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Production and Evaluation of "Robo" From Melon Seeds and Moringa Seeds

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ABSTRACT
"Robo" was produced from blends of melon and moringa seeds powder and coded as RBA (100% melon), RBB (90% melon + 10% moringa seeds powder), RBC (80% melon + 20% moringa seeds powder) and RBD (70% melon + 30% moringa seeds powder). The proximate, mineral, phytochemicals, antioxidant, heavy metals and sensory properties of the robo samples were analyzed using standard analytical methods. The proximate composition results ranged thus: moisture (10.02 – 11.60%), ash (5.39 – 6.88%), fat (37.35 – 40.77%), fibre (6.95 – 14.27%), protein (10.82 – 16.91%) and carbohydrate (12.70 – 22.61%). The mineral composition results showed that calcium ranged from (13.65 to 17.55 mg/100g), magnesium from (7.57 to 10.29 mg/100g), potassium from (266.35 to 386.64 mg/100g), iron from (0.29 – 0.41 mg/100g), zinc from (0.60 – 1.01 mg/g) and phosphorus from (0.95 – 2.35 mg/100g). The phytochemical properties result of the robo samples were of range: tannin (1.18 – 1.81 mg/100g), alkaloid (2.37 – 3.46 mg/100g), flavonoids (3.44 – 7.36 mg/100g), phenolic (2.86 – 16.85 mg/100g), steroids (1.09 – 4.46 mg/100g), terpenoids (1.96 – 4.25 mg/100g), cardiac glycosides (3.41 – 13.94 mg/100g) while anthroquinones and phlobatannins were below detectable levels (BDL) respectively. The antioxidant properties of the robo samples were FRAP (45.10 to 69.58 mmol/100g) and DPPH radical scavenging activity (15.08 to 25.70 mmol/100g) respectively. The results for the heavy metals were for arsenic (0.89 – 1.08 mg/100g), lead (0.66 – 0.90 mg/100g), mercury (0.04 – 0.13 mg/100g), cadmium (0.64 – 0.92 mg/100g) and chromium (0.01 – 0.09 mg/100g). RBA (100% melon robo) had the best ratings for all sensory properties evaluated (taste, colour, texture, aroma, appearance and overall acceptability. However, acceptable robo were produced from melon and moringa seeds powder blends. In conclusion, the study showed that enrichment of "robo" with moringa powder is capable of improving the nutritional properties and overall quality of the snack. The findings of this study is a pointer that indigenous snack of acceptable nutritional and sensory quality could be produced with moringa seeds as a promising raw material.

Keywords: Robo, Nutrition, Snack, Moringa, Sensory

I. INTRODUCTION

Snacks are a type of food that is convenient to eat and can quickly satisfy short-term hunger. They are often consumed quickly and contain significant amounts of sweeteners, preservatives, and aroma components that make them appealing to consumers (Ocheme et al., 2011).Although the majority of snacks are not primarily consumed for their nutrients, many snacks are made with nutrition in mind, and the snack food market is constantly changing in terms of product types. Snacks that are not only nutritionally superior but also look, feel, and taste good are what consumers seek (Kocherla et al., 2012).

"Robo" is a type of ready-to-eat snack that is made from the residue or cake left over after oil extraction from melon or groundnut. This snack is typically consumed in the southwest region of Nigeria. (Lanre-Iyanda and Adekunle, 2012).

According to Makinde and Ibim (2015), melon (Citrulluscolocynthis) is one of the most widely consumed oil plant seed foods. It has a place with the group of Cucurbitaceae and started from Africa, yet it is accessible in different mainlands of the world (Ingale and Shrivastava, 2011). According to Adeyeye et al., (2020), melon seeds contain approximately 53% oil, 28.4% protein (60% in defatted flour), 2.7% fiber, 3.6% ash, and 8.2% carbohydrates). Melon seeds have culinary uses and are valued for their anti-inflammatory and anti-diabetic properties, which come from the presence of Citrulluscolocynthis. (Templeton et al., 2005).

Melon (Citrulluscolocynthis) is one of the most commonly consumed oil plant seeds in the world (Makinde and Ibim, 2015). This plant belongs to the family Cucurbitaceae and is originally from Africa, although it is now available in other continents as well (Ingale and Shrivastava, 2011). The nutrients in melon seeds include about 53% oil, 28.4% protein (60% in defatted flour), 2.7% fiber, 3.6% ash, and 8.2% carbohydrates (Adeyeye et al., 2020). Melon seeds can also be used for culinary purposes and have anti-inflammatory and anti-diabetic properties, which are attributed to the presence of Citrulluscolocynthis (Templeton et al., 2005).

The "miracle plant," Moringa oleifera, has only recently been grown in West African regions. Moringa oleifera's seeds contain a significant amount of vitamins A, B, and C, as well as minerals like calcium, phosphorus, and iron. Additionally, it has medicinal properties (Olushola, 2006). Oil (44.78 percent), crude protein (25.97%t), ash (5.22%), and crude fibers (4.87%) are all found in abundance in Moringaoleifera seeds. They have been reported to have antimicrobial activity, have an acrid and bitter taste, and are known to be antipyretic (Anjorin et al., 2010; Anwar et al., 2007).
Hence, this study aimed to determine the nutritional composition of “robo” from melon enriched with moringa seeds powder

II. MATERIALS AND METHODS

Materials

The melon and moringa seeds were obtained from the Owode market in Offa Local Government Area of Kwara State, and the necessary equipment for the study was provided in the Food Processing Laboratory of the Food Technology Department at the Federal Polytechnic Offa, Kwara State.

Methods

Preparation of Moringa Seed Powder

According to the Ogunsina and Radha (2010) procedure, the moringa seed powder was made (figure 1). Using a 1:30 w/v ratio and regular boiling in clean water, the seeds were dehulled and debittered. At 80°C for 8 hours, the debittered seeds were dried in an oven. The debittered seeds were crushed and passed through 40 mesh sieves after being defatted using a screw press to get cold-pressed crude oil.

Production of Robo

According to figure 2, Robo was produced using the Makinde and Ibim (2015) technique. Manual dehulling followed by an 8-hour sun drying process was used for melon seeds. Shelled melon seeds were roasted over an electric burner in an open, dry saucepan. The seeds were continuously rotated till they became brown (10 – 15 min). After cooling, the roasted seeds were ground into a paste without the use of water in an attrition mill. After vigorously mixing the mixture (of known weight) until oil was extracted, seasonings (one Knorr cube and around 30 g of pepper), salt, and salt were added. The cake was kneaded for nearly an hour in a bowl as oil was released, at which point it became stiffer and firmer.

Robo was prepared according to the method of Makinde and Ibim (2015), as indicated in figure 3.2. Melon seeds were dehulled manually and then sundried for about 8 h. The shelled melon seeds were roasted in an open dry pot using electric stove. The seeds were turned constantly until they became brown (10-15 min). The roasted seeds were cooled and milled into paste without adding water using attrition mill. The paste (of known weight) was thoroughly kneaded until oil was extracted and pepper (about 30 g), salt (a pinch) and seasonings (one cube of knorr cube) were added. The kneading continued until oil was released for about 1 h in a bowl and the cake becomes harder and firmer. Small, spherical balls of cake were formed, and they were afterwards cooked in cake oil. The robo samples were stored in sealed containers and cooled to room temperature.

Table 1: Formulation of blends for robo production

Sample	Melon (%)	Moringa powder (%)
A	100	-
B	90	10
C	80	20
D	70	30

Source: Author’s computation

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Analyses

Determination of proximate composition of robo

Moisture content

The moisture content of the robo samples was determined using the AOAC's (Association of Analytical Methods) standard procedures. (2001). To remove any moisture that was on the dishes, an empty porcelain crucible was dried in the oven at 105°C for 30 minutes. After being placed in a desiccator, the crucible was given about 20 minutes to cool to ambient temperature. The empty porcelain crucible weighed a record amount. An analytical balance was used to weigh 2.00 g of thoroughly mixed material into the crucible. The crucible and its contents were put in the oven and dried at 105 ±5 ^{o}C until the weight remained constant, ideally for 6 h. For around 10 min, the porcelain crucible containing the sample was allowed to cool.

Moisture content of the robo samples was carried out according to the official methods of Association of Analytical Methods (AOAC) (2001). Empty porcelain crucible was dried in the oven at 105 ± 5^{0}C for 30 min to get rid of moisture present on the dishes. The crucible was transfer into a desiccator and allowed to cool to room temperature for about 20 min. The weight of the empty porcelain crucible was record. 2.00 g of well blended sample was weighed into the crucible using an analytical balance. The crucible and content was placed in the oven and dried at 105 ± 5 ^{o}C till constant weight or preferably for 6 h. The porcelain crucible containing the sample was allowed to cool for about 10min. The crucible was moved into the desiccators using a crucible tong, where it was left to cool for around 30 minutes to room temperature. The porcelain crucible's ultimate weight along with its contents were noted. The weight of the crucible and residue after drying was subtracted from the weight of the crucible and sample before drying to determine the moisture content.

