



# **Quality Assessment and Food Potentials of Flour Obtained From Sprouted and Non-Sprouted Watermelon Seeds (*Citrulus lanatus*) and Its Akara Making Potentials**

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## **Authors' contributions**

*This work was carried out in collaboration among all authors. Author OPO designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SSS and WAO managed the analyses of the study. Author AS managed the literature searches. All authors read and approved the final manuscript.*

## **Article Information**

DOI: 10.9734/EJNFS/2021/v13i230382

Editor(s):

(1) Dr. Michael Lokuruka, Karatina University, Kenya.

Reviewers:

(1) Julia Pertiwi, Veteran Bangun Nusantara University, Indonesia.

(2) Indah Epriliati, Widya Mandala Surabaya Catholic University, Indonesia.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/66733>

**Original Research Article**

**Received 15 January 2021**

**Accepted 20 March 2021**

**Published 20 April 2021**

## **ABSTRACT**

This study formulated different flours from sprouted water melon seed and evaluated the proximate and sensory properties akara-analogue potential in Nigeria. The results showed that proximate composition: moisture (7.06-8.46%), protein (19.14%-37.24%), fibre (0.23-0.36%), fat (22.77-26.58%), ash (2.44-3.47%) and carbohydrate (30.58-41.91%) were significantly different at  $p < 0.05$ . The bulk density ranged from 0.51-0.53g/ml, solubility index (40.30-40.01%), water absorption capacity (1.21-1.25%), swelling capacity (5.32-6.67%), pH (6.13-6.14); for sprouted and non-

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sprouted samples. Tannins, saponin, sterols, oxalate and phytate were detected in sprouted and unsprouted flour. Sprouting enhanced the amino acid content of composite flour. Mineral contents of Ca, P, K, Mg, Na, Cu, Zn and Mn were increased due to sprouting. The sensory analysis showed that the control samples have the highest taste score (7.35) and aroma (7.60) and were significantly different at  $p < 0.05$ . Enhanced amino acid composition of watermelon may enhance the use of this flour as protein supplement for the development of new food product.

**Keywords:** Food value; watermelon seeds; anti-nutritional; akara-analogue; protein; fatty acid.

## 1. INTRODUCTION

Food and nutrition security in developing nations of the world can be achieved by exploiting and utilizing all the available food sources and resources. Also, plant foods these nations have now become the main resource of diet used to meet individuals' nutritional conditions or necessity because they are very cheap and readily available. Several of these plant foods are known to possess fruits whose seeds are not consumed and have become a general problem in food processing due to waste generated [1]. These waste materials generated have been reported to bring about ecological problems such as proliferation of insects, rodents and have become economic burden. Hence, methods of beneficial application of these food materials are required for further studies [2]. During the processing of these fruits, the edible parts of several fruits are processed into ready to eat food dishes in which the seeds are usually thrown away as a waste product [3].

Watermelon (*Citrullus lanatus*) is a fruit that is widely eaten as snack without due regards to the seeds and are discarded either as feeds for animal or thrown away. Hence, there is a need to explore potential of the seeds by evaluating the chemical quality and nutritional profile of the flour that will be obtained from the seed [4]. Although, animal proteins have been reported to provide the body with required growth and maintenance but most households cannot afford animal protein due to their high cost. Hence, there is the need to conduct a research study on some of these under-utilized protein-rich oil-seeds such as watermelon seed as an alternative source of good quality protein for tackling the menace of food/nutrition insecurity which is fast becoming a world-wide economic problem in developing countries. Moreover, there is scanty research information on the effect of sprouting on the chemical quality of watermelon seed which may be used to effectively maximize the seed as a functional food ingredient in the formulation of new food products. Currently, there is scanty

information on functional properties of both sprouted and unsprouted watermelon seed flours which can be used to determine the level of the flour utilization in the formulation new food product. Therefore, the focus of this study was to investigate the chemical, functional, anti-nutritional and sensory properties of akara-analogue produced from sprouted and non-sprouted water melon seeds grown in Nigeria. It is anticipated that results obtained from this study will be used as the basis for stimulating extensive research into process optimization of watermelon seed sprouting which will consequently encourage production, utilization and consumption of the sprouted seed flour.

## 2. MATERIALS AND METHODS

### 2.1 Materials

Fresh watermelon fruits were obtained from Ketu market in Lagos, Nigeria, and were transported to the Food Processing laboratory of Food Technology Department, Yaba College of Technology.

### 2.2 Production of Sprouted and Unsprouted Watermelon Flour

The flesh was cut opened with a clean stainless steel knife to collect the seeds. The seeds obtained from the watermelon fruits were washed severally with distilled water to remove the juice, pulp and rind and was then sprouted by spreading on a muslin cloth at 40% humidity. Every 12 h, the seeds was washed thoroughly in running tap water using a sieve. Sprouting was observed for 3days by the modified method of Balogun and Olatidoye, (2011). The sprouted watermelon seeds was washed, drained and dried in a cabinet dryer at temperature of  $55 \pm 2^\circ\text{C}$  for 10 h. The dried seeds were milled using hammer mill and sieved through 60  $\mu\text{m}$  mesh sieve. The watermelon seeds flour was then sealed in a cellophane bag and stored at room temperature of  $25 \pm 2^\circ\text{C}$ ) for further analysis.

## 2.3 Proximate Analysis

Proximate composition of sprouted and unsprouted watermelon seeds flour samples was determined using the standard method described in the [5]. The sample flours were evaluated for moisture, fiber, ash, protein and fat while Carbohydrate was calculated by difference.

