Original Research Article

Effect of watermelon rind (*Citrullus lanatus)* addition on the chemical and sensory quality of sorghum based *mumu*

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ABSTRACT

Aims: The aim was to evaluate the effect of watermelon rind addition on chemical and sensory properties of sorghum based *mumu*

Study design: The experimental design used was the complete randomized design (CRD) and the Data obtained was subjected to Analysis of Variance (ANOVA) followed by Tukey's Least Significant Difference(LSD) test to compare treatment means; differences was considered significant at 95% (P≤0.05) (SPSS Version 21 software)

Place and Duration of Study: Department of ~~chemistry~~Chemistry, Benue State University, Makurdi, Benue State, Nigeria, between June 2018 and March 2019.

Methodology: Sorghum-based *mumu* was prepared from composite flours of 85:15, 75:15, 70:15 and 65:15% roasted sorghum flour and roasted partially defatted groundnut flour respectively and included with 0, 10, 15 and 20% watermelon rind powder respectively which were known as sample A, B, C and D accordingly. Subsequently, proximate composition, selected minerals and vitamins were determined using standard methods. ~~The *mumu* samples were also subjected to S~~Sensory evaluation was also conducted.~~.~~

Results: The addition of watermelon rind powder to sorghum-based *mumu* ~~resulted~~ showed a significantly higher ~~to significant difference~~ (P < 0.05) on ~~in~~ the ~~proximate composition;~~ protein, ash and fibre. Their values ranged from ~~increased with values ranging from~~ 13.67 to 15.97%, 1.99 to 3.17% and 1.33 to 1.67% respectively, while moisture, crude fat and carbohydrate decrease with values ~~ranging~~ ranged from 12.35 to 10.70%, 2.07 to 1.94% and 68.59 to 66.55% respectively. The energy values ranged from 347 to 348.76Kcal/100g).~~There was significant increase in minerals:~~ The results obtained from different minerals tested ranged as follows for ~~p~~phosphorus (124.10 to 155.67mg/100g), for magnesium (1.36 to 2.90mg/100g), for calcium (12.28 to26.67mg/100g) and for potassium (59.29 to 72.79mg/100g).~~;~~ ~~as well as v~~Vitamins ranged from ~~:~~ A (14.93 to 15.25ug/100g), C (5.97 to 8.12mg/100g), B_1 (0.43 to 0.54mg/100g) and B_2 (0.01 to 0.13mg/100g). Sensory evaluation results showed that the acceptability of the samples decreased significantly (P < 0.05) with increased level of watermelon rind powder.

Conclusion: The sorghum -based *mumu* supplemented with watermelon powder at 10% and 15% should be adopted since their sensory scores were high and the nutrient content significantly increased.

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Keywords: mumu, sorghum, watermelon rind, quality

1. INTRODUCTION

Cereals are the most important staple food for many people of the developed and developing countries. Examples of cereals are wheat, rice, maize, sorghum, millet, rye, barley and oat [1]. Sorghum (*Sorghum bicolor L. Moench*) is the fifth most important cereals in the world agricultural economy after wheat, maize, rice and barley and second (after maize) in ~~Sub~~sub-Saharan Africa. In 2013, the global area cropped with sorghum was 42.3 million hectares and world production was 61.5million metric tons. The USA, Nigeria, Mexico, India and Ethiopia are the main producers. It grows well in harsh environment where other crops grow or yield poorly, usually without application of fertilizer and because it is consumed by disadvantage group, it is often regarded as coarse or 'poor people's crop [2].

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Mumu is a traditional cereal-based food product in Nigeria, particularly consumed by Tiv people of North-central Nigeria. The product is produced from maize, sorghum or millet and consumed by both adults and children. *Mumu* is in powdered form and can be reconstituted in cold water with sugar to taste. It can be eaten at any time of the day and served as energy giving food. ~~The class of people that consume *m*~~*Mumu* is ~~are~~ mostly consumed by low income groups that cannot afford animal protein, therefore there is need to enrich *mumu* with plant proteins [3].

Sorghum, one of the cereals for production of *mumu* is rich in carbohydrate but low in protein and other micronutrients [4]. Like other cereals, sorghum has poor protein quality because of its lack of essential amino acids such as lysine and tryptophan [5] compounding this problem, sorghum proteins have poor digestibility [6]. This properties result in severe malnutrition when sorghum is consumed as the primary protein source [7].

The traditional practice of adding oilseeds such as groundnut and sesame seed during the milling process to enhance *mumu* flavour provides room for improvement on its protein quality. Protein deficiency is still a major problem in Nigeria and in Africa particularly among the low income groups. In Nigeria, this problem has become prevalent due to the faltering economy, which has led to declining import of costly protein-rich foods. Local production of protein-rich foods has also been low, a condition worsened by the low purchasing power of the people. The need, therefore, to look inwards for inexpensive quality protein foods cannot be overemphasized [4].

Grain legumes flours have been used since ancient times in indigenous foods to substitute cereals, enhance the nutrient of various food products and counteract the effect of inherent nutritional inhibitors (example tannins) present in cereals like sorghum [8]. Groundnut also called p~~P~~eanut is a legume crop that belongs to the family of *Fabaceae*, genus *Arachis*, and botanically named as *Arachis hypogaea.* Peanuts are consumed in many forms such as boiled peanuts, peanut oil, peanut butter, roasted peanuts, and added peanut meal in snack food, energy bars and candies [9]. Groundnut contains high quality edible oil, easily digestible protein and carbohydrates. It is also a significant source of resveratrol, a chemical compound that is reported to have a number of beneficial health effects, such as anti-cancer, antiviral, neuro protective, anti-aging, anti-inflammatory and life prolonging effects [10].

