal standard. The mixture was incubated at 70°C for 60 minutes, cooled to room temperature, and neutralized with 30 µL of 0.3 M hydrochloric acid. One millilitre of trichloromethane was added, and after vigorous mixing and phase separation, the organic layer was discarded. The aqueous phase was filtered through a 0.45 µm syringe filter and subjected to HPLC analysis. Standard sugar solutions containing glucose, arabinose, cellobiose, cellotriose, cellotetraose, and cellopentose were similarly derivatized and analyzed. Identification and quantification of carbohydrates were achieved by comparing retention times and peak areas with those of the corresponding standards.

Statistical Analysis

All data were presented as mean±standard deviation. Data were analysed with one-way analysis of variance (ANOVA). Results were compared using the Tukey HSD post hoc multiple comparison test and considered significant at $p<0.05$.

RESULT

Nutrient composition of a diet involves determination of key nutritional components (vitamins, minerals, amino acids and carbohydrates) of such a diet. This is important because it provides the nutritional profile of the diet and suggests its effective utilization. The results of nutrient composition of diets formulated from tigernut, date fibre and coconut are presented (Tables 1 – 5).

TABLE 1: Proximate Composition of Formulated Diets from Tigernut, Date Fibre and Coconut (%)

	A			B		
	A1	A2	A3	B1	B2	B3
Moisture	4.11±0.03^{b}	4.65±0.05	5.28±0.05*	4.99±0.00^{ab}	5.35±0.00*	5.52±0.00*
Fat	6.55±0.02^{ab}	16.49±0.06^{*b}	17.66±0.01^{*a}	9.28±0.00^{ab}	2.29±0.01^{b*b}	1.15±0.00^{*a}
Fibre	3.19±5.19^{ab}	0.39±0.00^{*b}	2.23±0.00^{*a}	2.19±0.00^{b}	2.69±0.00^{b}	0.69±0.00^{*a}
Ash	2.34±0.08	2.26±0.00	2.45±0.00	2.34±0.00^{ab}	3.46±0.04*	3.79±0.07*
Protein	2.82±0.06^{a}	1.75±0.00^{*b}	3.15±0.00^{a}	2.45±0.01^{a}	1.75±0.00*	2.11±0.01
Carbohydrate	83.94±0.00^{ab}	74.49±0.04^{*b}	69.25±0.02^{a*}	78.73±0.05^{ab}	84.49±0.049^{*b}	86.73±0.02^{*a}

*Values are expressed as mean±standard deviation. Values with the superscript * are significantly different when comparing A1 with (A2 & A3). Values with the superscript a are significantly different when comparing A2 with others (A1 & A3). Values with the superscript b are significantly different when comparing A3 with A1 & A2. Also, * are significantly different when comparing B1 with B2 & B3. Values with the superscript a are significantly different when comparing B2 with B1 & B3. Values with the superscript b are significantly different when comparing B3 with B1 & B2. The powdered samples were prepared in the ratios of 40:30:30 (A1), 30:30:40 (A2), 30:40:30(A3) and 70:20:10 (B1), 10:70:20 (B2), 20:70:10 (B3).*

Table 2: Vitamin Constituents of Formulated Diet from Tigernuts, Date Fibre and Coconut