### 2.3.1 Determination of moisture content (%)

Moisture content of the flour samples was determined by oven drying described by the method of AOAC [5]. About 5 g of each flour sample was weighed in petri dishes of a known weight which was then dried in the oven at  $105 \pm 1^\circ\text{C}$  for 4 h. The samples were placed in a desiccator to cool and weighed. The moisture content was then calculated by using the equation given below.

$$\text{Percentage moisture content} = \frac{\text{change in weight}}{\text{weight of food sample before drying}} \times 100$$

### 2.3.2 Determination of ash content (%)

The ash content of the flour sample was determined by the method described by AOAC [5]. About 2 g of samples were weighed into clean already weighed crucibles and placed in a muffle furnace (Carbolite, ELF11/14B, S336RB) England and the content was then incinerated at  $600^\circ\text{C}$  for 3 h. The ash content was then calculated by using the equation given below.

$$\text{Ash content} = \frac{\text{weight of Ash}}{\text{Weight of sample}} \times 100$$

### 2.3.3 Determination of fat content (%)

Fat content of flour sample was determined by using Soxhlet apparatus (Thermo scientific EME3100/CEB, UK) as described by AOAC [5]. About 2 g of each flour sample was weighed and then wrapped in filter paper. It was then placed in a clean, dried and weighed fat extraction thimble. The content was then filled with 25 mL of N-hexane and fitted into the round bottom flask. After extraction, the solvent was evaporated at  $105^\circ\text{C}$  for 2 h, cooled in a desiccator and weighed for fat content. The fat content was then evaluated using the equation given below.

$$\text{Fat content(\%)} = \frac{\text{Weight of fat extracted}}{\text{Weight of food sample}} \times 100$$

### 2.3.4 Determination of crude fiber content (%)

The method described by AOAC [5] was used to evaluate fiber content. About 5 g of each flour sample was weighed into a flask and 100 mL digestion reagent (Trichloroacetic acid) was added and then boiled for 40 min and refluxed. The content was then cooled and filtered through a 15.0cm Whatman paper. The residue was washed with hot water, dried at  $105^\circ\text{C}$  and was then transferred to a desiccator and weighed ( $W_1$ ). It was then incinerated in a muffle furnace at  $500^\circ\text{C}$  for 6 h, cooled and reweighed ( $W_2$ ). The crude fiber is calculated from the equation below.

$$\% \text{ Crude fibre} = \frac{W_1 - W_2}{W_0} \times 100$$

Where;  $W_0$  = Sample weight of dry food sample,  
 $W_1$  = Weight of crucible + ash  
 $W_2$  = Weight of crucible + fiber+ ash

### 2.3.5 Determination of crude protein (%)

Protein in the sample was determined by Kjeldahl method. The samples were digested by heating with concentrated sulphuric acid ( $\text{H}_2\text{SO}_4$ ) in the presence of digestion mixture. The mixture was then made alkaline. Ammonium sulphate thus formed, released ammonia which was collected in 2% boric acid solution and titrated against standard HCl. Total protein was calculated by multiplying the amount of nitrogen with appropriate factor (6.25) and the amount of protein was calculated.

$$\% \text{ crude protein} = 6.25 \times \% \text{ N}$$

$$\% \text{ N} = \frac{(\text{Sample titre value} - \text{Blank titre value})\text{N} \times \text{Dilution factor}}{\text{weight of sample}}$$

## 2.4 Determination of Functional Properties of the Flour

### 2.4.1 Determination of swelling power and solubility index

Swelling capacity and solubility index of the starch were estimated as described by Aina et al. [6]. Starch-water slurry produced by dispersing about 5g of starch in 178 ml of distilled water and the content was then heated in a water bath at  $60^\circ\text{C}$  for 30 min, with constant stirring. The slurry was centrifuged at 3,000 rpm for 15 min and the supernatant was decanted into a weighed evaporating dish and dried at  $100^\circ\text{C}$  to constant weight. The difference in weight of the evaporating dish was used to

calculate the water solubility. Swelling power was obtained by weighing the residue after centrifugation and dividing by original weight of the starch on dry weight basis.

#### 2.4.2 Determination of water absorption capacity

Water absorption capacity of the watermelon sample was determined according to the method of AOAC [5]. About 2 g of flour sample was dispersed in a 20 ml distilled water and the content was allowed to stand at room temperature ( $30 \pm 2^\circ\text{C}$ ) for 30 min, this is then followed by centrifugation for 30 min at 2,000 rpm. The volume of decanted supernatant fluid was measured and volume of water retained/bound per g of sample calculated. WAC was expressed as g of water bound/100 g of starch.

#### 2.4.3 Determination of oil absorption capacity

Samples of sprouted and unsprouted water melon flour were evaluated for oil absorption capacity by the method described by AOAC [5]. The flour samples were mixed with 20 ml vegetable oil and were kept at room temperature ( $30 \pm 2^\circ\text{C}$ ) for 30 min before centrifugation for 30 min. Volume of oil retained/bound per g of sample calculated and oil absorption capacity was expressed in %.

#### 2.4.4 Determination of bulk density

Bulk density was determined by modified method of AOAC [5]. About 30 g Samples of sprouted and unsprouted water melon flour was weighed into a 25 ml measuring cylinder and the volume occupied will be measured and recorded.