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In many African countries often deaths are reported as due to malnutrition, and they could possibly be prevented by providing a protein rich diet [11]. Peanut and peanut added foods could provide such a nutritious diet. The world health organization recommends an "average requirement" of 0.66 g of protein per kg of ideal body weight, and a "safe level" of 0.86 g/kg of body weight. According to a study peanuts contain more plant protein than any other legumes or nuts which can help in preventing malnutrition [9][12}. Blending of sorghum with groundnut will result in *mumu* with high protein content but low in micronutrient content [3]. Therefore need arises to further research into enriching groundnut *mumu* in terms of its micronutrient content using locally available plant sources [13].

Food wastes or by-products are produced in large amount in the food industries annually around the world. About 38% of food wastes occur during food processing. Food wastes streams however present a

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promising source of functional compounds which may be utilized because of their favourable nutritional, nutraceuticals and rheological properties [14].

Watermelon (family *Cucurbitaceae* and species *Citrullus lanatus*) is a major fruit widely distributed in the tropics and sub tropic regions [5]. Watermelon ~~(*Citrullus lantus*)~~ rind is the greenish outer covering of the fleshy, succulent sweet pulp and is usually wasted after consumption of the pulp and it is a good source of vitamins such as vitamin (A, C, B_1, B_2 and B_3) and minerals such as ~~(~~phosphorous, calcium, sodium,iron and zinc~~)~~ [15]. Watermelon rind is also high in citrulline, an amino acid the body uses to make another amino acid, arginine (used in the urea cycle to remove ammonia Cal from the body) [16].
Thus blending sorghum/groundnut *Mumu* with watermelon rind powder could significantly improve the nutritional value of the product especially in terms of its micronutrients content thereby improving the nutritional status of the consumers.

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2. MATERIAL AND METHODS

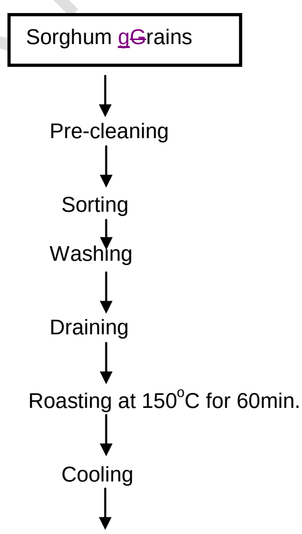
2.1 Sources of raw materials

Yellow sorghum (*Sorghum bicolor*) and g~~G~~roundnut (*Arachis hypogaea)* were purchased from Wurukum Market, Makurdi. Locally available fresh watermelon free from physical disorder was purchased from railway market Makurdi and the rinds were collected after the flesh has been separated.

2.2 Samples Preparation

2.2.1 Preparation of roasted sorghum flour

Roasted sorghum flour was prepared according to the method described by Ingbian and Adegoke [4] with slight modification, without fermentation of the grains as shown in Figure 1. Sorghum grains were sorted and winnowed to remove grain stalk, sticks and remaining husk. The grains were further subjected to visual screening to remove foreign particles such as stones. This was followed by washing with water to remove dust, soil particles and any over floats. Damaged, diseased or discolored grains as well as immature or sprouted grains were discarded. Cleaned sorghum grains were oven roasted at 150°C for 60min.The roasted grains were kept under silica gel to avoid moisture re-absorption until when required for milling and mixing for formulation of blends. A hammer mill was used to mill the roasted grains and a sieve of 0.5mm was attached to collect the milled product.



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Milling

↓

Sieving (using 0.5 sieve screen)

↓

Roasted Sorghum Flour

Fig. 1: Process Flow diagram for roasted sorghum flour preparation

Source:Modified from Ingbian and Adegoke [4].

2.2.2 Preparation of roasted partially defatted groundnut flour

Roasted defatted groundnut flour was prepared by the method described by Adjou *et al*., [17] with modification that the cake was milled into flour. The groundnuts were sorted to get rid of foreign matter, and roasted at 150^{o}C for about 6-8 minutes and then allowed to cool and the bran was removed and milled to obtain fine flour. To extract oil from groundnut flour, hot water extraction method was used. The flour was pressed in the mortal and pounded gently with addition of hot water till the oil was collected by pressing in muslin cloth. It was shaped and deep fried to form cake. The cake was cooled and milled into flour as shown in Figure 2.

2.2.3 Preparation of watermelon rind powder

Watermelon rind powder was prepared as describe by Lee-Hoon and Norhidayal, [18] Watermelon ~~(*Citrullus lanatus*)~~ rind was separated from washed fresh fruits manually with a sterile knife. The rind was cut into small pieces, sliced using the slicer before drying in a hot air oven at 50^{o}C for 24 h. The dried slices of watermelon rind were then ground in a laboratory mill and further sieved through a 0.5 sieve screen to fine powder and kept in an airtight plastic container and stored in a cool dry place prior to use as shown on Figure 3.