	A			B		
Vitamins (mg/100ml)	A1	A2	A3	B1	B2	B3
Calciferol	0.98±0.01^{bd}	0.43±0.02^{*d}	0.15 ±0.03^{*b}	0.94±0.01^{bd}	0.11±0.01*	0.13±0.02*
Tocopherol	0.36±0.27^{b}	0.24±0.03*	0.27±0.15	0.45±0.03^{bd}	0.24±0.32*	0.17±0.01*
Carotenoids	0.26±0.02	0.15±0.03	0.27±0.02	0.24±0.02^{d}	0.22±0.04^{d}	0.35±0.02^{*b}
Thiamine	0.01±0.00^{d}	0.10±0.01^{d}	0.55±0.01^{*b}	0.17±0.01	0.12±0.02	0.16±0.01
Riboflavin	0.02±0.01	0.01±0.01	0.02±0.00	0.00±0.00	0.05±0.01*	0.02±0.01*
Niacin	0.02±0.02	0.01±0.02	0.02±0.01	0.03±0.01	0.05±0.01	0.02±0.01
Pyridoxine	1.46±0.02	1.35±0.03	1.36±0.02	0.02±0.01^{bd}	1.27±0.02*	1.26±0.03*
Folate	0.02±0.01^{b}	0.23±0.01^{*d}	0.02±0.01^{b}	1.47±0.02^{bd}	0.02±0.01*	0.03±0.01*
Cobalamin	0.13±0.01	0.11±0.01	0.12±0.01	0.03±0.01^{bd}	0.19±0.02^{*d}	0.11±0.01^{*b}

*Values are expressed as mean±standard deviation. Values with the superscript * are significantly different when comparing A1 with (A2 & A3). Values with the superscript a are significantly different when comparing A2 with others (A1 & A3). Values with the superscript b are significantly different when comparing A3 with A1 & A2. Also, * are significantly different when comparing B1 with B2 & B3. Values with the superscript a are significantly different when comparing B2 with B1 & B3. Values with the superscript b are significantly different when comparing B3 with B1 & B2. The powdered samples were prepared in the ratios of 40:30:30 (A1), 30:30:40 (A2), 30:40:30(A3) and 70:20:10 (B1), 10:70:20 (B2), 20:70:10 (B3).*

Table 3: Mineral Content of Formulated Diet from Tigernuts, Date Fibre, and Coconut

Mineral (ppm)	A A1	A2	A3	B B1	B2	B3
Calcium	7.24±0.02^{bd}	8.14±0.04^{*d}	9.46±0.05^{*b}	6.18±0.01^{bd}	6.50±0.06^{*d}	7.31±0.04^{*b}
Sodium	10.13±0.05^{bd}	11.26±0.02^{*d}	12.28±1.15^{*b}	10.40±0.09^{bd}	9.65±0.03^{*d}	10.08±0.01^{*b}
Magnesium	8.17±0.10^{bd}	7.29±0.02^{*d}	5.16±0.04^{*b}	6.27±0.02^{bd}	5.12±0.05^{*d}	8.15±0.02^{*b}
Potassium	6.19±0.02^{bd}	5.38±0.03^{*d}	9.17±0.05^{*b}	8.22±0.03^{d}	8.17±0.02^{d}	9.23±0.04^{*b}
Phosphorus	9.13±0.02^{bd}	8.47±0.02^{*d}	7.26±0.05^{*b}	8.15±0.06^{bd}	9.25± 0.02^{*d}	8.43±0.10^{*b}

*Values are expressed as mean±standard deviation. Values with the superscript * are significantly different when comparing A1 with (A2 & A3). Values with the superscript a are significantly different when comparing A2 with others (A1 & A3). Values with the superscript b are significantly different when comparing A3 with A1 & A2. Also, * are significantly different when comparing B1 with B2 & B3. Values with the superscript a are significantly different when comparing B2 with B1 & B3. Values with the superscript b are significantly different when comparing B3 with B1 & B2. The powdered samples were prepared in the ratios of 40:30:30 (A1), 30:30:40 (A2), 30:40:30(A3) and 70:20:10 (B1), 10:70:20 (B2), 20:70:10 (B3).*

Table 4: Amino Acid Composition of Formulated Diet from Tigernuts, Date Fibre and Coconut (PPM)