Calculation:

$$\text{Bulk density (g/ml)} = \frac{\text{Weight of samples}}{\text{Volume occupied by sample}}$$

#### 2.4.5 Determination of pH of composite flour

The pH value for each sample of sprouted and unsprouted water melon was evaluated using an Accumet AB15 pH meter (Fisher Scientific). About 0.6 g both water melon samples were dispersed in 20 ml distilled water to obtain a 3% suspension. The pH of the suspension was measured using a pH meter.

## 2.5 Extraction of Oil

The oil sample was extracted from the watermelon seed flour using soxhlet extractor using petroleum ether of Analar grade (British Drug Houses, London), with a boiling range of  $60-80^\circ\text{C}$  for 8 h. The extraction was performed for 6 h on water bath. After extraction, the solvent was removed at  $40^\circ\text{C}$  under reduced pressure using rotary vacuum evaporator (Eyela Co. Ltd., Tokyo, Japan). The oil obtained was filtered using filter paper (Whatman No. 1) with a small amount of sodium sulphate anhydrous on it to absorb any traces of moisture. The oil was capped in a dark brown bottle and stored below  $5^\circ\text{C}$  until used for further analyses.

## 2.6 Determination of Physicochemical Properties of Oil

### 2.6.1 Determination of physical properties of oil

Refraction index of the oil at  $29^\circ\text{C}$  was determined using Abbe refractometer [7]. The state of the oil and colour of the oil were determined by visual observation at room temperature.

### 2.6.2 Determination of oil yield

The oil content was determined using the method described by AOAC [5]. About 10 g of the flour sample was weighed and wrapped up in a filter and then placed in the cleaned, dried and pre-weighed extraction thimble. The oil was extracted using Petroleum ether as the extraction solvent. After extraction, the flask and the content was then cooled in a dessicator and weighed. The oil content was calculated as follows:

$$\% \text{ Oil yield} = \frac{(X - Y)}{Z} \times 100$$

where: X= Weight of oil + flask  
Y= Weight of flask  
Z = Weight of Sample

### 2.6.3 Density measurement

Densities of oil samples before and after frying were measured by an relative density bottle with a capacity of 10 mL

### 2.6.4 Determination of Acid value

A standard method of AOAC [5] was used to determine the acid value. About 25 ml diethyl

ether was mixed with 25 ml alcohol and 1 ml phenolphthalein solution and carefully neutralized with 0.1M NaOH. Approximately 5 g of fat was then dissolved in the mixed neutral solvent and titrated with aqueous 0.1M NaOH and shaking constantly until the formation of pink color for 15 min was obtained. The amount of free fatty acid was calculated as a % of oleic acid using the formula given below.

$$\text{Acid value (\% oleic acid)} = \frac{\text{Titre (ml)} \times 5.61}{\text{wt of sample used}}$$

### 2.6.5 Determination of Saponification value

The saponification value was determined by the standard method described by AOAC [5]. Approximately 2 g of oil samples extracted from watermelon seed flour were weighed into a conical flask and 25 ml of 0.5 N alcoholic KOH solutions was added. This content was refluxed in boiling water bath for 1 h and was shaken frequently. 1ml of phenolphthalein (1%) solution was added and titrated hot alkali with 0.5 N HCl hydrochloric acid (a ml), with a blank titration carried out at the time (b ml) :

$$\text{Saponification value} \left( \frac{\text{KOH}}{\text{g oil}} \text{ sample} \right) = \frac{(b - a) * 28.05}{\text{weight of sample}}$$

### 2.6.6 Determination of peroxide value (PV)

The peroxide value was determined by the standard method described by AOAC [5]. One gram (1 g) of oil sample extracted from watermelon seed flour was weighed into 250 ml glass stoppered flask. 1g of potassium iodide was mixed with an acetic acid chloroform (2:1) was added using pipette. After heating, 30 ml of water was added and the mixture was titrated with 0.01 ml sodium thiosulphate solution until a blue color disappeared. The peroxide value was given as:

$$\text{Peroxide value} \left( \frac{\text{meq}}{\text{kg}} \right) = \frac{((V - B) \times N_f)}{W} 1000$$

where:

V: volume of sodium thiosulphate consumed

B: volume of sodium thiosulphate consumed during blank titration

W: weight of the sample, g

N<sub>f</sub>: Normality of sodium thiosulphate \* Factor

### 2.6.7 Determination of iodine value

The iodine value was evaluated by the method described by Wijis reported by Ohimain et al.

(2013). Oil sample (5.00 g) was weighed from each flour samples into beaker and then tarred up to 250 ml. 20 ml of Wijis solution was added and stoppered. The mixture was placed in the dark after shaking for 30 min. About 15 ml of 10% (w/v) potassium iodide solution and 100 ml of distilled water was added and the content was titrated using 0.1 M sodium thiosulphate solution to give a yellow colour. About 0.5 ml of starch was used as indicator (a ml) with blank carried out at the same time with 10 ml of carbon tetrachloride (b ml).

$$\text{Iodine value (\%)} = \frac{(b - a) 1.269}{\text{wt of oil sample}}$$

### 2.6.8 Viscosity measurements

The viscosity of the oil from water melon seed was measured with a rheometer by the method described by Nzikou et al. (2009). The viscosity value of the oil from watermelon seed flour measured in mPa.s is determined from the speed and the geometry of the probe when the concentric cylinder is plunged into the oil and the force that is required to overcome the resistance of the viscosity to the rotation is then measured which represent the viscosity of the oil using 100s<sup>-1</sup> as shear rate.