Groundnut g~~G~~rain

↓

Sorting

↓

Roasting for 6-8 minutes

↓

Cooling

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Removal of Bran

↓

Milling

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Addition of boiled water

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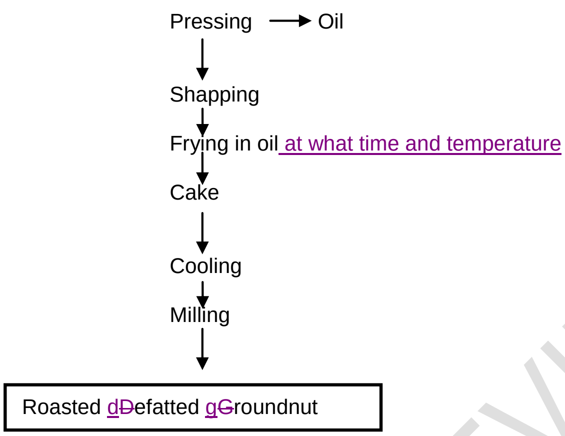
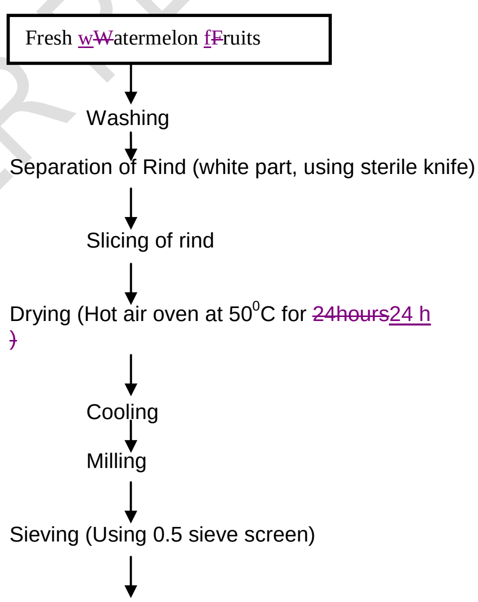


Fig. 2: Process flour diagram for roasted defatted groundnut flour

Source: Modified from Adjou et al., [17]



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Watermelon rRind pPowder

Fig. 3: Process flow diagram for watermelon rind powder.
Sources: Lee-Hoon and Norhidayah [18].

2.2.4 Formulation of blends

Four blends, A, B, C and D were formulated using different ratios according the method by Shar *et al*. [13] for soy-mumu formulation: Sample A was comprising 85% roasted sorghum flour, 15% roasted defatted groundnut flour and 0% watermelon rind powder which served as the control; sample B comprising 75% roasted sorghum flour, 15% roasted defatted groundnut flour and 10% watermelon rind powder; sample C comprising 70% roasted sorghum flour, 15% roasted defatted groundnut flour and 15% watermelon rind powder and sample D comprising 65% roasted sorghum flour, 15% roasted defatted groundnut flour and 20% watermelon rind powder as shown in Table 1.

Table 1: Formulation of blends from roasted sorghum flour, roasted defatted groundnut flour, and watermelon rind powder.

Sample	% Roasted sorghum flour	% Roasted groundnut flour	% Wwatermelon rind powder
A	85	15	0
B	75	15	10
C	70	15	15
D	65	15	20

Source

2.2.5 Preparation of *mumu* Product

The resulting *mumu* from four blends A, B, C and D were prepared by reconstitution of powdered form *mumu* in cold water with desired consistency and sugar added to taste

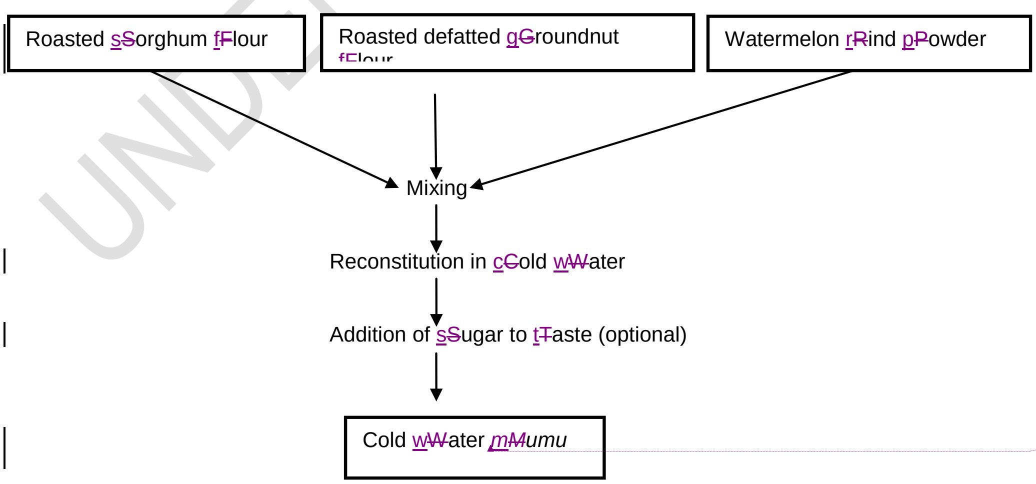

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Figure 4: Flow diagram for the production of cold water *mumu*.
Source: (Ingbian and Adegoke, [3]

2.3 Determination of the proximate composition of sorghum based *mumu* blends and ingrdients.

2.3.1 Moisture Determination

Moisture content was determined using the air oven dry method (19). A clean dish with a lid was dried in an oven (GENLAB, England B6S, serial no: 85K054) at 100°C for 30 min. It was cooled in desiccators and weighed. Two (2) grams of sample was then weighed into the dish. The dish with its content was then put in the oven at 105°C and dried to a fairly constant weight. The loss in weight from the original sample (before heating) was reported as percentage moisture.

$$\%\,Moisture = \frac{weight\ loss\ (W2 - W3)}{Weight\ of\ Sample\ (W2 - W1)}\ x\ 100\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (1)$$

Where: W_1 = weight of dish, W_2 = weight of dish + sample before drying, W_3 = weight of dish + sample after drying.