	A A1	A2	A3	B B1	B2	B3
Glycine	----	----	11.867±0.015	0.280±0.010^{ab}	7.470±0.026^{*b}	14.880±0.010^{*a}
Alanine	9.203±0.015^{ab}	6.753±0.015^{*b}	15.660±0.020^{*a}	22.570±0.072^{ab}	2.376±0.015^{*b}	12.170±0.010^{*a}
Serine	3.380±0.010^{ab}	7.673±0.118^{*b}	1.783±0.031^{*a}	12.557±0.067^{ab}	-----	15.880±0.010*
Proline	20.063±0.015^{ab}	30.847±0.015^{*b}	15.950±0.036^{*a}	11.296±0.045^{ab}	2.870±0.026^{*b}	42.170±0.010^{*a}
Valine	10.337±0.042^{ab}	4.353±0.015^{*b}	8.530±0.017^{*a}	5.333±0.017^{ab}	12.843±0.035^{*b}	2.847±0.015^{*a}
Threonine	18.727± 0.047^{ab}	16.387±0.015^{*b}	13.613±0.025^{*a}	13.177±0.015^{ab}	4.147±0.025^{*b}	11.753±0.015^{*a}
Isoleucine	38.210 ±0.026^{ab}	30.090±0.026^{*b}	22.647±0.032^{*a}	29.437±0.015^{ab}	3.550±0.036^{*b}	3.893±0.021^{*a}
Leucine	1.833±0.021	1.587±0.015	1.783±0.012	2.550±0.026^{ab}	4.347±0.032*	4.120±0.010*
Aspartate	2.147±0.025^{ab}	0.973±0.015^{*b}	1.537±0.015^{*a}	1.740±0.459^{ab}	4.230±0.044^{*b}	0.290±0.010^{*a}
Lysine	4.877±0.025^{ab}	3.457±0.031^{*b}	1.850±0.017^{*a}	2.743±0.384^{ab}	5.160±0.044^{*b}	0.650±0.020^{*a}
Methionine	1.180±0.010^{ab}	0.893±0.021*	0.800±0.010*	0.827±0.021^{ab}	2.433±0.015^{*b}	0.633±0.025^{*a}
Glutamate	5.660±0.020^{ab}	2.760±0.020^{*b}	2.150±0.046^{*a}	2.847±0.021^{b}	2.783±0.012^{*b}	0.287±0.015^{*a}
Phenylalanine	4.243±0.042^{ab}	1.533±0.032^{*b}	2.047±0.012^{*a}	2.083±0.012^{a}	3.343±0.030*	----
Histidine	2.073±0.015^{ab}	1.180±0.010^{*b}	0.880±0.010^{*a}	0.957±0.021^{a}	3.567±0.015*	-----
Arginine	18.707±0.061^{ab}	9.177±0.015^{*b}	7.507±0.051^{*a}	7.470±0.020^{ab}	5.780±0.010^{*b}	0.833±0.021^{*a}
Tyrosine	5.570±0.026^{ab}	3.830±0.020^{*b}	0.657±0.021^{*a}	0.650±0.030^{a}	1.960±0.026*	-----
Tryptophan	7.490±0.061^{ab}	1.757±0.025*	1.846±0.031*	1.277±0.006^{ab}	2.433±0.032^{*b}	0.427±0.021^{*a}
Cysteine	16.633±0.252^{ab}	1.353±0.031^{*b}	0.757±0.015^{*a}	1.563±0.015^{ab}	2.547±0.021^{*b}	0.270±0.010^{*a}

Values are expressed as mean±standard deviation. Values with the superscript * are significantly different when comparing A1 with (A2 & A3). Values with the superscript a are significantly different when comparing A2 with others (A1 & A3). Values with the superscript b are significantly different when comparing A3 with A1 & A2. Also, * are significantly different when comparing B1 with B2 & B3. Values with the superscript a are significantly different when comparing B2 with B1 & B3. Values with the superscript b are significantly different when comparing B3 with B1 & B2. The powdered samples were prepared in the ratios of 40:30:30 (A1), 30:30:40 (A2), 30:40:30(A3) and 70:20:10 (B1), 10:70:20 (B2), 20:70:10 (B3).