## 2.7 Determination of Mineral Elements Composition

The elemental composition of watermelon sample is determined by dry ashing method in which about 0.5 g of the samples was weighed into a clean, dry crucible and the content was ashed in a muffle furnace at 600°C for 4 h. The ash was then cooled and dissolved in dilute HCl (HCl: glass distilled water 1:3, v/v) in which a few drops of concentrated nitric acid is then added. The content was then transferred to 50 ml volumetric flask and the volume was made up to the 50 ml mark by distilled water and allowed to cool. The solution obtained was then used for the determination of the element zinc, Copper, iron and Manganese while sodium, potassium and Magnesium was determined using appropriate lamps; Calcium was evaluated by flame photometer (Model, 405, Corning, UK) and phosphorus was determined with vanadomolybdate using a spectrophotometer at 425 nm. The minerals were reported as mg/ 100 g.

## 2.8 Determination of Anti-nutritional Factor

### 2.8.1 Determination of phytic acid

Spectrophotometric method as describe by Pearson, [7] was used for the of phytic acid content. About 5g of the watermelon flour sample was weighed into 100 ml beaker and 20 ml of 0.30 N HCl was added which was stirred for 1 h on a magnetic hot plate. The content was extracted three times with 20 ml of 0.30 N HCl and then filtered into a 100 ml volumetric flask. The combined extract was diluted to 100 ml mark of the volumetric flask.

### 2.8.2 Determination of oxalate content

Oxalate content was determined by modified method of Day and Underwood [8] as described by Olawoye and Gbadamosi, [9]. 1 g of the flour sample was dispersed into 100 ml conical flask which was followed by the addition of 75 ml of 1.5M H<sub>2</sub>SO<sub>4</sub>; the and the content in the flask was carefully intermittently stirred with a stirrer and then filtered through a Whatman no1 filter paper. About 25 ml of the filtrate was collected was then titrated hot (80-90°C) against 0.05M KMnO<sub>4</sub> solution until a faint pink colour persisted. The oxalate was calculated as the sodium oxalate equivalent.

1 ml of 0.05M KMnO<sub>4</sub> =2 mg sodium oxalate equivalent/g of sample.

### 2.8.3 Determination of alkaloid content

Alkaloid content of water melon seed flour was evaluated by modified method of Ogunlakin et al., (2012). A known weight of the sample was dispersed in 10% acetic acid solution a ratio of 1:10 (10%) and allowed to stand for 4 h at 28°C. The content was then filtered using Whatman No.1 filter paper, and the filtrate was evaporated and treated with concentrated aqueous NH<sub>4</sub>OH to precipitate the alkaloid. The precipitated alkaloid was then washed with 1% ammonia solution and dried in the oven at 80°C. Alkaloid content was calculated and expressed as mg/100g of the weight of sample analyzed.

### 2.8.4 Determination of tannin content

Tannin was evaluated by the modified method of Ogunlakin et al., (2012). About 0.2 g of the flour sample was dispersed into 20 mL of 50% methanol in a beaker and placed in a water bath

at 80°C for 1 h with continuous stirring. The extract was filtered with Whatman No.1 filter paper into a 100 mL volumetric flask using 50% methanol to rinse. This was made up to mark with distilled water and thoroughly mixed. Then, 1 mL of sample extract was pipetted into 50 mL volumetric flask, 20 mL of distilled water, 2.5 mL of Folin-Denis reagent and 10 mL of 17% Na<sub>2</sub>CO<sub>3</sub> was added and mixed properly. The mixture was made up to mark with distilled water, mixed well and allowed to stand for 20 min when bluish-green coloration developed. Standard tannic acid solutions of range 0–10 ppm were treated similarly as 1 mL of the sample. The absorbance of the tannic acid standard solutions as well as samples was read after color development on a Spectronic 21D Spectrophotometer at a wavelength of 760 nm.

$$\text{Tannin (mg/100g)} = \frac{\text{Absorbance of sample} \times \text{Av gradient} \times \text{dilution factor}}{\text{Wt of Sample}}$$

### 2.8.5 Determination of saponin content

Saponin content was determined by spectrophotometric method as described by Ogunlakin et al., (2012). About 1 g sample was weighed into a 250 mL beaker containing 100 mL isobutyl alcohol. The content was shaken for 5 h and then filtered through a Whatman No. 1 filter paper into a 100 mL beaker containing 20 mL of 40% saturated magnesium carbonate solution. The mixture was filtered through a Whatman No. 1 filter paper to obtain a colorless solution. Then, 1 mL of the colorless solution was pipetted into 50 mL volumetric flask and 2 mL of 5% FeCl<sub>3</sub> solution was added and made up to mark with distilled water. It was allowed to stand for 30 min for blood red color to develop. Then, 0–10 ppm standard saponin solutions were prepared from saponin stock solution. The standard solutions were treated similarly with 2 mL of 5% FeCl<sub>3</sub> solution. The absorbance of the sample as well as standard saponin solutions was read after color development on a T60 UV-visible spectrophotometer, U.K. at a wavelength of 380 nm (Ogunlakin et al., 2012).

$$\text{Saponin (\%)} = \frac{\text{Absorbance of sample} \times \text{Av gradient} \times \text{dilution factor}}{\text{Weight of Sample}}$$

### 2.8.6 Determination of flavonoids

Flavonoid in the test sample was determined by the acid hydrolysis spectrophotometric method by modified method of Oluwole et al. (2017). 0.5g of the sample was mixed with 5ml of dilute HCl

and boiled for 30 min. The boiled extract was then allowed to cool and filtered. 1 ml of the filtrate was added to 5ml of ethylacetate and 5ml of 1% NH<sub>3</sub>. Then the absorbance was read at 420 nm.