2.3.2 Crude Protein Determination

The Kjeldahl method as described by AOAC (19) was used to determine the percentage crude protein. Two (2) g~~rams~~ of sample was weighed into a Kjeldahl digestion flask using a digital weighing balance (3000 g x 0.01g 6.6LB). A catalyst mixture weighing 0.88g (96% anhydrous sodium sulphate, 3.5% copper sulphate and 0.5% selenium dioxide) was added. Concentrated sulphuric acid (7ml) was added and swirled to mix content. The Kjeldahl flask was heated gently in an inclined position in the fume chamber until no particles of the sample was adhered to the side of flask. The solution was heated more strongly to make the liquid boil with intermittent shaking of the flask until clear solution was obtained. The solution was allowed to cool and diluted to 25 ml with distilled water in a volumetric flask. Ten (10) ml of diluted digest was transferred into a steam distillation apparatus. The digest was made alkaline with 8ml of 40% NaOH. To the receiving flask, 5 ml of 2% boric acid solution was added and 3 drops of mixed indicator was dropped. The distillation apparatus was connected to the receiving flask with the delivery tube dipped into the 100ml conical flask and titrated with 0.01 HCl. A blank titration was done. The percentage nitrogen was calculated from the formula:

$$\%\,Nitrogen = \frac{(S-B)\times 0.0014\times 100\times D}{sample\ weight}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

Where, S = sample titre, B = Blank titre, S - B = Corrected titre, D = Diluted factor
% Crude Protein = % Nitrogenx 6.25 (correction factor).

2.3.3 Crude Fat Determination

Fat was determined using Soxhlet method as described by AOAC (19).Samples were weighed into a thimble and loose plug fat free cotton wool was fitted into the top of the thimble with its content inserted into the bottom extractor of the Soxhlet apparatus. Flat bottom flask (250ml) of known weight containing 150 – 200ml of 40 – 60°C hexane was fitted to the extractor. The apparatus was heated and fat extracted for 8h. The solvent was recovered and the flask (containing oil and solvent mixture) was transferred into a hot air oven (GENLAB, England B6S, serial no: 85K054) at 105^{o}C for 1 h to remove the residual moisture and to evaporate the solvent. It was later transferred into desiccator to cool for 15 min before weighing. Percentage fat content was calculated as:

$$\%\,Crude\ Fat = \frac{weight\ of\ extracted\ fat}{Weight\ of\ Sample}\ x\ 100\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (3)$$

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2.3.4 Crude Fibre Determination

The method described by AOAC (19) was used for fibre determination. Two (2) grams of the sample was extracted using Diethyl ether. This was digested and filtered through the california Buchner system. The resulting residue was dried at 130 ± 2^{o}C for 2 h, cooled in a dessicator and weighed. The residue was then transferred in to a muffle furnace (Shanghai box type resistance furnace, No.:SX2-4-10N) and ignited at 550^{o}C for 30 min, cooled and weighed. The percentagecrude fibre content was calculated as:

$$\%\ Crude\ fibre\ = \frac{Loss\ in\ weight\ after\ incineration}{Weight\ of\ original\ food} \times 100 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (4)$$

2.3.5 Ash Determination

The AOAC (19) method for determining ash content was used. Two (2) gram of sample was weighed into an ashing dish which had been pre-heated, cooled in a desiccator and weighed soon after reaching room temperature. The crucible and content was then heated in a muffle furnace at 550°C for 6-7 h. The dish was cooled in a desiccator and weighed soon after reaching room temperature. The total ash was calculated as percentage of the original sample weight.

$$\%\ Ash = \frac{(W3-W1)}{(W2-W1)}\ x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (5)$$

Where:
W1 = Weight of empty crucible,
W_2 = Weight of crucible + sample before ashing,
W_3 = Weight of crucible + content after ashing.

2.3.6 Carbohydrate Determination

Carbohydrate content was determined by difference according to Ihekoronye and Ngoddy (20) as follows:

$$\%\ Carbohydrate = 100 - (\%moisture + \%Protein + \%Fat + \%Ash\ +\ \%Fibre) \ldots\ldots 6$$

2.3.7 Determination of energy value

The energy value of the fruit bars were calculated using the protein, fat and carbohydrate contents according to the method described by AOAC (19)

2.3.8 Determination of mineral Content of sorghum based *mumu*

Mineral elements (phosphorus, magnesium, potassium and calcium) were determined using AOAC [19] method. Two grams (2g) of oven dry sample was weighed and placed in a crucible and mineralized at 600^{o}C for 3 hours. After cooling in the desiccators, the ashes were transferred into individual beakers and 20ml of concentrated HNO_3 was added in each case and was transferred by b10ml of H_2O_2. The mixture was heated to a temperature of 90^{o}C for one hour and after wards, cooled and filtered. The filtrate was transferred into 250ml volumetric flask and distilled water was added to fill the flask to the mark from this stock solution, 2ml were pipette into 50ml flask and was made up to the required volume with distilled water. Mineral content of the solution were determined by Atomic Absorption spectrophotometer (Perkin-Elmer 2380, USA, 1976) for the various element, from stock solution of 100ppm, working standard solution of the elements (BDH England) were prepared at 100ppm by dilution. The element included sodium, magnesium, lead, chromium, mercury, copper, and iron, from the prepared stock solution of 100ppm; standard solution at 0.5, 1.0, 1.5 and 2.0ppm were prepared for each element by dilution with distilled water. The absorbance of the sample solution obtained and their elemental concentration were calculated using the formulae

Calculation in ppm in test= A_{test} X Concentration standard/Astd …………… (7)

Where;

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A_{test} is the absorbance of the unknown element
Astd is the absorbance of the standard and concentration

3.3.9 Determination of vitamin content

Vitamin C and B (B_6, B_1) in the sample were determined using high performance liquid chromatography according to AOAC, [19] method. 3g of sample was mixed with 5 ml n-hexane and 20 ml grade water. The mixture was homogenized using an ultra turax macerator at 12,000 rpm and then centrifuged at 3500 rpm for 30 minutes. The aqueous phase was filtered through a whatman 42 filter paper and 0.45 membrane filters sequentially, then 15 ml of supernatant were injected into the HPLC system equipped with a UV-V detector which was set to 254 nm in absorbance mode. The vitamins standards were prepared in mobile phase. Peaks were verified by adding the standard vitamin to some samples and each peak areas were calculated in relation to the standard peak. The results were calculated on dry weight basis.