Ash content

According to Vasantrao's approach, the ash content of the robo samples was measured. (2013). In a previously weighed empty porcelain crucible, 5.00 g of sample was weighed. The crucibles and their contents were then ashed for nearly three hours at 550 ^{o}C. The crucibles were ashed, then allowed to cool before having their ultimate weight measured with a weighing scale.

The % total ash content was calculated thus

$$\frac{\text{(Crucible weight + Ash residue) – Weight of crucible}}{\text{Weight of sample}} \times 100$$

Crude protein

The standard microKjeldahl method was used to determine the amount of crude protein present. In a micro-Kieldahl flask, 0.2 grams of each sample were weighed, and 3.5 mL of concentrated tetraoxosulphate (VI) acid, 0.4 grams of a mixed catalyst, sodium tetraoxosulphate, and copper (II) tetraoxosulphate, respectively, were added. Every one of the example and the substance were warmed on an electrical warmer for 2 hr (Absorption). After being cooled, the digested material was put into the distillation apparatus; 20 mL of 40% NaOH was added and blend was warmed and refined until 50 mL was gathered in a 100 mL tapered jar, the smelling salts developed was gotten in 10 mL of 2% boric corrosive. Using a universal indicator (Bromo cresol green and methyl red in alcohol), the trapped ammonia was titrated against 0.02 N hydrochloric acid (HCL). The percentage of protein was determined as follows:

$$\text{\% crude protein} = \frac{\text{Molarity of Hcl x 0.014 x Titre value x dilution factor x 100}}{\text{Weight of sample}}$$

Crude fat

The official method of the Association of Analytical Chemists (AOAC) (2008) was used to measure the robo samples' crude fat content. 5.00 g of very much mixed sample was weighed into the thimbles and cotton fleece was put on the example inside the thimble to forestall spilling out of the example during extraction. The round base jar was dried in the broiler at 60 ^{o}C and the initial void weight recorded. The flask was filled with 80 milliliters of hexane, and the thimble containing the sample was also fitted into the extractor. The heating mantle was turned on, and water for cooling was set to flow through the condenser. After allowing the extraction to continue its reflux for two hours, it was stopped. After that, the flash was dried once more in an oven to get rid of any remaining hexane. The weight of the empty flask was subtracted from the final weight to determine the percentage of crude fat or oil in the sample.

Crude fiber content

Newly pre-arranged sulfuric acid (1.25%, 200 mL) was added to 2 g of the example (W_1) in a 500 mL cone-like carafe. To maintain a constant volume, the mixture was gently boiled for 30 min with a cooling finger. After that, a muslin cloth was used to filter the mixture, and the residue was washed until it was free of acid. After adding about

200 milliliters of 1.25% NaOH, the mixture was boiled for 30 min. The combination was again sifted utilizing a muslin material and afterward washed completely with hot refined water (multiple times) and flushed once with 10% HCl and multiple times with hot refined water. The buildup was additionally flushed with ethanol and multiple times with petrol ether (40-60 ^oC bubbling reach) and was permitted to deplete and moved to a silica dish recently lighted at 600 ^oC and cooled. After the dish and its contents were dried to a constant weight (W_2) at 105 ^oC, the organic matter in the residue was burned off in a muffle furnace for 30 minutes at 600 ^oC, cooled in a desiccator, and weighed (W_3). The crude fiber reported as the loss in ignition was calculated as follows:

$$\% \text{ crude fiber} = \frac{(W_2 - W_3) \times 100}{W_1}$$

Carbohydrate by difference

The difference in dry sample weight was used to determine the robo samples' percentage of carbohydrates. Protein, crude fat, total ash content, crude fiber, and moisture content were all reduced by one hundred percent. The results were then presented in terms of dry weight.

% carbohydrate = 100% - (sum of the % of moisture, ash, fat, crude fiber and crude protein)

Determination of selected mineral composition of robo samples

The Atomic Absorption Spectrophotometer (AAS) was used to place a lamp that corresponded to the mineral in the AAS and set the wavelength specific to the mineral or heavy metal to be measured. After running the standards for the selected minerals (calcium, magnesium, potassium, iron, zinc, and phosphorus), the AAS siphoning hose was submerged in the digested sample. The convergence of the metal in the arrangement was shown on the screen of the AAS machine (Relationship of Logical Scientists (AOAC), 2010).

Determination of selected phytochemical composition of robo samples

The robo samples' phytochemical composition, which included alkaloids, flavonoids, tannins, phenols, steroids, terpenoids, cardiac glycosides, anthroquinones, and phlobatannins, was examined.

Determination of tannin

This was determined using the approach Yusuf (2019) explained. A water bath was used to heat a mixture of approximately 2 ml of water and 0.5 g of each sample. After filtering the mixture, a 10% FeCb solution was added to the filtrate in the amount of 1 ml. The presence of tannins was detected by a blue-black solution.

Determination of alkaloids

Tiwari et al. (2011)'s method was used to determine the alkaloid contents of the robo samples. A conical flask containing 5 g of the sample (w_0) was filled with 200 ml of 10% acetic acid in ethanol. After shaking the flask for 4 h, the contents were filtered, and the filtrate evaporated to approximately one quarter of its original volume. Scarcely any drops of ammonium hydroxide was added to precipitate (ppt) the alkaloid. The ppt was caught by separating through a formerly weighed filter paper (W_1). The filter paper was dried at 60 ^oC and its final weight, W_2, was recorded.

$$\text{The \% alkaloid was calculated as } \frac{(W_2 - W_1) \times 100}{W_0}$$

Determination of flavonoids

Mahajan and Badujar's (2008) method was used to estimate this. In a conical flask, 1 g of the sample was weighed, and 50 ml of methanol at 80% was added. Shaking was performed while the flask was placed on a low-temperature hot plate for 30 minutes. After 30 minutes, the mixture was cooled, filtered into a volumetric flask, and 80 percent methanol was added to make it up to the mark. After transferring 3 milliliters of the filtrate into a test tube, 0.1 milliliters each of 10% aluminum chloride, sodium potassium tartrate, and distilled water were added. Using a UV visible spectrophotometer and 80 percent methanol as the blank, the test tube was shaken before its absorbance was measured at 415 nm. Extrapolating the absorbances down the concentration asix of a rutin standard or an existing rutin standard graph obtained through the same procedure was used to compute the flavonoid content.

Determination of phenols

The Singleton et al. (1999) method was used to determine the total phenol content of the robo samples. In a conical flask, one gram of the sample was mixed with 10 milliliters of ethanol to extract phenol. After 30 min of vigorous shaking and cocking, the flask was filtered. The total phenol assay was performed on the filtrate. 1.00 ml of the ethanolic extricate was taken into a cylinder and 0.5 ml 2N Folin - Ciocalteu reagent, 1.5 ml 7% sodium carbonate added and made up to 10 ml with water. A UV visible spectrophotometer was used to measure the absorbance at 765 nm after the mixture was properly shaken for 90 minutes for color development. Extrapolating the absorbances down the concentration asix of a tannic acid standard graph obtained through a similar procedure or an existing tannic acid standard graph obtained through a similar procedure yielded the phenol content. The amount of phenol was reported as mg/kg TAE. Tannic acidequivalent).

Test for steroids

This was done by expansion of 4 ml of acidic anhydride to 1 g of every one of the rough concentrate (independently) with additional option of H_2S0_4 (2 ml). The color changed from violet to blue or green when steroids were present.

Test for terpenoids

Parekh and Chands' Salkowski's (2008) test was used to accomplish this. To 4 ml of chloroform, 10 ml of the rough concentrate was added, trailed by the cautious further option of 5 ml concentrated (H_2SO_4). Development of the ruddy earthy colored shading at the connection point means that a positive outcome for the presence of terpenoid.

Test for cardiac glycosides

The Keller-Killani test technique depicted by Parekh and Chands (2008) was utilized for cardiac glycosides evaluation. To 2 ml of chilly acidic corrosive containing one drop of ferric chloride (FeCl3) arrangement, 5 ml of the plant remove was added, this was trailed by option of 1 ml concentrated Sulfuric corrosive. At the interface, a brown ring formed, indicating the presence of cardenolide deoxy sugar. Below the brown ring, a violet ring may appear; however, a greenish ring may also appear gradually throughout the acetic acid layer.

Test for anthroquinones

10 ml of sulfuric acid (H_2SO_4) were added to 5 ml of each plant extract while boiling, and the mixture was immediately filtered. 5 ml of chloroform was added to the filter and shaken. One milliliter of diluted ammonia was added after the chloroform layer was pipette into another test tube. Color variations in the final solution were evaluated (Sofowara, 1993).

Test for Phlobatannins

An aqueous extract of the food sample(s) wasboiled with 1% aqueous hydrochloric acid. Appearance of red precipitate indicates the presence of phlobatannins (Adekanmi et al., 2020).

Determination of selected antioxidant composition of robo samples

Total reducing power (FRAP)

The procedure utilizing potassium hexacyanoferrate was slightly modified to determine the reducing power of the sample extracts (Nobosse et al., 2017). 0.2 M phosphate buffer (pH 6.6) and 1% K4Fe (CN)6 were combined with an aliquot of the extract (100 L), which was then incubated for 20 min at 50 °C before being precipitated with 10% TCA. The supernatant was diluted with equivalent quantities of distilled water after 15 min of centrifugation at 3,500 rpm, and 0.1% $FeCl_3$ was added to test the extracts' ability to reduce ferric iron. At 700 nm, the absorbance was measured against a blank for the reaction. Results were reported as the ascorbic acid equivalent (gAAE/100 g DM) using ascorbic acid as the reference standard.