### 2.8.7 Determination of terpenoid content

Total terpenoid content was determined by the method of Ghorai et al. (2012)17. 3 mL of chloroform was dispensed to 1 mL of the watermelon four samples. The sample mixture was thoroughly mixed and allowed to stand for 3 min. Then 200 µl of concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) was added, incubated at room temperature for 2 h until a reddish brown precipitate was formed. 3 mL of 95% (v/v) methanol was added to supernatant and mixed until all the precipitation dissolve in methanol completely. The absorbance was then taken at 538 nm using UV/visible spectrophotometer and terpenoid content was determined in mg/100 g.

### 2.8.8 Determination of cardiac glycoside

Cardiac glycoside content in the flour sample was evaluated using Buljet's reagent by the method described by El-Olemy, 2017. About 2 g of the flour samples from water melon was added to freshly prepared Buljet's reagent which contains 95ml aqueous picric acid + 5ml 10% aqueous NaOH. The blank was also prepared by adding distilled water to Buljet's reagent. The difference between the intensity of colors from the experimental and blank samples gives the absorbance and represent concentration of the glycosides.

### 2.9 Determination of Amino Acid Composition of Sprouted Unsprouted Watermelon Seed

The content of amino acid profile of sprouted and unsprouted watermelon seed flour was determined by defatting, hydrolysis and then evaporating in a rotary evaporator which was then loaded into Gas Chromatography flame ionization detector (GC-FID). About 2.0 g of flour samples were weighed into the extraction thimble and the fat extracted with chloroform /methanol (2:1 v/v) mixture using a soxhlet apparatus [5], in 6 h. About 30 mg of defatted samples was weighed into glass ampoules followed by the addition of 7 ml of 6M HCl. The glass ampoule was then sealed in a flame and then placed in an oven at a preset temperature of 105±5°C for 22 h for hydrolysis to take place. The ampoule was

then cooled, opened at the tip and the content was filtered. The filtrate was then evaporated to dryness at 40°C under vacuum in a rotary evaporator while the residue was dissolved in 5 ml of acetate at a pH 2.0 and stored in plastic specimen bottle for Gas Chromatography analysis. The gas chromatography (GC) conditions were as follows: detector temperature set at 28°C; injector 20°C; column (HP-INNOWax-cross-linked polyethylene glycol, 30 m × 0.32 mm i.d., 0.25mm, HP-INNOWax, Agilent Technologies, Palo Alto, CA) set at conditions of temperature programming as follows: 50°C for 5min and then the temperature was increased to 200C for 5min at 4C/min. The temperature was then kept constant at 200°C for 5min. The sample (1 mL) was injected into the GC using helium as carrier gas at a flow rate of 1.3 mL/min. Injections were conducted with a split ratio of 1:20. Fragmentation was performed by Electrothermal Impact, with ionization voltage at 70eV and scan mode between 50 and 450 mass units. Quantification was carried out from peak areas of components.

### 2.10 Determination of Fatty Acid Composition of Watermelon Seed Oil

About 0.2 g of oil extracted from watermelon samples were mixed with 5 ml 0.5 N methanolic NaOH and boiled for 10 min. This is followed by the addition of 5 ml of BF<sub>3</sub> and boiled for 1 min. Then 5 ml of the heptane was added and allowed cool; the content was then transferred into the 25 ml flask followed by the addition of saturated NaCl solution and shaken gently. About 1ml of solution was transferred into a bottle and kept in a deep freezer for analysis. The fatty acid constituents were identified on a Gas Chromatography (Agilent 6890N) equipped with Flame Ionization Detector and a 30 x 0.32m DB-225 silica capillary column (J and W Scientifics, USA). The split injector (1 mL) and detector were operated at a temperature of 230°C and 25°C respectively, while the oven temperature of 160°C/2 min was increased to 230°C on a scale of 4°C/min. Nitrogen was the carrier gas at a flow rate of 1.5 mL/min. The peaks were compared with standard methyl esters while the percentage area was recorded with standard Chemstation system.

### 2.11 Sensory Evaluation of Akara-analogue from Watermelon Flour

Sensory evaluation was carried out on the akara-analogue produced from both sprouted and

unsprouted water melon flour and compared with akara samples. Fifty (50) panelists aged 20 and 30, who are familiar with akara-like products participated in the test. The akara-like samples were coded and were presented to the fifty members trained panelists in clean dishes. The panelists were provided with water to rinse their mouth in between tests. The panelist evaluated the akara samples on quality attributes of colour, taste, aroma, mouth-feel, after taste and overall using 9-point hedonic scale, where 1 represents dislike extremely while 9 represents like extremely [10].

## 2.12 Statistical Analysis

Values were presented as means  $\pm$  SD (standard deviation) of duplicate analysis. The data obtained was subjected to analysis of variance (ANOVA) to determine if difference exists among the flour samples as a result of sprouting. Duncan's multiple range tests was used to separate means where significant differences at  $p < 0.05$  probability level existed. Statistical software (SPSS version 17.0) was used to perform the analysis at  $p < 0.05$  probability level [11].