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2.3.10 Determination of β-carotene content

The β – carotene content of the samples was determined using the method [21]. The samples were weighed, W_1 and homogenized in methanol in the ratio of 1:10 (%) using a laboratory blender. The homogenate was filtered using a filter paper of measured weight, W_2 to obtain the initial crude extract, washed with 20 ml of distilled water in separating funnel. The other layer was recovered and evaporated to dryness at a low temperature (35 – 50°C) in vacuum desiccator. The dry extract was saponified with 20 ml of ethanoic potassium hydroxide and was left overnight in a dark cupboard. After a day, the β – carotene was taken up in 20 ml of ether and then washed with two portions of 20 ml distilled water. The β – carotene content extract (ether layer) was dried in a desiccator and treated with petroleum (petroleum spurt) and allowed to stand overnight in a freezer. The next day, the precipitated steroid was removed by centrifugation and β – carotene extract was evaporated to dryness in a desiccator and weighed, W_3. The weight of the β – carotene was
determined and expressed as a percentage of the sample weight.

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$$\%\beta - \text{Carotene content} = \frac{(W3-W1)}{(W2)}\ x\ 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Where W_1 = Weight of sample; W_2 = Weight of
empty filter paper and W_3 = Weight of filter paper + Weight of precipitate.

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2.3.11 Sensory Evaluation of the *mumu* Samples

Sensory evaluation of *mumu* product was carried out according to the method described by Ihekoronye and Ngoddy [20]

2.4 Statistical analysis

Data obtained was subjected to Analysis of Variance (ANOVA) followed by Tukey's Least Significant Difference(LSD) test to compare treatment means; differences was considered significant at 95% (P≤0.05) (SPSS Version 21 software).

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3. RESULTS AND DISCUSSION

3.1 Effect of watermelon rind addition on the proximate composition and energy value of sorghum based *mumu* and ingredients.

The proximate composition of the various ingredients used for *mumu* food formulations in this study is presented in Table 2. Roasted groundnut flour has the highest crude protein and crude fat content of

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18.60% and 5.30% respectively, Watermelon rind flour had the highest crude fiber and ash content of 12.01% and 6.40% respectively while sorghum had highest carbohydrate content of 74.79%. A blend of these ingredients was therefore expected to give *mumu* product of very balanced nutritional value, in terms of macro-and micro–nutrients.

The results of the effect of WRP addition on the proximate composition of sorghum based *mumu* product is as shown in Table 3. The moisture content of *mumu* samples decreased significantly (P<0.05) from sample A (12.35%) to D (10.70%) as level of watermelon powder increased. This result is in agreement with soy-mumu supplemented with moringa leaves powder reported by Shar *et al*, [13] where moisture decreased from 10.4 to 9.3%. This result could be due to low moisture content of the watermelon rind powder used in the blends as shown by Table 2. This is advantageous because reduction in moisture content will reduce the proliferation of spoilage microorganism especially mold, thus improving shelf stability of the product [22].

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The protein content of *mumu* samples increased significantly (P<0.05) with increased watermelon rind powder from sample A 13.67 to 15.97% (sample D). There was no significant difference between samples C (15.94%) and D (15.97%) but the increase in protein content of the *mumu* samples improved the nutritional quality of the blends. This result is similar to values (13.53-15.90%) for African yam bean, sorghum, maize and soybean breakfast meal [23] and values (9.79 to 15.35%) for wheat cookies supplemented with watermelon rind powder [24]. Higher protein content has been reported in maize/soybean/peanut food formulations fortified with *Moringa oleifera* leaf powder [25]. This result could be due to substitution effect as evidenced by the nutritional composition of the individual ingredients. This observation is not in doubt as watermelon rind powder has been reported to contain relatively good protein content [26][27]. Proteins are essential constituents of all body tissues, which help the body to produce new tissues. They are therefore extremely important during growth, pregnancy and when recovering from wounds [25]

The increase in the level of watermelon rind inclusion significantly (P<0.05) decreased the fat content from sample A 2.07 to 1.94% (sample D). The decreased in fat could be due to substitution effect, as a result of low fat content of watermelon rind powder as reported in Table 2. This is in agreement with the report [28] that watermelon rind has low fat content. This result is in agreement with studies by Okoye *et al*, [29] in which sorghum was fortified with African yam bean. The low fat content in the blends is beneficial as it ensures longer shelf life for the *mumu* product [30] because all fats and fat containing food contain some unsaturated fatty acids and are potentially susceptible to oxidative rancidity [31]. The low fat content of the developed products would also be suitable for weight watchers [32].

The ash content of the *mumu* blends significantly (P<0.05) increased as the level of watermelon rind powder addition increased. The values ranged from sample a1.99 to 3.17% (sample D). Similar trend was reported by Olaitan *et al* [24] in the studies of effect of watermelon rind addition on wheat cookies. The result also agrees with the observation by Al-sayed and Ahmed [168] whereby cake fortified with sharlyn melon peels and watermelon rinds powder led to significant increase in ash content from 1.7 to 2.04% for sharlyn melon peels and 1.78 to 2.11% for watermelon rind powder. This result is expected since watermelon rind contains good quantity of ash as reported in Table 2. This is also in agreement with reports by Glavins et al., [15] and Kutyauripo and Matenda [33] that watermelon rind contains high ash content. The high ash content of the samples is an indication that they are good sources of minerals [34]. The ash contents of the blends were within the recommended level of not more than 5% [35].