DPPH radical scavenging activity

Assay Radical scavenging activity of extracts of samples was measured by the modified method described by Nobosse et al. (2017). In ethanol, DPPH is a stable radical with a dark violet hue. Its interaction with a hydrogen donor bleaches its hue. For the analyses, 2 mL of a 100 M DPPH solution in ethanol were combined with 0.1 mL of each extract. The control included 2 mL of DPPH and 0.1 mL of ethanol. The reaction mixture was incubated for 30 min. at 25°C in the dark before the absorbance was measured at 517 nm and compared to a blank for the reagent. According to equation, the proportion of free radical scavenging activity was determined.

$$\text{Scavenging activity (\%)} = \frac{(\text{Abs. control} - \text{Abs. test}) \times 100}{\text{Abs control}}$$

Where: Abs is the absorbance at 517 nm

Determination of heavy metals

The content of heavy metals such As, Pb, Hg, Cd, and Cr was assessed using the (AOAC, 2001). The SOLAAR M Atomic Absorption Spectrophotometer was used to measure the concentrations of Ar, Pb, Hg, Cd, and total Cr in the digested "Robo" samples. Each test was made in triplicate and the mean mineral content in g/100 g was reported.

Determination of sensory evaluation of spiced robo

Consumers' acceptance test was used to evaluate the sensory attributes of the robo as described by Hough et al. (2006). The sensory evaluation was carried out to determine the taste, color, texture, aroma, appearance and overall acceptability.

Statistical analysis

The data are means of duplicates ± standard deviation and were subjected to statistical analysis using IBM SPSS version 20.0 software. Mean differences were compared using Duncan's Multiple Range Test (p≤0.05) to study the difference among means (Adeyeye et al., 2019).

III. RESULTS AND DISCUSSION

Proximate composition of robo samples

Table 1 presents the results for the proximate composition of robo from melon and moringa seeds. The mean results for the moisture contents of the robo varied between (10.02 – 11.60%). The highest moisture content (11.60%) was observed in robo from RBC (80% melon + 20% moringa powder) while robo from whole melon seeds (RBA) the least value (10.02%). The moisture contents of the robo differed significantly at (p < 0.01). Although not chronological, there were increase in moisture contents of the robo with increased level of moringa seeds powder supplementation. The moisture contents of the robo samples are within the recommended level for flour based food products (≤13%) (Eke-Ejifor and Owuno, 2012). The findings of the current report are higher than the values (7.36 – 8.13%) reported for moisture content of watermelon-melon robo respectively by Adeyeye et al. (2020). Similarly, Sade et al. (2013) and Osuolale and Olayiwola (2014) reported (8.43 – 8.93%) and (9.25 – 12.19%) for the moisture contents of defatted groundnut-melon kernel flour robo and soy flour-ginger spice kokoro which are slightly in consonance with the findings of the current work. The moisture content of the robo samples in this study fall within the recommended moisture content of snack (10 – 14%) (Guzman, 2012). Low moisture content is desirable in snack such as robo, as high moisture content could result in loss in crispiness of the snack, and accelerate other biochemical changes such as oxidative rancidity and microbial proliferation (Osuolale and Olayiwola, 2014).

The ash contents of the robo differed significantly (p < .05) with values ranging between (5.39 – 6.88%). Robo from RBD (70% melon + 30% moringa powder) had the highest ash content (7.88%) while the least value (5.39%) was observed in whole melon robo (RBA). The result showed significant (p < .05) increase in ash contents of the robo samples with increase in supplementation of moringa powder. This could be attributed to the significant minerals (calcium, phosphorus and iron) inherent in moringa (Olushola, 2006). The total ash contents of robo in slight conformity with the values (5.04 – 5.82%) reported for ash content of robo from watermelon and melon seeds by Adeyeye et al. (2020). The reports of Akande et al. (2021) for ash content of melon seed-groundnut robo (5.33 – 18.02%) are higher than the findings of the current work. Contrarily, Ayinde et al. (2012) reported (2.36 – 2.60%) for ash contents of maize-beniseed kokoro which are lower than the report of the current work. The total ash content of samples in this study are commendable; hence, indication of mineral elements in the robo (Akansha et al., 2018). Akiode et al. (2018) further supported that the ash content can provide an estimate of the mineral content of a product.

The fat contents of the robo differed significantly (p < 0.01) with values ranging between (37.35 – 40.77%) with robo from RBA (100% melon) significantly (p < .05) having the highest fat content (40.77%) while the least value (37.35%) was observed in robo from RBB (90% melon + 10% moringa powder). Although not chronological, the result showed reduction in fat contents of robo due to inclusion of moringa powder to the robo samples. Although moringa seeds contains appreciable amount of fat (44.78%) (Al-Juhaimi et al., 2017); however, the insignificant (p > .05) reduction of fat contents in the robo could be attributed to defatting process to which the moringa seeds were subjected during the robo production. The results reported for fat content of the robo in this study are higher than the values (16.80 – 17.53%) reported for defatted groundnut-melon flour robo by Osuolale and Olayiwola (2014). Similarly, Kolapo et al. (2012) and Fekiria et al. (2012) also reported (9.87%) and (7.76%) for fat contents of kuli kuli and groundnut flour respectively which are lower than the values reported for fat content of samples in this study. Variation of values in this current study and those in the cited literatures may be attributed to the varietal differences and processing methods employed in the respective studies. Fats have been shown to enhance the taste and acceptability of foods. However, high fat content could predispose 'robo' to rancidity under high relative humidity and high ambient temperature (Makinde and Ibim, 2015).

The mean results for the fibre contents of robo indicated a range of values ranging between (6.95 – 14.27%) with robo from RBD (70% melon + 30% moringa powder) having the highest fibre content (14.27%) while the least value (6.95%) was observed in whole melon robo (RBA). Significantly ($p < .05$), the fibre contents of the robo increased with increase in moringa powder supplementation. Inherently, moringa seeds contains about (4.87%) fibre (Al-Juhaimi et al., 2017); hence, justifying the increase in fibre contents of the robo. Olanipekun et al. (2021) reported (6.52 – 6.94%) for crude fibre contents of robo analogue from melon seed and bambara groundnut which are in conformity with the values reported for crude fibre content of samples in this study. However, the report of Adeyeye et al. (2020) for crude fibre contents (5.97 – 6.31%) of watermelon-egusi melon robo are lower than the findings of the current work. It is known that crude fiber helps human digestive systems (Ayinde et al., 2012);consumption of fiber and risk of cancer in general and coronary heart disease are inversely correlated (Lattimer and Haub, 2010).

The protein contents of the robo samples ranged between (10.82 – 16.91%) with robo from RBD 70% melon + 30% moringa powder) having the highest protein content (16.91%) while the least value (10.82%) was observed in whole melon seed robo (RBA). There were significant differences ($p < .05$) between the protein contents of the robo samples. The result indicated significant ($p < .05$) increase in protein contents of the robo samples with increase in moringa seeds powder inclusion. Moringa seeds are of high protein content (25.97%) (Al-Juhaimi et al., 2017); this contributed to the significant ($p < .05$) increase in protein contents of the robo in the current study. The protein contents of robo in this study are lower than the values (39.17 – 41.00%) reported for defatted groundnut-melon kernel flour robo by Osuolale and Olayiwola (2014). Variation in values may be attributed to the high level of inherent protein found in groundnut (≥36.4%) (Lewis et al., 2013). Denaturation of protein during frying of robo samples in this study is also a factor contributing to the slightly lower protein content of the samples as compared to the cited literatures. Sade and Aderonke (2013) reported the values (8.32 – 15.91%) for protein content of soy flour-ginger spiced kokoro which are in consonance with the findings of the current report. Values obtained for the protein content of robo samples in this study are not comparable to the recommended protein level of 18% - 20% for protein-rich snacks (Sade and Aderonke, 2013).

The carbohydrate contents of the robo varied between (12.70 – 22.61%) with robo from 100% melon (RBA) having the highest value (22.61%) while the least value (12.70%) was observed in robo from RBD (70% melon + 30% moringa powder). There were significant differences ($p < .05$) between the carbohydrate contents of the robo. Significantly ($p < .05$), there were reductions in carbohydrate contents of the robo with increased level of moringa powder supplementation. This could be due to moringa seed powder being of high protein content (25.97%) (Al-Juhaimi et al., 2017). The findings of the current report are in conformity with the report (18.28 – 21.29%) of Osuolale and Olayiwola (2014) for carbohydrate contents of defatted groundnut-melon kernel flour robo. Contrarily, Sade and Aderonke (2013) reported (40.54 – 57.13%) for carbohydrate content of soy flour-ginger spiced kokorowhich are higher than the carbohydrate contents of robo in this study. Carbohydrates are generally available as an immediate energy source (Mehra et al., 2015).