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate Composition of Sprouted and Non-sprouted Watermelon Flour

The proximate composition of watermelon seeds flour for sprouted and non-sprouted is presented in Table 1. Non-sprouted water melon and sprouted water melon samples have moisture content of 8.46% and 7.06% respectively. These values were within the acceptable moisture value for good keeping quality of flour samples reported at 10%. The low moisture value is in close agreement with the value of 6.39% reported for pawpaw seeds [12], but lower than the value reported for cowpea (10.39%) by

Mashood and Rizwana, [13]. Moisture content of food has been reported to be quality factor for food stability [14]. The low moisture content reported in these seeds flours may give rise to long shelf life when properly packaged. Crude protein value obtained for sprouted water melon flour is 34.24% and higher than the value obtained for non-sprouted water melon flour (19.14%) and are significantly different from each other at  $p < 0.05$ . Nonogaki et al. [15] reported in their studies that higher sprouting time may give rise to increase the crude protein content. Also, Konberg and Beeves, (1999) also reported in their studies a reduction in content of lipids and carbohydrate during sprouting. This result is in agreement with the report of Hassan et al. [16] that watermelon seeds are good source of protein. The high protein content of the flour will be of advantage in a society with high protein deficiency and will also complement protein from cereals in the diets of Nigerians. The non-sprouted water melon sample had the higher fat content (26.58%) and is significantly different ( $p < 0.05$ ) from sprouted water melon flour with fat content of 22.27%.

Onimawo and Asugo [17] reported that fat content of sprouted cowpea is lower than non-sprouted samples due to exhaustion of the fat stored during sprouting. The high crude fat content of 22.27% and 26.58% obtained for the sprouted and non-sprouted seeds flour is expected because the seed is known to contain oil. Fats are essential to human body because they have the ability to provide the body with maximum energy and also facilitate absorption and transportation of fat-soluble vitamins in the body. The total ash content obtained in non-sprouted water melon samples (3.47%) is higher and is significantly different at  $p < 0.05$  from sprouted water melon samples (2.44%). These results are similar to the result reported for watermelon seeds flour by Nasr and Abifoul [18].

**Table 1. proximate composition of sprouted and non-sprouted watermelon seeds flour (%)**

Sample	Non-sprouted flour	Sprouted flour
Moisture	8.46+0.41a	7.06+0.01b
Crude Protein	19.14+0.22a	37.24+1.16a
Crude Fibre	0.36+0.07a	0.23+0.07a
Crude Fat	26.58+0.8a	22.27+0.38b
Ash	3.47+0.03a	2.44+0.35b
Carbohydrate	41.91+0.53a	30.58+1.13b

*Means with different letters in the same row are significantly different ( $p < 0.05$ ). while those with the same letters has no significant different ( $p > 0.05$ )*



The value for non-sprouted is not significantly different from the value obtained for sprouted water melon samples at  $p < 0.05$  in fibre content and this is also similar to the value of 0.65% obtained for watermelon seeds flour reported by Nasr and Abufoul, 2004. The carbohydrate value of 30.53% and 41.91% for non-sprouted water melon and sprouted water melon and is significantly different ( $p < 0.05$ ) from each other. Vidal-valde et al. [19] reported reduction carbohydrate content after sprouting which is used as source of energy for embryonic growth during sprouting.

### 3.2 Functional Properties of Sprouted and Non-sprouted Watermelon Seeds Flour

The characteristics behaviour food materials during processing and storage are dependent on physicochemical properties which may be useful for consumption and/or industrial usage. Adebowale and Lawal, [20] also reported that functional properties are very useful in water-protein interactions which play an important role in their behaviour in food systems. The results of functional properties are presented in Table 2. Bulk density of both sprouted water melon samples (0.53g/ml) and unsprouted water melon samples (0.51g/ml) did not show any significant difference at  $p < 0.05$ . The values obtained from this study compared favourably with the report of Obatolu and Cole, (2000) but higher than 0.035g/ml and 0.357g/ml reported for pawpaw seeds and melon seeds flour respectively by Olorode et al., [12] which could be attributed to high protein content of the seed. The bulky density value shows that a good weaning food could be produced from water-melon seeds as reported by Obatolu and Cole, 2000. Bulk density is also a factor of consideration in packaging requirement and material handling [21]. The water absorption capacities ranged between 3.01-2.90% and there was no significant difference at  $p < 0.05$  between the two samples. This result compared favourably with the water absorption capacity report by Adebowale et al., [20] for mucuna bean flour. Water absorption capacity is a useful factor to be considered in the formulation of several food products such as dough and baked products and watermelon seeds flour could therefore be useful ingredient.

Sprouted water melon samples had the higher swelling capacity (6.67 %) and is significantly different at  $p > 0.05$  from non-sprouted water melon samples (5.32 %). High swelling capacity

has been reported as a factor used in identifying good quality flour [21]. The values for oil absorption capacity for both sample sprouted (1.25%) and non-sprouted water melon samples (1.21%) is not significantly different from each other at  $p < 0.05$ . The solubility index for both samples, non-sprouted water melon seeds (40.30%) and sprouted water melon flour samples (41.01%) show no significant differences at  $p > 0.05$ . The result obtained for pH for non-sprouted flour and sprouted flour is 6.14 and 6.13 respectively. There was no significant different ( $p > 0.05$ ) between the water-melon flour samples. The result shows that the flour samples are acidic and acidic products are more shelf stable than non-acidic food products. Similar observation has been reported by Ikpeme et al., [22]. Ikpeme et al., [22] reported that both pH and titratable acidity are measure of acidity in food samples but pH is more accurately measure. The value recorded for titratable acidity in this report ranges from 0.07 and 0.12 for samples non-sprouted flour and sprouted water melon samples respectively which are significantly different ( $p < 0.05$ ) from each other. The increase in the sprouted water melon samples compared well with the results of the study reported by Ikpeme et al., [22].