Table 5: Carbohydrate Constituents of the Formulated Diet from Tigernuts, Date Fibre, and Coconut (PPM)

	A A1	A2	A3	B1	B B2	B3
HMF	0.180±0.010^{a}	0.163±0.025^{a}	1.347±0.025^{*b}	0.180±0.010	0.147±0.015	0.113±0.006
Ribose	0.780±0.010	0.570±0.020	0.573±0.006	0.880±0.010^{ab}	0.460±0.030*	0.476±0.012*
Fructose	3.880±0.010	2.373±0.015*	-----	------	0.230±0.174	0.177±0.015
Mannitol	-----	3.273±0.006	3.270±0.010	3.363±0.012	3.280±0.010	3.447±0.252
Galactose	0.425±0.316^{b}	0.127±0.439^{b}	1.276±0.015^{*a}	1.080±0.010^{ab}	0.215±0.160*	0.436±0.112*
Xylose	0.072±0.054^{ab}	1.780 ±0.010^{*b}	0.240±0.010^{*a}	0.270±0.010	0.041±0.001	0.170±0.010
Raffinose	----	----	----	----	----	----
Sucrose	2.030±0.020^{a}	0.533 ±0.015^{*b}	2.263±0.015^{a}	2.376±0.021	2.577±0.021	2.280±0.010
Sorbitol	0.577±0.029^{a}	0.0620±0.002^{*b}	0.380±0.010^{a}	0.450±0.020	0.557±0.006	0.420±0.010
Maltose	1.267±0.006^{ab}	2.767±0.032^{*b}	0.167±0.006^{*a}	0.031±0.002^{ab}	1.450±0.017*	1.323±0.015*
Glucose	2.083±0.006^{ab}	1.340±0.010^{*b}	2.480±0.010^{*a}	2.080±0.010	2.140±0.010	2.280±0.010
Arabinose	1.080±0.010^{ab}	0.470±0.010^{*b}	1.560±0.010^{*a}	1.042±0.010	1.042±0.001	1.257±0.015

*Values are expressed as mean±standard deviation. Values with the superscript * are significantly different when comparing A1 with (A2 & A3). Values with the superscript a are significantly different when comparing A2 with others (A1 & A3). Values with the superscript b are significantly different when comparing A3 with A1 & A2. Also, * are significantly different when comparing B1 with B2 & B3. Values with the superscript a are significantly different when comparing B2 with B1 & B3. Values with the superscript b are significantly different when comparing B3 with B1 & B2. The powdered samples were prepared in the ratios of 40:30:30 (A1), 30:30:40 (A2), 30:40:30(A3) and 70:20:10 (B1), 10:70:20 (B2), 20:70:10 (B3).*

DISCUSSION

Table 1 showed the results of sample A; it was observed that the values of fibre and carbohydrates were significantly ($p< 0.05$) higher in A1 when compared to others. The % values of moisture, fat, ash and protein were significantly higher in A3 when compared to others. For the B samples, it was noted that the values of fat and protein content were significantly higher in the B1 sample compared to others. Fibre was significantly higher in B2, while the % values of moisture, ash, and carbohydrate were significantly higher in B3 when compared to others.

The highest fibre and carbohydrate levels recorded in sample A1 are consistent with an increased proportion of tigernut or date components, as tigernut is notably rich in insoluble dietary fibre and resistant starch, while dates contribute substantially to simple and complex carbohydrates [10]. The elevated moisture, fat, ash, and protein values in sample A3 reflect a higher inclusion of coconut, which contains significant lipid content, moderate protein levels, and mineral-rich tissues while also retaining more moisture due to its structural water-holding capacity [11]. In the B samples, the high fat and protein levels in B1 likewise indicate a dominant coconut fraction, given coconut's high oil content compared with tigernut and dates. The fibre concentration in B2 can be attributed to a greater tigernut proportion, as tigernut contains high amounts of insoluble fibre relative to both coconut and dates. The high moisture, ash, and carbohydrate values in B3 suggest a formulation richer in dates, which naturally provide high sugars (therefore elevating total carbohydrate), considerable moisture, and mineral content reflected in higher ash values [10]. Overall, the distribution of nutrients across samples aligns with established proximate profiles of tigernut, date, and coconut, where relative increases in carbohydrate, fibre, fat, and protein ingredients systematically alter the corresponding proximate parameters of the composite diet.