Mineral composition of robo samples

Table 2 presents the results for the mineral composition of robo from melon and moringa seeds. The calcium contents of the robo ranged between (13.65 – 17.55 mg/100g) with robo from RBD (70% melon + 30% moringa powder) having the highest calcium content (17.55 mg/100g) while the least value (13.65 mg/100g) was observed in whole melon robo (RBA). There were significant differences ($p < .05$) between the calcium contents of the robo which indicated that increase in supplementation of moringa powder to the respective robo improved the their calcium contents. These values are in consonance with the reports (16.21 –17.63 mg/g) of Adeyeye et al. (2020) for calcium contents of watermelon and egusi melon robo. Calcium is a component of bones and aids in blood clotting, nerve communication, and proper body contraction. The body will draw calcium from the bones on its own if the supply of calcium to the body becomes inadequate. Over time, if the body continues to use up more calcium than it can replenish, the bones will weaken and crack easily. Since calcium is crucial for preventing and controlling disease, it may help explain why moringa has therapeutic properties (Aliyu et al., 2008).

The magnesium contents of the robo samples differed significantly at ($p < .05$) with values ranging between (7.57 – 10.29 mg/100g).

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Robo from RBD (70% melon + 30% moringa powder) had the highest magnesium content (10.29 mg/100g) while the least value (7.57 mg/100g) was observed in robo from RBA (100% melon). The findings of the current study are in consonance with the report of Adeyeye et al. (2019) for magnesium contents 9.49 – 10.11 mg/100g of robo but lower than 935.10 – 1460.45 mg/kg obtained for magnesium contents of aadun from selected states in Nigeria by Idowu et al. (2012).

The potassium content of the robo samples differed significantly (p<.05) with values ranging from 266.35 – 386.64 mg/100g. The highest potassium content (386.64 mg/100g) was observed in robo supplemented with 30% moringa seeds (RBD) while the least value (266.35 mg/100g) was observed in 100% melon robo (RBA). Significant (p < .05) increase in potassium contents of robo samples due to moringa seeds powder supplementation could be attributed to the inherently high potassium contents (732 mg/100g) in Moringaoleifera seeds. These values corroborate the report of Sade and Aderonke (2013) for potassium contents (380 – 1978 mg/g) of soy-ginger spiced kokoro. Contrarily, the potassium contents (26.11 – 23.76 mg/g) of robo from watermelon and egusi melon by Adeyeye et al. (2020) are lower than the report of the current work. Having a high concentration of potassium in the body can increase iron utilization and is beneficial for individuals who take diuretics to control hypertension and experience excessive excretion of potassium through their body fluids (Arinanthan et al., 2003; Adeyeye, 2002).

The iron contents of samples ranged between (0.29 – 0.41 mg/100g) with robo supplemented with 30% moringa powder (RBD) having the highest value (0.41 mg/100g) while the least iron content (0.29 mg/100g) was observed in robo from 100% melon (RBA). The iron contents of the robo differed significantly at (p < 0.01). However, the result indicated significant (p < .05) increase in iron contents of robo at 20% and 30% moringa powder supplementation, as shown in RBC and RBC respectively. Adeyeye et al. (2020) reported (5.38 mg/g) and (6.20 mg/g) for iron content of water melon and egusi melon robo which are higher than the values reported for samples in this study. Iron plays a vital role in the formation of blood and the transportation of oxygen and carbon dioxide between tissues. A deficiency of iron can lead to anemia and impaired learning ability and behavioral problems in children (Jacob et al., 2015).

The mean score values for the zinc contents of robo samples ranged from 0.60 to 1.01 mg/g with robo from RBD (70% melon + 30% moringa powder) having the highest value (1.01 mg/100g) while the least zinc content (0.60 mg/100g) was observed in robo from RBA (100% melon). Although melon contains lower amount of zinc (0.25 mg/g) (Imafidon et al., 2018); slightly higher zinc content of robo samples in this study may be attributed to moringa powder utilized in the current study. Our bodies require zinc in small amounts to support the immune system, aid in cell division and growth, facilitate wound healing, and assist in the breakdown of carbohydrates. Zinc is also essential for our sense of smell and taste(Aremu et al., 2013; Adeyeye et al., 2019). Zinc is important for healthy hair, proper functioning of certain sense organs, including taste and smell, as well as carbohydrate and protein metabolism. It also aids in the metabolism of vitamin A from liver storage, and helps in the synthesis of DNA and RNA required for cell production (Jacob et al., 2015).

The phosphorus contents of the robo samples differed significantly (p < .05) with values ranging between (0.95 – 2.35 mg/100g). The highest phosphorus content (2.35 mg/100g) was observed in robo from RBD (70% melon + 30% moringa powder) while the least value (0.95 mg/100g) was noted in whole melon robo (RBA). The phosphorus contents of watermelon-melon robo (21.88 – 22.99 mg/100g) reported by Adeyeye et al. (2019) are higher than the findings of the current report. Phosphorus is crucial in the body for waste filtration, tissue and cell repair. A deficiency in the balance of phosphorus and calcium can lead to health problems such as osteoporosis, arthritis, pyorrhea, rickets, and tooth decay (Asaolu et al., 2012).

Phytochemical properties of robo samples

The results for the phytochemical properties of the robo from melon and moringa seeds powder are presented in table 3. The mean score values for the tannin contents of the robo differed significantly (p < .05) with values ranging between (1.18 – 1.81 mg/100g). Robo from RBD (70% melon + 30% moringa powder) had the highest value (1.81 mg/100g) while the least tannin content was observed in RBA (100% melon). Increase in level of tannin in the robo samples due to moringa seed flour supplementation is an indication of their potential as antibacterial, antiviral, and anti-parasitic food samples (Lu et al., 2004). Our findings are within the recommended level of tannin (560 mg) for foods by World Health Organization (WHO) (2003). The values obtained for tannin contents of robo in the current study is lower than (39.40 mg/g) reported for tannin contents of egusi melon by Jacob et al. (2015), 28 – 43 mg/g for sorghum grains by Elemo et al. (2001) and 5.50 mg/g for pigeon pea by Ayodele and Kigbu (2005). Tannins and flavonoids have been found to possess anti-diarrheal properties by inhibiting intestinal motility and showing anti-secretory effects in general(Sharma and Chauhan, 2017).

Alkaloids have various pharmacological functions such as treating diseases or illnesses with their antimalarial, antihypertensive, anticancer, antifungal, and antibacterial properties. (Iwu et al., 2016; Zanrate et al., 2018). The alkaloid contents of the robo samples were of range (2.37 – 3.46 mg/100g). RBD (70% melon + 30% moringa powder) significantly ($p < .05$) had the highest alkaloid content (3.46 mg/100g) while the least value (2.37 mg/100g) was observed in melon from 100% melon (RBA). Our findings are lower than (8.63 mg/g) and (15.69 mg/g) for musk melon seeds and water melon seeds reported by Mehra et al. (2015) and the report of Omokpariola et al. (2021) for alkaloids content (5.85 g) of Moringaoleifera seeds. The presence of alkaloid in the robo samples, especially as it increased with increase in inclusion of moringa seeds depicts their antibacterial and anti-diabetic viabilities (Akinyeye et al., 2014).

Flavonoids are polyphenolic molecules that are water-soluble and are utilized for various activities such as anti-inflammatory, enzyme inhibition, antimicrobial, estrogenic, antiallergic, antioxidant, antiulcerogenic, vascular, and cytotoxic antitumor activities (Sixl-Daniell et al., 2011; Iwu et al., 2016, 2018). The flavonoids content of the robo samples differed significantly ($p < .05$) with values ranging between (3.44 – 7.36 mg/100g). The highest flavonoids (7.36 mg/100g) was observed in RBD (70% melon + 30% moringa seeds powder) while robo from 100% melon seeds had the lowest value (3.44 mg/100g). Significant ($p < .05$) increase in flavonoid contents of the robo samples were observed with increased level of moringa seeds supplementation. This could be attributed to the flavonoids content of Moringaoleifera (5.97%) (Omokpariola et al. 2021) which increased the flavonoids content of the robo samples. Amadi (2017) reported (0.45 – 0.69 mg/100g) for flavonoids content of wheat-moringa cookies which are lower than the values obtained in the current report.

Phenolic compounds are naturally occurring plant-based products with significant potential as antioxidants. Consuming foods rich in phenolic compounds can contribute to human health and help prevent the oxidation of fats and oils (Naczk and Shahidi, 2006; Jokic et al., 2010). The mean scores for the phenol contents of the robo samples ranged between (2.86 – 16.85 mg/100g). Robo from RBD (70% melon + 30% moringa powder) had the highest phenol content (16.85 mg/100g) while the least value (2.86 mg/100g) was observed in 100% melon robo (RBA). The phenol contents of the robo samples differed significantly at ($p < 0.01$). Increase in phenolic contents of robo samples supplemented with moringa seeds powder is an indication of their potency in biological effects including antioxidant, antimicrobial and free radical scavenging activities (Danlam et al., 2015). Our findings are higher than 0.02 – 0.72 mg/100g reported for phenol contents of different medicinal plants by Krishnaiah et al. (2009) and 0.76 mg/g for melon (Citrullus lanatus)by Irabor et al. (2020) but in conformity with 19.65 mg/100g obtained for moringa seeds by James et al. (2022).