There was significant (P<0.05) increase in fibre content of the sorghum based *mumu* blends as watermelon rind powder increased. The values ranged from sample A 1.33 to 1.67%. According to Al-sayed and Ahmed, [26] watermelon rind powder has fibre content of 17.27% which is higher than orange peels (13.38%) and mandarin peels (7.14%) observed by (Magda *et al*., [36]. Significant increase in fibre content upon addition of watermelon rind powder to wet yellow noodles was recorded by Lee-Hoon and Norhidayal [18]. With the increase in fiber content in the composition, the blends can be considered as fibre enriched. Fibre is one of the essential components that are often used to develop enriched foods as a consequence of their demonstrated functionality which contributes to the great offer of competitive functional foods in the market [37]. Fibre is considered an efficient protective agent for a wide variety of

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illnesses, including cardiovascular disease, colon cancer and constipation [38] [39]. In order to increase the consumption of fibre, the American Dietetic Association (ADA) recommended the inclusion of a variety of grains, mushrooms, vegetables, and fruits for an active and healthy life [40].

There was significant (P<0.05) decrease in carbohydrate content of the *mumu* samples as level of watermelon rind powder addition increased. The values ranged from 68.59 to 66.55%. This result is in agreement with observed decrease in carbohydrate (69.96 to 55.07%) showing the watermelon rind flour has low carbohydrate content as recorded by Olaitan et al, [24]. Such decrease in carbohydrate with increased in kidney bean flour has been reported in kidney bean wheat composite flours [41] Lower carbohydrate content was also reported by Nnam, [42] where eight multi-mixes were formulated as complementary foods from processed soybeans, cowpeas, maize, sorghum, yams, cocoyam, plantain and sweet potatoes in the ratio of 65% cereal, 30% legume and 5% starch staple. A range of 41.13 to 73.79 g/100 g carbohydrate is recommended by Codex Alimentarius Standards [35].

The values obtained for the total energy content of *mumu* samples ranged from 347.40 to 348.76Kcal. Apart from the sample C containing 70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder formulation, all other samples were not significantly different (p<0.05) and the values were found to be within the range recorded for breakfast cereals made from treated and untreated sorghum and pigeon pea (316.46-420kcal) [43]. These values represent the amount of energy in food that can be supplied to the body for maintenance of basic body functions such as breathing, circulation of blood, physical activities and thermic effect of food [32]

Table 2: Proximate composition of sorghum, groundnut and watermelon rind powder

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Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscript in a Column are significantly different (P<0.05).
Key: A = (85% Roasted sorghum, 15% roasted defatted groundnut), B = (75% Roasted sorghum, 15% Roasted defatted groundnut, 10% Watermelon rind powder),C = (70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder),D= (65% Roasted sorghum, 15% roasted defatted groundnut, 20% Watermelon rind powder)RFL=Roasted Sorghum Flour, RGF=Roasted Groundnut Flour, WRP =Watermelon Rind Powder
LSD = Least Significant Different

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Table 3: Effect of WRP addition on the proximate composition and energy value of sorghum based *mumu*

Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscript in a

Sample	Moisture Content (%)	Crude Protein (%)	Crude fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)
RSF	12.11^{b}±0.00	8.10^{c}±0.11	1.50^{b}±0.10	1.50^{c}±0.00	2.01^{b}±0.10	74.79^{a}±0.00
RGF	12.00^{a}±0.00	19.60^{a}±0.02	5.30^{a}±0.53	2.81^{b}±0.01	1.50^{c}±0.10	58.79^{c}±0.05
WRP	8.20^{c}±0.01	9.69^{b}±0.02	1.01^{c}±0.12	6.40^{a}±0.10	12.01^{a}±0.01	63.69^{b}±0.02
LSD	0.13	0.12	0.16	0.16	0.11	0.62

Column are significantly different (P<0.05). Key: A = (85% Roasted sorghum, 15% roasted defatted groundnut), B = (75% Roasted sorghum, 15% Roasted defatted groundnut, 10% Watermelon rind powder), C = (70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder), D= (65% Roasted sorghum, 15% roasted defatted groundnut, 20% Watermelon rind powder).LSD = Least Significant Different, NS=No significant difference

Table 4: Effect of WRP addition on the some mineral content (Mg/100g) of sorghum based *mumu*

Samples	Phosphorus	Magnesium	Calcium	Potassium
A	124.10^{d}±0.02	1.36^{d}±0.02	12.28^{d}±0.05	59.29^{d}±0.06
B	133.72^{c}±0.01	1.99^{c}±0.00	19.32^{c}±0.21	59.61^{c}±0.33
C	139.90^{b}±0.01	2.09^{b}±0.01	23.47^{b}±1.05	68.45^{b}±0.45
D	155.67^{a}±0.01	2.90^{a}±0.01	26.67^{a}±031	72.79^{a}±0.45
LSD	1.156	0.020	0.455	0.675
US RDA	0.5-4.5	280-350	1000	3.5

Sample	Moisture content (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Fibre (%)	Carbohydrates (%)	Energy (Kcal/100g)
A	12.35^{a}±0.01	13.67^{d}±0.06	2.07^{a}±0.02	1.99^{d}±0.00	1.33^{d}±0.01	68.59^{a}±0.00	347.67^{b}±0.02
B	12.04^{b}±0.01	15.10^{c}±0.02	2.06^{ab}±0.03	2.16^{c}±0.01	1.56^{c}±0.01	67.08^{b}±0.05	347.40^{b}±0.26
C	11.10^{c}±0.01	15.94^{b}±0.02	2.04^{c}±0.01	2.66^{b}±0.02	1.60^{b}±0.01	66.66^{cd}±0.02	348.76^{a}±0.03
D	10.70^{d}±0.28	15.97^{a}±0.00	1.94^{d}±0.02	3.07^{a}±0.01	1.67^{a}±0.01	66.55^{d}±0.26	347.54^{b}±0.14
LSD	0.259	0.059	0.015	0.022	0.017	0.245	0.273

Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscript in a Column are significantly different (P<0.05).
Key: A = (85% Roasted sorghum, 15% roasted defatted groundnut), B = (75% Roasted sorghum, 15% Roasted defatted groundnut, 10% Watermelon rind powder), C = (70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder), D= (65% Roasted sorghum, 15% roasted defatted groundnut, 20% Watermelon rind powder) LSD = Least Significant Different, NS=No significant different, US RDA= United States recommended daily allowance.