The results showed that varying the formulation ratios of *Cyperus esculentus*, *Phoenix dactylifera*, and *Cocos nucifera* significantly influenced the nutritional composition of the formulated diets. Samples with higher tiger nut and date proportions exhibited increased fibre and carbohydrate contents, while coconut-dominant samples showed higher lipid and moisture contents. These findings agree with recent studies by [12] and [9], who reported that tiger nut and date fruits are rich in dietary fibre and carbohydrates, whereas coconut contains high levels of fats and moderate protein. The increased dietary fibre improves gastrointestinal function and reduces glucose absorption, while higher lipid content contributes to energy storage and membrane synthesis.

Results in Table 2 showed that the values of retinol, calciferol, tocopherol, niacin, pyridoxine and cobalamin were significantly ($p< 0.05$)higher in A1 when compared to A2 and A3. Folate was significantly higher in A2 compared to A1 and A3, while Carotenoids and thiamine were significantly higher in A3 compared to A1 and A2. In B1, the values of retinol, calciferol, tocopherol, thiamine, and folate were significantly higher when compared to B2 and B3. Riboflavin, niacin, pyridoxine, and cobalamin were significantly higher in B2 when compared to B1 and B3. Carotenoids were significantly higher in B3 when compared to B1 and B2. This can be attributed to the significant nutritional contributions of tigernut, which is known to contain various fat-soluble and water-soluble vitamins [14]. The high concentration of folate in A2 suggests that coconut might be a better source of this vitamin. The result obtained in this study agrees with the findings of [14], who reported that tigernut is a major source of vitamins such as vitamins B and D.

The vitamin results demonstrated significant variations among formulations, with some samples showing higher levels of pyridoxine, folate, riboflavin, and cobalamin. [12] observed that tigernut contains appreciable amounts of B-vitamins and antioxidant vitamins. These vitamins play important biochemical roles as coenzymes in carbohydrate, protein, and lipid metabolism, while antioxidant vitamins help protect cells against oxidative stress and free radical damage.

Table 3 results showed that magnesium and phosphorus were significantly ($p< 0.05$) higher in A1 among the A samples. Calcium, sodium, and potassium were significantly higher in A3 when compared with A1 and A2. Among the B samples, sodium was significantly higher in the B1 sample compared with B2 and B3. Phosphorus was significantly higher in B2 compared to B1 and B3. Also, calcium, magnesium, and potassium were significantly higher in B3 when compared with B1 and B3.

The study also revealed significant variations in the mineral content across the different diet formulations. In the A samples, magnesium and phosphorus were found in the highest concentrations in A1 (higher tigernut ratio). This shows that tigernuts are excellent sources of these essential minerals. The highest concentrations of calcium, sodium, and

potassium were found in A3 (high date ratio), indicating the mineral richness of dates. This result is also in agreement with the findings of [9], who reported that tigernuts are rich in minerals such as magnesium and phosphorus.

Mineral analysis revealed elevated calcium, potassium, magnesium, sodium, and phosphorus contents in specific formulations. This observation is consistent with the reports of [13] and [12], who documented that dates, tiger nuts, and coconut are good sources of essential minerals. Calcium and phosphorus are essential for bone mineralization, potassium and sodium regulate fluid balance and nerve impulse transmission, while magnesium functions as a cofactor for several metabolic enzymes.