The steroids contents of the robo samples varied from 1.09 to 4.46 mg/100g with RBD (70% melon + 30% moringa powder) having the best steroids (4.46 mg/100g) while the least value (1.09 mg/100g) was observed in RBA (100% melon). There were no significant differences ($p > .05$) between RBB and RBC respectively while other robo samples differed significantly ($p < .05$). Increase in steroids contents of the robo samples due to moringa seeds flour supplementation infer their suitability as antifungal, antibacterial agents thus helping to boost the immune system (Braide et al., 2012; Sadiq et al., 2016). The report of the current study conform to the findings of Omokpariola et al. (2021) and Shina et al. (2021) whose study reported presence of steroids in Moringa oleifera and watermelon respectively. Performance enhancing drugs, which are commonly used by athletes, contain fat-soluble chemicals known as steroids (Sixl-Daniell et al., 2011).

The terpenoids contents of the robo samples differed significantly ($p < .05$) with values ranging between (1.96 – 4.25 mg/100g). The highest value (4.25 mg/100g) was observed in RBD (70% melon + 30% moringa powder) while the least value (1.96 mg/100g) was observed in RBA (100% melon). The robo samples with added moringa seeds powder will offer better wound and scar healing properties as well as helping to lower complications associated with diabetics and blood sugar levels than 100% melon robo(Hawkins and Ehrlich, 2006). Our report is in support of the studies of Krishnaiah et al. (2009) and Irabor et al. (2020) whose study showed presence of terpenoids in Moringa oleifera and watermelon seeds respectively. However, Ijarotimi et al. (2013) reported 20.00 – 27.50 mg/100g for terpernoids content of raw, germinated and fermented Moringa oleifera seed flour which are higher than those obtained in the current report.

Cardiac glycosides have been used for treating congestive heart failure by directly increasing the strength of myocardial contractions (Ezeonu and Ejikeme, 2016). The mean results for the cardiac glycosides of the robo samples ranged between (3.41 – 13.94 mg/100g) with robo supplemented with 30% moringa seeds powder (RBD) having the highest value (13.94 mg/100g) while the least value (3.41 mg/100g) was observed in 100% melon robo (RBA). There were significant differences at 95% confidence level between RBA and RBB while no significant differences ($p > .05$) were observed between RBC and RBD respectively. Our findings are contradictory to the report of Krishnaiah et al. (2009) whose study observed absence of cardiac glycosides in Moringaoleifera. Differences in agronomical conditions of Moringa oleifera seeds in the current study and those in the cited literature could have contributed to variation in cardiac glycosides. The presence of cardiac glycosides in this study may have a beneficial effect on treating congestive heart failure and cardiac arrhythmia (Krishnaiah et al., 2009).

The anthroquinones and phlobatannins contents of the robo samples were below detectable levels. This is in tandem with the findings of Olufunmilayo et al. (2012), Ezeonu and Ejikeme (2016) and Chikezie (2017) whose studies showed the absence of anthraquinone and phlobatannins in Moringaoleifera and walnut seeds respectively. Contrarily, our findings are contradictory to the claim of Krishnaiah et al. (2009) and whose study observed presence of phlobatannins in moringa seeds.

Antioxidant properties of robo samples

The results for the antioxidant properties of robo from melon and moringa seeds are depicted in table 4.4. The reducing power (FRAP) of the robo samples differed significantly ($p < .05$) with values varying from 45.10 to 69.58 mmol/100g. The reducing power of the RBD (70% melon + 30% moringa seeds powder) was significantly ($p < .05$) the highest (69.58 mmol/100g) while robo from 100% melon had the least (45.10 mmol/100g) reducing power. Supplementation of the robo samples with moringa seeds powder significantly ($p < .05$) improved their respective reducing power (FRAP). The highest FRAP observed in RBD could be attributed to its significantly ($p < .05$) highest phenolic content. James et al. (2022) supported that the level of antioxidants or reducing power is closely related to the amount of phenolic compounds present in a substance.

Heavy metal properties of robo samples

Table 5 presents the results for the heavy metal properties of robo from melon and moringa seeds. Heavy metals influence the nutritive upsides of horticultural materials and furthermore meaningfully affect individuals. Controlling heavy metal concentrations in food should become an increasingly important aspect of food quality because national and international food quality regulations set the maximum levels of toxic metals that can be present in human food(Radwan and Salama, 2006; Sobukola et al., 2008).

Exposure to arsenic through work environments or diet has been associated with an increased incidence of cancer, leading to the classification of arsenic as a human carcinogen(Food Safety Authority of Ireland (FSAI), 2009). The arsenic content of the robo samples were of range (0.89 – 1.08 mg/100g); which is higher than 0.1 – 0.2 mg/kg reported for permissible level of arsenic in foods by Codex Alimentarius (2015). The highest arsenic (1.08 mg/100g) was observed in RBA (100% melon) while robo supplemented with 10% moringa seeds powder (RBB) had the least value (0.89 mg/100g). These values are within 0.23 – 1.25 mg/100g reported for arsenic content of kulikuli but higher than 0.018 – 0.069 mg/100g for robo from Abeokuta in Ogun state Nigeria by Lanre-Iyanda and Adekunle (2012). Idowu et al. (2012) reported 0.16 – 3.07 mg/kg for arsenic contents of aadun from selected states in Nigeria which are also within the values obtained in the current study. The consumption of seafood is more commonly linked to arsenic intake than drinking water, although arsenic may also be present in groundwater (WHO, 2000) and during food preparation, ground water used for washing can be a source of contamination and introduce arsenic into the food (Idowu et al., 2012).

Lead exposure has been linked to several adverse health effects, such as the development of renal tumors, impaired cognitive development, elevated blood pressure, and an increased risk of cardiovascular diseases in adults (Raman et al., 2004; Garcia-Rico et al., 2007). The mean results for the lead contents of the robo samples ranged between (0.66 – 0.90 mg/100g) with robo from 100% melon (RBA) having the highest lead (0.90 mg/100g) while the least value (0.66 mg/100g) was observed in RBD (70% melon + 30% moringa seeds powder). Supplementation of moringa seeds powder with melon for robo significantly ($p < 0.01$) resulted in reduction of their respective lead contents. Our findings conform to 0.01 – 3 mg/100g permissible for lead contents in foods (Commission Regulation, 2006, 2015). Children are more susceptible to the toxic effects of lead than adults because of the sensitivity of their internal organs and the greater ease with which lead can be absorbed by their bodies (Ekhator et al., 2017). However, the low lead contents of the robo samples in the current study indicate their suitability for consumption by children and adults. Our findings are in consonance with (0.04 – 1.54 mg/kg) and (0.16 – 1.23 mg/kg) reported for lead contents of plantain chips, potato chips, doughnut and biscuits by Dada et al. (2017).

Mercury's organic form is more toxic than its inorganic form because it can be easily absorbed through ingestion, and this can have harmful effects on fetal and children's development (Obeid et al., 2011). The mercury contents of the robo samples varied from 0.04 – 0.13 mg/100g with RBA (100% melon) significantly ($p < .05$) having the highest mercury content (0.13 mg/100g) while the least mercury content (0.04 mg/100g) was observed in robo with 30% moringa seeds powder (RBD). No significant differences ($p > .05$) were observed between the robo samples supplemented with moringa seeds powder; RBB, RBC and RBD respectively. The values reported in the current study are in line with the recommended tolerable level (0.5 – 1 mg/100g) for mercury in foods by Codex Alimentarius (2015). Adeyeye et al. (2020) reported 0.80 – 0.81 µg/kg for mercury contents of watermelon and egusi melon robo which are higher than the findings of the present study. Variation in values could be attributed to different natural causes including environmental contamination by industrial or other uses (Nwaoguikpe, 2011).

Cadmium does not have any known biological functions and can interfere with essential zinc-dependent functions, inhibiting enzyme reactions and nutrient utilization. It can also catalyze oxidation reactions, leading to free-radical tissue damage (World Health Organization (WHO), 1992). Divrikli et al. (2010) also contributed that cadmium is considered a non-essential element in food and natural water sources, and it has a tendency to accumulate in the kidneys and liver.The mean results for the cadmium contents of the robo samples ranged from 0.64 – 0.92 mg/100g with RBA (100% melon) having the highest cadmium content (0.92 mg/100g) while the least cadmium content (0.64 mg/100g) was observed in robo supplemented with 30% moringa seeds powder (RBD). There were significant differences at ($p < 0.01$) between the cadmium contents of the robo samples. Increase in moringa seeds powder supplementation to the robo samples resulted in reduction of their respective cadmium contents. Our results are in tandem with 0.90 – 1.00 mg/100g reported for robo from watermelon-egusi melon robo by Adeyeye et al. (2020) but higher than 0.018 – 0.069 mg/kg for kuli-kuli-robo by Lanre-Iyanda and Adekunle (2012).