3.2 Effect of WRP addition on some mineral content (Mg/100g) of sorghum based *mumu*

Table 4 shows the effect of WRP addition on the mineral content of sorghum based *mumu.* There was significant (p<0.05) increased in phosphorus content of the *mumu* samples as level of watermelon addition increased. The values ranged from 124.10 to 155.67 mg/100g. Higher values (148-219 mg/100 g) were recorded for malted cereals, soybean and groundnut composite flours [44] as well as values (175.40 mg/g to 341.50 mg/g) were received for wheat/watermelon rind cookies [24]. Phosphorus, like calcium serve as a structural component of bones and teeth and it is concerned with the release and transfer of energy inside the cells [45].

The magnesium content of the *mumu* product increased significantly (p<0.05) with increased inclusion of watermelon rind powder. The Magnesium content obtained for the sample ranged from 1.36 mg/100 g to

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2.90 mg/100 g. The highest value was recorded for the sample D. These values were lower than the US RDA which was 350 mg for men and 280 mg for women. Magnesium is an activator of many enzyme systems and maintains the electrical potential in the nerves [46]. It works with calcium to assist in muscle contraction, blood clotting, and the regulation of blood pressure and lung functions [47].

There was significant ($p<0.05$) increased in calcium content of *mumu* samples as level of watermelon inclusion increased. The calcium content obtained from the samples ranged between 12.28mg/100g and 26.67 mg/100 g. The highest value occurred in the sample D containing 65% roasted sorghum, 15% roasted defatted groundnut, 20% watermelon rind powder. These values were lower than that recorded for wheat/watermelon rind cookies (42.63mg/g to 172.70 mg/g) [24] and less than the US RDA (1000mg). Higher values (156±13.2 mg/kg) were also recorded for breakfast cereals made from maize, sorghum, soybeans and AYB composite flour [48] and breakfast cereals made from sorghum and pigeon pea (137.05-156.34 mg) [43]. Calcium is by far the most important mineral that the body requires and its deficiency is more prevalent than any other mineral [49] Calcium, phosphorus and vitamin D combine together to eliminate rickets in children and *osteomalacia* (the adult rickets) as well as osteoporosis (bone thinning) among older people [46]. Since the products contain significant amounts of the element they can make an ideal meal for children and adults alike.

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There was significant ($p<0.05$) increased in potassium content of *mumu* samples as level of watermelon inclusion increased**.** The potassium content of the *mumu* product ranged from 59.29 to 72.79mg/100g. The highest value occurred in the sample D formulation. This range was lower than the value (88.0±0.02 to 191.0±0.02 mg/100g) recorded for the breakfast cereals food [32] but higher than the US RDA for both men and women (3.5 mg). Higher values (312.25 to 399.9 mg/100 g) were recorded for weaning food from quality protein maize, soybean and cashew nut flour [50] while values (107.0-238.0 mg/100 g) were recorded from breakfast cereals made from sorghum and pigeon pea [43]. Potassium is required for proper functioning of cells, tissue and organs in the body. It is also crucial to heart functioning and plays a key role in skeletal and smooth muscle contraction making it important for normal digestive and muscular function [51]

Table 5: Effect of WRP addition on the vitamin Content (Mg/100g) of sorghum based *mumu*

Samples	**Vitamin A (Beta carotene equiv. µg/100 g)**	**Vitamin C**	**Vitamin B_1**	**Vitamin B_2**
A	N.D	N.D	$0.43^{d}\pm0.00$	$0.01^{d}\pm0.00$
B	$14.93^{c}\pm0.06$	$5.97^{c}\pm0.01$	$0.49^{c}\pm0.00$	$0.07^{c}\pm0.01$
C	$14.99^{b}\pm0.01$	$6.99^{b}\pm0.01$	$0.51^{b}\pm0.00$	$0.08^{b}\pm0.01$
D	$15.25^{a}\pm0.06$	$8.12^{a}\pm0.01$	$0.54^{a}\pm0.00$	$0.13^{a}\pm0.00$
LSD	0.093	0.245	0.002	0.013
US RDA	900-700	30-60.00	1.50	1.70

Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscript in a Column are significantly different (P<0.05).

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Key: A = (85% Roasted sorghum, 15% roasted defatted groundnut), B = (75% Roasted sorghum, 15% Roasted defatted groundnut, 10% Watermelon rind powder), C = (70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder), D= (65% Roasted sorghum, 15% roasted defatted groundnut, 20% Watermelon rind powder) LSD = Least Significant Different, NS=No significant difference. US RDA= United States recommended daily allowance.