Table 4 showed high concentrations of valine, threonine, isoleucine, leucine, aspartate, lysine, methionine, glutamate, phenylalanine, histidine, arginine, tyrosine, tryptophan and cysteine in sample A1, this indicate a greater contribution from tigernut, which has been reported to contain relatively higher levels of essential amino acids, including branched-chain amino acids (BCAAs) [13] The elevated serine and proline levels in A2 suggest a higher inclusion of date, as dates contain significant amounts of these non-essential amino acids. The increased glycine and alanine concentrations in A3 reflect a greater proportion of coconut, which contains higher quantities of these amino acids due to its characteristic seed protein profile [11].

The higher levels of alanine, threonine, isoleucine, glutamate, and arginine in B1 are indicative of the contributions of coconut and tigernut, as both ingredients possess glutamate-rich storage proteins and moderate concentrations of BCAAs. The predominance of valine, leucine, aspartate, lysine, methionine, phenylalanine, histidine, tyrosine, tryptophan and cysteine in B2 suggests a higher tigernut fraction, which is consistent with its richer essential amino-acid spectrum compared with coconut and date [16]. The glycine, serine, and proline in B3 show a greater date contribution, given the naturally higher proportions of these amino acids in date fruit protein.

The amino acid profile showed significant increases in essential amino acids such as valine, leucine, lysine, methionine, and isoleucine, especially those rich in tigernut. This agrees with findings of [12], which reported that tigernut possesses an appreciable amino acid profile. Biochemically, this implies that these amino acids are important for protein synthesis, tissue growth, enzyme production, and muscle metabolism, while branched-chain amino acids contribute to energy production and metabolic regulation.

Table 5 showed that the values of ribose, fructose, and sorbitol were significantly ($p< 0.05$) higher in A1 when compared to others. It was also recorded that mannitol, xylose, and maltose were significantly higher in A2 when compared to others. HMF, galactose, sucrose, glucose and arabinose were significantly higher in A3 when compared to others. In the B series, ribose, galactose, and xylose were significantly higher in B1 when compared to others. HMF, fructose, sucrose, sorbitol, and maltose were significantly higher in B2 when compared to others. Also, mannitol, glucose, and arabinose were significantly higher in B3 when compared to others.

The high values of ribose, fructose, and sorbitol detected in A1 align with the known monosaccharide profile of dates, which are rich in fructose and contain moderate amounts of polyols such as sorbitol, while ribose may appear in small quantities due to pentose phosphate pathway activity in plant tissues. The significantly elevated mannitol, xylose, and maltose concentrations in A2 suggest a greater contribution from tigernut, which exhibits the highest level of sugars including xylose and possesses starch fractions capable of partial hydrolysis into maltose during processing [9].

Collectively, these results reflect predictable shifts in sugar composition that occur according to ingredient proportions and processing-induced carbohydrate transformations.

The carbohydrate composition also varied significantly among the formulations, with increased levels of glucose, fructose, maltose, sucrose, and arabinose in different samples. Similar observations were reported by [9], who noted that dates are rich in natural sugars and energy-yielding carbohydrates. These carbohydrates serve as major energy sources required for ATP production and cellular metabolism.

CONCLUSION

This study showed that different formulation ratios of Cyperus esculentus, Phoenix dactylifera, and Cocos nucifera significantly affected the nutritional composition of the formulated diets. The diets contained appreciable amounts of carbohydrates, proteins, lipids, vitamins, minerals, amino acids, and other beneficial nutrients. Variations in ingredient proportions produced predictable changes in nutrient composition, with tiger nut- and date-rich samples showing higher fibre and carbohydrates, while coconut-rich samples showed higher lipid

and mineral contents. The findings suggest that these locally available food materials can be effectively combined to develop nutritious and functional dietary products that may contribute to improved nutrition, dietary diversity, and health promotion.

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RECOMMENDATION

Further studies should evaluate sensory quality, shelf stability, and physiological effects to support functional food development. In addition, scale-up trials are recommended to validate nutrient stability during processing and storage. Application-specific blends should be developed; for example, a formulation emphasizing proteins and essential amino acids could be designed for metabolic support, while alternatives prioritizing fibre and carbohydrate balance could be targeted for dietary management.

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