The chromium contents of the robo samples varied between (0.01 – 0.09 mg/100g) with RBA (100% melon) having the highest chromium content (0.09 mg/100g) while the least value (0.01 mg/100g) was observed in robo from 100% melon (RBA). No significant differences ($p > .05$) were observed between moringa seeds supplemented robo samples; RBB, RBC and RBD respectively. These values conform to the safe limit of 0.2 mg/kg reported by Food and Agricultural Organization (FAO/WHO) (Ogunkunle et al., 2014). Our report is lower than (0.13 – 0.16 mg/100g) obtained for chromium contents of common fruits from selected markets in Lagos Nigeria by Rotimi et al. (2018) and 0.64 – 0.74 µg/kg or robo from watermelon-egusi melon robo by Adeyeye et al. (2020).

Sensory evaluation of robo samples

Table 6 presents the results for the sensory evaluation of robo samples. The mean score values for the taste of the robo samples ranged between (7.1 – 8.7) with whole melon robo (RBA) having the highest rating (8.7) while the least value (7.1) was observed in robo from RBD (70% melon + 30% moringa powder). The result showed significant ($p < .05$) reduction in taste of the robo samples.

In terms of colour, the results ranged from 7.6 to 8.2 with RBB (90% melon + 10% moringa powder) having the highest value (8.2) while RBD (70% melon + 30% moringa powder) had the least value (7.6). There were no significant differences ($p > .05$) between the colour of the robo samples.

For texture, the result ranged from 6.9 to 7.6. Robo from RBA (100% melon) had the highest rating (7.6) while RBD (70% melon + 30% moringa seeds powder) had the least value (6.9). No significant differences ($p > .05$) existed between the texture of the robo samples.

The mean score values for the aroma of the robo samples had no significant differences ($p > .05$) with values ranging between (7.4 – 8.2). Whole melon seed robo (RBA) had the highest value (8.2) while the least rating (7.4) was observed in RBC and RBD respectively.

According to Okwunodulu et al. (2018), appearance is regarded an imperative sensory attribute of any food product which resolves acceptability of food as consumers' first prediction of a food's level of satisfaction is determined through appearance. The mean results for the appearance of the robo samples indicated a range between (7.5 – 8.2) with RBA having the best rating (8.2) while the least value (7.5) was observed in RBC (80% melon + 20% moringa powder).

For overall acceptability of the robo samples, the results had a range between (7.5 – 8.3). Robo from RBA (100% melon) had the highest rating (8.3) while the least value (7.5) was observed in robo from RBB and RBC respectively.

IV. CONCLUSION

Robo enriched with melon and moringa seeds were produced in this study. The proximate composition result showed significant ($p < .05$) increase in ash, fibre and protein but significant reduction ($p < .05$) fat and carbohydrate contents of the robo in moringa seeds powder supplementation. The moisture contents are within recommendation (<13%); hence, would have long shelf stability. Inclusion of moringa seeds powder significantly ($p < .05$) improved the mineral contents of the robo samples which were attributed to the commendable inherent mineral contents of moringa seeds. Significant increase ($p < .05$) in phytochemicals of the robo owing to supplementation with moringa seeds powder were also reported. The level of antioxidant properties of the robo samples could be considered viable for ameliorating free radicals. However, the heavy metal properties of the robo samples significantly ($p < .05$) reduced with inclusion of moringa seeds powder. The sensory properties result revealed that whole melon robo had the best ratings for all sensory properties evaluated (taste, colour, texture, aroma, appearance and overall acceptability. However, other robo samples supplemented with moringa seeds powder had commendable ratings for all sensory properties; hence, an indication that acceptable robo could be produced from melon and moringa seeds powder. Overall, the study infer that enrichment of robo with moringa powder is capable of improving the nutritional properties and overall quality of the snack.

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Conflicts of Interest

The authors assert that they have no competing interests, and the study was not influenced by any funding sources in terms of design, data collection, analysis, interpretation, manuscript writing, or decision to publish.

Ethical Statements

REFERENCES

[1]. Adekanmi, A.A., Adekanmi, S.A., and Adekanmi, O.S., (2020). Qualitative and Quantitative Phytochemical Constituents of Moringa Leaf. International Journal of Engineering and Information Systems (IJEAIS), 4(5): 10 – 17

[2]. Adeyeye, E.I., (2002). Determination of Chemical Composition of the Nutrionally Valuable Parts of Male and Female Common West African Fresh Water Crab (Sudananoutesafricanus). Intl. Journal of Food Sciences and Nutrition, 53:189-196

[3]. Adeyeye, S.A.O., Bolaji Olushola T., Abegunde, T.A., Adebayo-Oyetoro, A.O., Tiamiyu, H.K., and Idowu-Adebayo, F., (2019). Evaluation of nutritional composition, physico-chemical and sensory properties of 'Robo' (a Nigerian traditional snack) produced from watermelon (Citrulluslanatus (Thunb.) seeds. Food Research, 19: 1-9

[4]. Adeyeye, S.A.O., Bolaji, O.T., Abegunde, T.A., Adebayo-Oyetoro, A.O., Tiamiyu, H.K., and Idowu-Adebayo, F., (2020). Evaluation of nutritional composition, physico-chemical and sensory properties of 'Robo' (a Nigerian traditional snack) produced from watermelon (Citrulluslanatus (Thunb.) seeds. Food Research, 4(1): 216-223

[5]. Akinyeye, A.J., Solanke E.O., and Adebiyi, I.O., (2014). Phytochemical and Antimicrobial Evaluation of Leaf and Seed of Moringaoleifera Extracts.International Journal of Research in Medical and Health Sciences, 4(6): 1-10

[6]. Akpakpan, E.I., Onyeike, E.N., and Ogunka-Nnoka, C.U., (2019). In vitro Antioxidant Potentials of Ethanol Extract of Unripe and Ripe Dennetiatripetala Fruits. Journal of Complementary and Alternative Medical Research, 7(2): 1-8

[7]. Anjorin, T.S., Ikokoh, P., and Okolo, S., (2010). Mineral composition of Moringa Oleifera leaves, pods and seeds from two regions in Abuja, Nigeria. International

Journal of Agriculture and Biology, 12: 431-434.

[8]. Anwar, F, Latif, S., Ashraf, M., and Gilani, A.H.,(2007). Moringaoleifera: A Food Plant with Multiple Medicinal Uses. Phytotherapy research, 21, 17 – 25

[9]. AOAC (2008) Official method of Analysis. 20th Edition, Association of Officiating Analytical Chemists, Washington, DC

[10]. AOAC (2010) Official method of Analysis. 20th Edition, Association of Officiating Analytical Chemists, Washington, DC

[11]. AOAC International. (2001). Official methods of analysis. 16th ed. Gaithersburg, MD: AOAC.

[12]. Arinanthan, V., Mohan, V.R., and Britto, A.J., (2003). Chemical composition of Certain Tribal Pulses in South India. Intl. Journal of Food Sciences and Nutrition, 3: 103-107

[13]. Ayodele, J.T., and Kigbu, P.E. (2005): Some antinutritional factors in Cajanus cajan, Sterculia setigeraand Vigna dekindtiana. Biological and Environmental Sciences Journal for the Tropics, 2(2):43- 45

[14]. Braide, W., Odiong I.J., and Oranusi, S., (2012). Phytochemical and Antibacterial properties of the seed of watermelon (Citrulluslanatus). Prime Journal of Microbiology Research, 2(3), 99-104

[15]. Chikezie, U.N., (2017). 'Phytochemical and proximate composition of Tetracarpidium conophorum (African Walnut) seeds', International Journal of Research Studies in Biosciences, 5(10), 25– 31

[16]. Codex Alimentarius, (2015). Codex general standard for contaminants and toxins in food and feed - CODEX STAN 193-1995. Joint FAO/WHO, 2015 p. 59. Available: 10.13140/RG.2.1.4910.2560

[17]. Commission Regulation (EC) No 1881/2006. Commission Regulation (EC) No 1881/2006 of 19 December 2006 setting maximum levels for certain contaminants in foodstuffs (OJ L364). EU, 2006. Available: https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX:02006R1881-20100701

[18]. Commission Regulation (EU) 2015/1006. Commission Regulation (EU) 2015/1006 of 25 June 2015 amending Regulation (EC) No 1881/2006 as regards maximum levels of inorganic arsenic in foodstuffs (OJ L161). EU, 2015 Jun. Report No.: OJ L161. Available: http://data.europa.eu/eli/reg/2015/1006/oj/eng

[19]. Dada, E.O., Ojo, O.N., Njoku, K.L., and Akinola, M.O., (2017). Assessing the Levels of Pb, Cd, Zn and Cu in Biscuits and Home-made Snacks obtained from Vendors in Two Tertiary Institutions in Lagos, Nigeria. Jasem, 21(30: 521 – 524

[20]. Ekhator, O. C., Udowelle, N. A., Igbiri, S., Asomugha, R. N., Igweze, Z. N., and Orisakwe, O. E. (2017). Safety Evaluation of Potential Toxic Metals Exposure from Street Foods Consumed in Mid-West Nigeria. Journal of Environmental and Public Health, 1–8

[21]. Elemo, B.O., Elemo, G.N., Agboola, O.O. and Oyedun, A.B. (2001): Studies on some anti-nutritive factors and in-vitro protein digestibility of Thaumatococcusdanielli (Benth) waste.Nigerian Journal of Biochemistry and Molecular Biology, 16:43-46.