3.3 Effect of WRP addition on the vitamin content (Mg/100g) of sorghum based *mumu*

Table 5 shows the effect of WRP addition on the vitamin content of sorghum based *mumu* product. There was significant ($p<0.05$) increase in vitamins A as level of watermelon rind powder addition increased. The values ranged from 14.93 g to 15.25 u/g of *mumu* blends. Sample A which is the control does not contain vitamin A and this is expected since Cordain, [52] reported that cereals contain no vitamin C or vitamin B12, no vitamin A and, apart from yellow corn, no beta-carotene. Similar trend was recorded when soy-*mumu* was supplemented with moringa leaves flour [13]. Vitamin A is an essential nutrient required for maintaining immune function, playing an important role in the regulation of cell-mediated immunity and in hormonal antibody responses. It helps in the maintenance of healthy teeth, skeletal, soft tissue, mucos-membranes, skin and is also known as retinol because it produces the pigment in the retina of the eye [53]

There was significant ($p<0.05$) increased in vitamin C as level of watermelon rind powder addition increased. The results obtained for vitamin C content of the formulated samples ranged from 5. 97 to 8.12 mg/100 g. These values are lower than the US RDA for men, women and children (30-60 mg/100 g), but it was discovered that the control sample does not contain vitamin C. Cordain [52] reported that cereals contain no vitamin C or vitamin B_{12}, no vitamin A and, apart from yellow corn, no beta-carotene. Vitamin C is a water-soluble vitamin that is necessary for normal growth and development. It is an antioxidant that helps maintain the connective tissue protein collagen, protects against infection, and helps iron absorption [54].

There was significant ($p<0.05$) increased in vitamin B1 content of the *mumu* samples as level of watermelon rind powder increased. The values obtained for the thiamin content of the products ranged from 0.43 to 0.54 mg/100 g. These result was higher than values (0.09 to 0.31 mg/100 g) observed for breakfast cereals [228] but less the US RDA (1.5 mg/100 g). Thus 100g of the formulated samples can provide 28.67-36% of vitamin B_1 of the US RDA for adults. Vitamin B_1 is cofactor during metabolic processes and contributes to the structure and function of cellular membranes, including neurons and neuroglia [55]

There was significant ($p<0.05$) increased in vitamin B_2 content of the *mumu* samples as level of watermelon rind powder increase. The values for the vitamin B2 content of the products ranged from 0.01 to 0.13 mg/100 g and were lower than the recorded values for the US RDA (1.70 mg/100 g). Higher values (0.17 mg/g to 0.21mg/g) were observed for wheat/watermelon rind powder cookies [24]. The two flavoprotein coenzymes derived from riboflavin, FMN and FAD are crucial rate limiting factors in most cellular enzymatic processes [55]

Table 6: Effect of WRP addition on the sensory score of sorghum based *mumu*

Samples	Mouth feel	Aroma	Appearance	Texture	Overall acceptability
A	8.85^{a}	7.48^{a}	8.00^{a}	7.55^{a}	8.05^{a}
B	7.25^{b}	6.05^{b}	6.40^{b}	6.00^{b}	7.33^{b}
C	6.40^{c}	5.30^{c}	5.50^{c}	5.40^{c}	6.50^{c}
D	5.65^{d}	5.20^{c}	4.10^{d}	5.35^{cd}	5.40^{cd}
LSD	0.456	0.344	0.617	1.06	0.663

Values are shown as mean ± standard deviation of replicates. Mean values followed by different superscript in a Column are significantly different ($P<0.05$).
Key: A = (85% Roasted sorghum, 15% roasted defatted groundnut),
B = (75% Roasted sorghum, 15% Roasted defatted groundnut, 10% Watermelon rind powder),
C = (70% Roasted sorghum, 15% Roasted defatted groundnut, 15% Watermelon rind powder),
D= (65% Roasted sorghum, 15% roasted defatted groundnut, 20% Watermelon rind powder)
LSD = Least Significant Different, NS=No significant different

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3.4 Effect of WRP addition on the sensory score of sorghum based *mumu*

Table 6 shows the sensory characteristics; mouth feel, aroma, appearance, texture and overall acceptability. For mouth feel sample A (control) received the highest score of 9 corresponding to like-extremely while sample D with 20 percent water melon rind powder had a score of 5 corresponding to neither like nor dislike.

For aroma, appearance and texture, sample A (control) received scores of 7, 8 and 8 respectively for each. This corresponds moderately like, very much like and very much like respectively while sample D with 20 percent watermelon rind powder received scores of 5 for aroma and texture corresponding to neither like or dislike and score of 4 for appearance corresponding to dislike slightly. However, there was no significant difference ($P<0.05$) between sample C and sample D with 10 and 15 percent watermelon rind powder respectively in terms of aroma and texture.

For overall acceptability, there were significant differences ($P < 0.05$) among all the four samples, with the control sample without watermelon rind powder having the highest score of 8 that corresponds to like very much, followed by sample B (having 10% watermelon rind powder) with score of 7 which corresponds to like moderately and sample D with 20% watermelon rind powder had the least score of 5 corresponding to slightly dislike.
The decrease in likeness for appearance as the percentage of watermelon rind powder increased could be ascribed to the green appearance of the *mumu* products imparted by the chlorophyll content of the rind while that of aroma could be attributed to the characteristic unappealing aroma of watermelon rind powder.

4. CONCLUSION

This study has shown that watermelon rind which is usually a waste can be utilized as functional food ingredients. There was significant increase in protein, fibre, ash and decrease in fat and carbohydrate content of *mumu* product and a high caloric energy value were observed. There was significant increase in the minerals (Phosphorus, Magnesium, Calcium, and Potassium) and vitamins (A, C, B_1 and B_2) contents of the Sorghum based *mumu* with increased level of watermelon rind powder addition. The overall acceptability of all the products was high, with all the products having scores up to 5 which is the minimum acceptable value on a nine point hedonic scale. The sorghum based *mumu* incorporated with watermelon powder at 10% and 15% should be adopted since their sensory scores were higher and the nutrient content significantly increased. Finally, there is also need for a study on pasting, functional properties, microbiological quality and shelf stability of the *mumu* product and the best packaging material that may contribute to its stability.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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