### 3.3 Physicochemical Properties of oil from Sprouted and Unsprouted Watermelon Seeds

Table 3 represents the physical properties of oil extracted from sprouted and unsprouted watermelon seed flours. The results of this study revealed that the oil has a light yellow colour which is in liquid state at room and refrigeration temperatures. The colour of the unsprouted was found to be light yellow which compares with that reported by Egbuonu et al.(2015) while that of the sprouted sample was found to be golden yellow which may be as a result of the sprouting treatment applied. Also, the refractive index of the sprouted sample and unsprouted sample has the same mean value of 1.71 but the value is higher than 1.518 reported by Arinola and Ogunbusola (2013). The specific gravity of the unsprouted sample (1.08) was found to be higher than the sprouted sample (0.92) which compares favourably with the value of 0.910-0.920 reported by Olaofe et al., (2012) for melon seed oil which may as a result of the density of water being higher than oil and will therefore make the oil flow and spread easily on the skin hence useful in cream production. The viscosity of the sprouted sample was 1580 mPa.s while the

unsprouted sample was 3400 mPa.s both at 30 rpm. The texture of the oils was also liquid at 37°C.

The saponification value of the unsprouted sample was found to be 118.04 mgKOH/g which compared with the value of 115.94 mgKOH/g reported for both oven and sun dried watermelon seed oil by Taiwo et al., (2008); while that of the sprouted sample was 106.8 mgKOH/g. These values are lower than 175.98 mgKOH/g reported by Ebuehi and Awobode, (2006) for *Citrullus lanatus* oil. Saponification value is important for soap production and may also be used as a means of characterizing the oil but the low saponification value means that the oil may not be suitable for soap making and shampoo production. This result have also shown that the oil contain higher fatty acid compounds and can therefore be regarded as non-edible oils (Aremu et al., 2015). The acid values of both unsprouted and sprouted samples were 15.57 mg KOH/g and 17.49 mgKOH/g respectively but higher than the limit value (10 mg KOH/g) for edible oils which has high stability against rancidity (Egbonu et al., 2015). The high acid value of the oils may be due to the processing methods employed. The percentage yield of oil recovered from the sprouted sample was 56.80% which is higher than that of the unsprouted sample having a value of 51.29% as a result of the quantity of the flour which was 410g and 115 g respectively after milling the seeds. The pH of both unsprouted and sprouted samples was determined to be 5.25 and 5.45 respectively. The results are within the range reported by Egbonu et al., 2015 (4.9) which shows that the oils are acidic. Iodine value in the unsprouted sample with a mean value of 6.14 meq/g is lower than the sprouted sample with a mean value of 9.25 meq/g. Aremu et al., [23] reported that the lower the iodine value may reduce the tendency of the oil to undergo oxidative rancidity due to the presence of lower number of unsaturated bonds.

Hence, the sprouted water melon sample will be less prone to rancidity. The peroxide value of the unsprouted which was 6.14 meq/kg was found to be lower than the sprouted sample of 9.25 meq/kg. Peroxide value greater than 10.00 meq/kg may indicate high susceptibility of oil to auto-oxidation due to the presence of water and/or trace elements such as copper [24]. Thus, the low peroxide value of the unsprouted sample suggested its high degree of stability and non-susceptibility to oxidative rancidity. The lower the peroxide value of water melon oil is an indication of the better the quality oil (Codex Alimentarius, 1999).

### 3.4 Mineral and Vitamin Content of Sprouted Band Unsprouted Watermelon Seeds

Table 5 shows that all the sprouted and unsprouted samples contained good amount of calcium, magnesium, sodium, phosphorus and potassium. The results revealed that water melon seed flour may provide a sufficient amount of mineral to meet the recommended dietary allowance for human mineral requirement (NRC/NAS, 1989). The result also shows that the mineral content of watermelon seeds were most abundant for both samples in potassium (K), the sprouted sample having 95.27 mg/100 g which was significantly higher than 65.83 mg/100g of the unsprouted. This is closely related to the work reported by Aremu et al. (2005) that potassium was the most abundant mineral present in food products in Nigeria. High content of potassium in the body was reported to improve iron utilization in the body (Adeyeye, 2002). Similar observations have been reported for mucuna beans [20] but a contrary report was given on fluted pumpkin by Fagbemi, [25]. Potassium may be useful in alleviating diabetes since potassium helps to control blood pressure and possibly prevents stroke [26]. Potassium

**Table 2. Functional properties of sprouted and non-sprouted watermelon seeds flour**

Sample	Non-sprouted watermelon flour	Sprouted watermelon flour
Bulk density(g/ml)	0.51±0.1 <sup>a</sup>	0.53±0.01 <sup>a</sup>
Solubility Index (%)	40.30±0.014 <sup>a</sup>	41.01±1.12 <sup>a</sup>
Water absorption Capacity (%)	3.01±0.03 <sup>a</sup>	2.90±0.14 <sup>a</sup>
Oil Absorption Capacity (%)	1.21±0.02 <sup>a</sup>	1.25±0.03 <sup>a</sup>
Swelling Capacity (%)	5.32±0.02 <sup>b</sup>	6.67±0.01 <sup>a</sup>
pH	6.14±0.07 <sup>a</sup>	6.13±0.04 <sup>a</sup>
Titrateable Acidity	0.07±0.00 <sup>b</sup>	0.12±0.00 <sup>a</sup>