[22]. Ezeonu, C.S., and Ejikeme, C.M., (2016). Qualitative and Quantitative Determination of Phytochemical Contents of Indigenous Nigerian Softwoods. New Journal of Science, 1 – 9

[23]. FSAI. (2009). Assessment of Mercury, Lead, Cadmium, Tin and Arsenic in Food. Toxicology, 1, 1–13

[24]. Garcia-Rico, L., Leyva-Perez, J., and JaraMarini, M. E. (2007). Content and Daily Intake of Copper, Zinc, Lead, Cadmium and Mercury from Dietary Supplements in Mexico. Food and Chemical Toxicology, 45, 1599–1605.

[25]. Hawkins, E.B., and Ehrlich, S.D., (2006). Gotu Kola. University of Maryland Medical Center. Baltimore. USA

[26]. Hough, G., Van Hout, D., and Kilcast, D., (2006). "Workshop summary: sensory shelf-life testing". Food Quality and Preference, 17(7–8), 640–650.

[27]. Ijarotimi, O.S., Adeoti, O. and Ariyo, O., (2013). Comparative study on nutrient composition, phytochemical, and functional characteristics of raw, germinated and fermented Moringa

Oleifera seed flour. Food SciNutr, 1 (6):452-463.
[28]. Ingale, S., and Shrivastava, S.K., (2011). Nutritional study of new variety of groundnut (ArachishypogaeaL.) JL-24 seeds, African Journal of Food Science, 5(8): 490-498
[29]. Irabor, G.E., Ebhoaye, J.E., and Odia, A., (2020). Qualitative and quantitative screening of some phytochemical compounds in watermelon (Citrulluslanatus) seeds cultivated in Esan West Local Government area of Edo state. International Journal of Engineering Applied Sciences and Technology, 5(1): 268 – 273
[30]. Iwu, I.C., Onu, I.U., Chijioke-Okere, M., Ukaoma, A.A., and Azorji, J.N.,(2016). GC-MS, Phytochemical and antimicrobial analysis of Pentaclethramacrophylla leaf. Int. J. Sci. Tech., 4 (7), 151-159.
[31]. Iwu,I.C., Onu, I.U., Chijioke-Okere, M., Ukaoma,A.A., and Azorji,J.N.,(2016). GC-MS, Phytochemical and antimicrobial analysis of Pentaclethramacrophylla leaf. Int. J. Sci. Tech., 4 (7), 151-159
[32]. James, S., Yakubu, C.M., Maxwell, Y.M.O., Audu, Y., Bankole, B.M., and Lawal, B.S., (2022). Effects of Processing Methods on Total Phenolic, Total Flavonoid and Antioxidant Capacities of Moringa Seeds. HSOA Journal of Food Science and Nutrition, 8, 138, 1 – 7
[33]. Jokic, S., Velic, D., Bilic, M., Bucic-Kojic, A., Planinic, M., Tomas, S., (2010).Czech J. Food Sci., 28, 206-212.
[34]. Kocherla, P., Aparna, K., and Lakshmi, D.N., (2012). Development and evaluation of RTE (Ready to Eat) extruded snack using egg albumin powder and cheese powder. Agric Eng Int: CIGR Journal. Vol. 14, No. 4
[35]. Krishnaiah, D., Devi, T., Bono, A., and Sarbatly, R., (2009). Studies on phytochemical constituents of six Malaysian medicinal plants. Journal of Medicinal Plants Research, 3(2): 067-072
[36]. Lanre-Iyanda, T.Y., and Adekunle, I.M., (2012). Assessment of heavy metals and their estimated daily intakes from two commonly consumed foods (kulikuli and robo) found in Nigeria. Ajfand, 12(3): 6157 – 6169
[37]. Lu, L., Liu, S., Jiang, S., and Wu, G. (2004). "Tannin Inhibit HIV-1 Entry by Targeting gp41", Journal of Acta-Pharmacology, 25: 8-213
[38]. Mahajan, R.T., and Badujar, S.B., (2008). "Phytochemical investigations of some laticiferous plants belonging to Khandesh region of Maharashtra" Ethnobotanical Leaflets. 12, 1145 – 1152
[39]. Makinde, F.M., and Ibim, S., (2015). Nutritional, physicchemical and sensory properties of Robo (a Nigerian traditional snack) made from Sesame (Sesamum indicum, Linn). Nigerian Food Journal, 33(2), 88 – 95
[40]. Naczk, M., and Shahidi, F. J., (2006).Pharm. Biomed.Anal., 2006, 41, 1523-1542.
[41]. Nobosse, P., Fombang, E.N., Mbofung, C.M.F., (2017). The Effect of Steam Blanching and Drying Method on Nutrients, Phytochemicals and Antioxidant Activity of Moringa (Moringaoleifera L.) Leaves. American Journal of Food Science and Technology, 5(2): 53 - 60
[42]. Nwaoguikpe, (2011). The Effect of Crude Oil Spill on the Ascorbic Acid Content of Some Selected Vegetable Species: Spinacea oleraceae, Solanummelongena and Talinumtriangulare in an Oil Polluted Soil, Pakistan Journal of Nutrition, 10(3): 274-281
[43]. Obeid, P. J., El-Khoury, B., Burger, J., Aouad, S., Younis, M., Aoun, A., and El-Nakat, J. H., (2011). Determination and Assessment of Total Mercury Levels in Local, Frozen and Canned Fish in Lebanon. Journal of Environmental Science, 23(9), 1564–1569.
[44]. Ocheme, O.B., Ariahu, C.C., and Igyor, M.O., (2011). Assesment of traditionally produced Dakuwa(A cereal/legume based Nigerian snack) in Niger state, Nigeria. Nigerian Food Journal, 29(1):63-69.
[45]. Ogunsina, B.S., Radha, C., and Sign, R.S.V., (2010). Physicochemical and functional properties of full-fat and defatted Moringa oleifera kernel flour. International Journal of Food Science and Technology, 45, 2433–2439
[46]. Olufunmilayo, E.A., Kolapo, A.L., and Folarin A.O., (2012). Moringaoleifera Lam. (Moringaceae) Grown in Nigeria: In vitro Antistickling Activity on

Deoxygenated Erythrocyte cells, Journal of Pharmacy and Bioalllied Sciences,4(2): 118-122

[47]. Olushola, A.T.E., (2006). The Miracle Tree, Moringaoleifera (Drumstick). In: Achieve Vibrant Health with Nature, Keep Hope Alive Series 1, Unijos Consultancy Limited.

[48]. Omokpariola, D.O., Precious-Egere, S.C., Omokpariola, P.L., and UchechukwuOkechukwu, V., (2021). Phytochemical and Anti-Microbial Analysis of Metabolites in seeds of Moringa oleifera grown in Nigeria. Progress in Chemical and Biochemical Research, 4(3), 268-277

[49]. Parekh, M., and Chanda, K., (2007). In Vitro antibacterial activity of crude methanol extracts of WoodfordiafruticosaKurz flower a(Lythaceae). Brazillian Journals of Microbiology, 38, 2 - 10

[50]. Radwan, M.A., and Salama, A.K., (2006). Market basket survey for some heavy metals in Egyptian fruits and vegetables. Food Chem. Toxicol., 44:1273–1278.

[51]. Raman, P., Patino, L. C., and Nair, M. G., (2004). Evaluation of Metal and Microbial Contamination in Botanical Supplements. Journal of Agricultural Food Chemist, 52, 7822– 7827

[52]. Rotimi, O.T., Ogunyebi, A.L., and Fingesi, T.S., (2018). Evaluation of Heavy Metals Level and Proximate Analysis of Common Fruits from Selected Markets in Lagos, Nigeria. J. Appl. Sci. Environ. Manage., 22(5): 791 – 795

[53]. Sadiq, I. S. Duruminiya, N. I. Balogun, J. B. kwada, D. and Izuagie, T., (2016). Nutritional and Anti-nutritional Value of Tamarind Fruit (Tamarindusindica). International Journal of Applied Research and Technology, 5(3): 50-56.

[54]. Sharma, K., and Chauhan, E.S., (2017). Nutritional and Phytochemical Evaluation of Fruit Pulp Powder of AegelMarmelos (Bael). Journal of Chemical and Pharmaceutical Sciences, 10 (2): 809-814.

[55]. Shina, S.I., Yakasai, S.M., Lawal, Z., Olarewaju, A.A., Enesi, S.L., and Ali, D.Z., (2021). Proximate Analysis and Phytochemical Screening of Watermelon (Citrulluslanatus) Pulp, Peels and Seeds. Dutse Journal of Pure and Applied Sciences (DUJOPAS), 7(4a): 174 – 182

[56]. Singleton, V.M.L., Orthofar, R., and Lamuela-Raventos, R.M., (1999). Analysis of total Phenols and other oxidation substrates and antioxidants by means of Folin ceocalteus reagent. Methods Enzymol., 299

[57]. Sixl-Daniell, K., Sixl,W., Sixl,G., and Fuchs,W.,(2011). The use of Moringaoleifera as a medicinal plant in India and the Philippines. Fitomedicina, 1-5.

[58]. Sobukola, O.P., Awonorin, S.O., Idowu, M.A.,and Bamiro, F.O., (2008). Chemical and physical hazard profile of 'robo' processing – a street vended melon snack. Inter. J. Food Sci. Technol.,43(2): 237-242.

[59]. Sofowara, A., (1993). Medicinal Plants and Traditional Medicine in Africa, Spectrum Books, Ibadan, Nigeria, 1993

[60]. Templeton, S.B., Marlette, M.A., and Panemangalore, M., (2005). Competitive foods increase the intake of energy and decrease the intake of certain nutrients by adolescents consuming school launch, Journal of the American Dietetic Association, 105(2): 215- 220.

[61]. Tiwari, P, Kumar, B, Kaur, M, Kaur, G, Kaur, M, Kaur, G. and Kaur, H., (2011). Phytochemical screening and extraction: A review. International Pharmaceutica Sciencia, 1(1): 98-106

[62]. Vasantrao, B.K., (2013). Determination of water soluble Ash values of some Medicinal Plants of Genus Sesbania

[63]. WHO (2000). World Health Organization Fact sheet No 237: Food Safety and Food borne illness – Revised September. WHO Headquarter Geneva Switzerland

[64]. WHO, (1992). World Health Organization. Cadmium Environmental Health Criteria, Vol. 134, Geneva 1992.

[65]. WHO/FAO (2004). Human vitamin and mineral requirements. Report of a joint FAO/WHO consultation, Bangkok, Thailand. Rome, Italy: Food and Agriculture Organization of the United Nations (FAO) and World.

[66]. Yusuf, C.S., (2019). Evaluation of Phytochemical, Mineral, and Nutrient Content of Ginger (Zingiberofficianale) in Mubi. Adamawa State University Journal of Scientific Research, 7(2): 41-47

[67]. Zanrate, H., Susana, M., Juarez, M.D. Rosario, C.G. Abel, O.L. Cesar, G.

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Table 1: Results for proximate composition of robo samples

Parameters (%)	RBA	RBB	RBC	RBD
Moisture	10.02±0.27[a]	10.09±0.35[a]	11.60±0.10[b]	11.18±0.28[b]
Ash	5.39±0.40[a]	6.88±0.02[b]	7.35±0.04[c]	7.88±0.05[d]
Fat	40.77±0.04[c]	37.35±0.33[a]	37.64±0.23[a]	40.05±0.42[b]
Fibre	6.95±0.08[a]	11.97±0.02[b]	13.87±0.02[c]	14.27±0.04[d]
Protein	10.82±0.02[a]	14.86±0.04[b]	15.29±0.02[c]	16.91±0.06[d]
Carbohydrate	22.61±0.67[b]	21.58±0.72[c]	14.15±0.78[a]	12.70±0.18[d]

Values are mean ± standard deviation. Data with different superscripts in the same row are significantly different at $p < .05$

Key:
RBA = 100% melon
RBB = 90% melon + 10% moringa powder
RBC = 80% melon + 20% moringa powder
RBD = 70% melon + 30% moringa powder

Table 2: Results for mineral composition of robo samples

Parameters (mg/100g)	RBA	RBB	RBC	RBD
Calcium	13.65±0.05[a]	14.96±0.05[b]	17.07±0.06[c]	17.55±0.05[d]
Magnesium	7.57±0.02[a]	8.53±0.03[b]	9.77±0.03[c]	10.29±0.03[d]
Potassium	266.35±0.16[a]	289.87±0.41[b]	315.19±0.63[c]	386.64±0.91[d]
Iron	0.29±0.01[a]	0.29±0.00[a]	0.39±0.01[b]	0.41±0.01[c]
Zinc	0.60±0.01[b]	0.67±0.03[c]	0.75±0.02[a]	1.01±0.01[d]
Phosphorus	0.95±0.01[a]	1.01±0.00[b]	1.47±0.01[c]	2.35±0.01[d]

Values are mean ± standard deviation. Data with different superscripts in the same row are significantly different at $p < .05$

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RBD = 70% melon + 30% moringa powder

Table 3: Results for phytochemical properties of robo samples

Parameters (mg/100g)	RBA	RBB	RBC	RBD
Tannin	1.18±0.01[a]	1.61±0.01[b]	1.98±0.03[c]	1.81±0.02[d]
Alkaloids	2.37±0.05[a]	2.44±0.06[a]	2.93±0.08[ab]	3.46±0.43[b]
Flavonoids	3.44±0.08[a]	4.51±0.13[b]	5.72±0.19[c]	7.36±0.42[d]
Phenols	2.86±0.06[a]	13.99±0.47[b]	14.95±0.71[bc]	16.85±1.13[c]
Steroids	1.09±0.08[a]	2.60±0.11[b]	3.04±0.11[b]	4.46±0.45[c]
Terpenoids	1.96±0.11[a]	2.73±0.17[b]	3.23±0.11[c]	4.25±0.07[d]
Cardiac glycosides	3.41±0.21[a]	9.19±0.65[b]	12.29±0.84[c]	13.94±0.82[c]

Anthroquinones	BDL	BDL	BDL	BDL
Phlobatannins	BDL	BDL	BDL	BDL

Values are mean ± standard deviation. Data with different superscripts in the same row are significantly different at p < .05; BDL = below detectable level

Key:
RBA = 100% melon
RBB = 90% melon + 10% moringa powder
RBC = 80% melon + 20% moringa powder
RBD = 70% melon + 30% moringa powder

Table 4: Results for antioxidant properties of robo samples

Parameters	RBA	RBB	RBC	RBD
FRAP	$45.10{\pm}0.79^{a}$	$64.01{\pm}0.72^{b}$	$66.18{\pm}0.74^{c}$	$69.58{\pm}0.11^{d}$
DPPH	$15.08{\pm}0.04^{a}$	$20.05{\pm}0.24^{b}$	$24.11{\pm}0.73^{c}$	$25.70{\pm}0.85^{d}$

Values are mean ± standard deviation. Data with different superscripts in the same row are significantly different at p < .05

Key:
RBA = 100% melon
RBB = 90% melon + 10% moringa seeds powder
RBC = 80% melon + 20% moringa seeds powder
RBD = 70% melon + 30% moringa seeds powder

Table 5: Results for heavy metal properties of robo

Components (mg/100g)	RBA	RBB	RBC	RBD
Arsenic	$1.08{\pm}0.06^{b}$	$0.89{\pm}0.04^{a}$	$0.94{\pm}0.03^{a}$	$0.97{\pm}0.01^{a}$
Lead	$0.90{\pm}0.02^{c}$	$0.85{\pm}0.04^{bc}$	$0.77{\pm}0.03^{b}$	$0.66{\pm}0.04^{a}$
Mercury	$0.13{\pm}0.01^{b}$	$0.06{\pm}0.01^{a}$	$0.05{\pm}0.00^{a}$	$0.04{\pm}0.00^{a}$
Cadmium	$0.92{\pm}0.11^{c}$	$0.90{\pm}0.02^{bc}$	$0.71{\pm}0.08^{ab}$	$0.64{\pm}0.06^{a}$
Chromium	$0.09{\pm}0.03^{b}$	$0.02{\pm}0.00^{a}$	$0.02{\pm}0.00^{a}$	$0.01{\pm}0.01^{a}$

Values are mean ± standard deviation. Data with different superscripts in the same row are significantly different at p < .05

Key:
RBA = 100% melon
RBB = 90% melon + 10% moringa seeds powder
RBC = 80% melon + 20% moringa seeds powder
RBD = 70% melon + 30% moringa seeds powder

Table 6: Results for sensory evaluation of robo

Parameters	RBA	RBB	RBC	RBD
Taste	$8.7{\pm}0.68^{b}$	$7.4{\pm}0.69^{a}$	$7.4{\pm}0.84^{a}$	$7.1{\pm}0.88^{a}$
Colour	$8.1{\pm}0.74^{a}$	$8.2{\pm}0.63^{a}$	$7.7{\pm}0.95^{a}$	$7.6{\pm}0.84^{a}$
Texture	$7.6{\pm}1.08^{a}$	$7.5{\pm}0.85^{a}$	$7.5{\pm}0.85^{a}$	$6.9{\pm}0.88^{a}$
Aroma	$8.2{\pm}1.03^{a}$	$7.5{\pm}0.97^{a}$	$7.4{\pm}1.17^{a}$	$7.4{\pm}1.27^{a}$
Appearance	$8.2{\pm}0.92^{a}$	$7.8{\pm}0.63^{a}$	$7.5{\pm}0.85^{a}$	$7.7{\pm}0.82^{a}$

Overall Acceptability	8.3±0.68[a]	7.5±0.85[a]	7.5±0.85[a]	7.7±0.91[a]

Values are mean ± standard deviation. Data with different superscripts in the same row are significantly different at $p < .05$

Key:
RBA = 100% melon
RBB = 90% melon + 10% moringa seeds powder
RBC = 80% melon + 20% moringa seeds powder
RBD = 70% melon + 30% moringa seeds powder