Means with different letters in the same row are significantly different ( $p < 0.05$ ). while those with the same letters has no significant different ( $p > 0.05$ )

**Table 3. Physico-chemical properties of oil extracted from watermelon seed**

Parameter	Unsprouted watermelon seed	sprouted watermelon seed flour
State	Liquid at 37°C	Liquid
Colour	light yellow	golden yellow
Oil yield (%)	51.29±0.05	56.8±0.03
Specific gravity	1.08 <sup>a</sup> ±0.00	0.92 <sup>a</sup> ±0.05
Refractive index	1.71±0.05	1.71±0.05
Viscosity (mPa.s)	1580	3400
pH	5.25±0.07	5.45±0.01
Iodine value(meq/g)	6.14±0.03	9.25±0.03
Acid value (mgKOH/g)	15.57±0.19	17.4±0.09
Saponification value (mgKOH/g)	118.04±0.27	168.0±0.21

and sodium are important component in intracellular and extracellular digestion hence the ratio of Na/K is useful in the determination of health status of an individual. A ration of less than one has been recommended to prevent high blood pressure. The second most abundant mineral is magnesium with a value of 41.54 mg/100 g for the sprouted sample and lower value of 26.32 mg/100 g for the unsprouted sample. Magnesium is responsible for calcium metabolism in bones, improve insulin sensitivity and prevent circulatory diseases. The calcium content ranged between 26.24 mg/100 g and 41.08 mg/100 g for unsprouted and sprouted watermelon seeds flour respectively. This result is similar to those found by Abayomi et al., [27] and Adegoke et al., [28]. Calcium plays an important role in bone formation and blood coagulation; hence, the high calcium content in water melon seeds could make it a source of calcium supplementation for pregnant and lactating mother. Hence, calcium content of water melon seed of the present study was relatively high thus could supply the required recommended daily allowance [29]. Phosphorus was found to have a value of 24.88 and 18.02 mg/100 g for sprouted and unsprouted water melon seed flour respectively. Phosphorus is an essential component of the blood and a constituent of certain enzymes and hormones in the body. Lower values of the minerals was found in manganese (Mn) and copper (Cu). The sprouted and unsprouted sample was found to be 329 mg/100 g and 0.1310 mg/100 g respectively for manganese. Manganese plays important role in the transfer of oxygen during carbohydrate, fat and protein metabolism in the body. Magnesium is an important cofactor in the synthesis of chlorophyll and also an important mineral element in connection with ischemic heart disease and calcium metabolism in bones, in addition to its coenzyme activity [30]. The

values 0.1407 mg/100 g and 0.298 mg/100 g of copper were reported for the unsprouted and sprouted samples respectively. Copper plays an important role in prevention of free radical-induced damage in human body. Zinc is also present in the sample analyzed and is involved in the normal functioning of the immune system while iron (Fe) is an essential trace element for hemoglobin formation. The ration of Na/K is responsible for prevention of high blood pressure and Na/K ratio less than one is recommended [23]. Hence, with sodium/potassium ratio (Na/K) range of 0.06 to 0.29, the consumption of watermelon flour may probably reduce high blood pressure. Ca/P ratio of watermelon seed flour is greater than 1 which may be an indication that flour would serve as a good source of mineral for bone formation. Also, mineral supplementation can be used as an alternative approach to correct this imbalance.

Table 5 also represents the vitamins content for both unsprouted and sprouted samples. The study shows that both samples contain appreciable amounts of Vitamin C with the sprouted sample having 38.48 mg/100g which is higher than 24.23 mg/100 g for the unsprouted sample. Also, Vitamin B<sub>2</sub> was significantly higher in the sprouted sample when compared with the unsprouted sample with values of 48.43 mg/100 g and 5.30 mg/100 g respectively. Vitamin B<sub>6</sub> as well was more pronounced in the sprouted sample than the unsprouted sample having 16.48 mg/100g and 4.53 mg/100 g respectively. The high values observed in the sprouted sample may be as a result of the sprouting treatment applied. During sprouting, an increase was observed for vitamin B1. Bibi et al., [31] also reported an increase in water soluble vitamins due to synthesis of this vitamin during sprouting. Chavan, [32] also reported a decrease in thiamine, riboflavin, niacin, and vitamin C content

in malted cereals. The increase in the values of vitamin could be due to synthesis of vitamin during sprouting. Hence, in this present study, it could be inferred that both sprouted and unsprouted flour contain an appreciable amount of essential minerals like magnesium, calcium and iron which are very essential for the body.

### 3.5 Anti-nutritional Content of Sprouted and Non-sprouted Watermelon Seeds Flour

Phytochemical content of both sprouted and non-sprouted watermelon seeds flour is shown in Table 6. Non-sprouted water melon samples had a higher oxalate content and is significantly different ( $p<0.05$ ) from sprouted samples. Nasr and Abufoul [18] reported in their study that sprouting process have the tendency to reduce anti-nutritional factors in cereals and leguminous seeds. Oxalates in foods may form complexes with dietary mineral and make them unavailable to humans hence, a reduction in its bioavailability [33]. Non-sprouted water melon samples had the highest phytate content while sprouted samples had the least phytate content showing the significant effect of sprouting and is significantly different ( $p<0.05$ ) from non-sprouted samples. Tannins are one of the many secondary compounds found in plants also has value which decreases from 13.72 mg/100 g (non-sprouted samples) to 11.21 mg/100 g (sprouted samples). Studies by several authors have shown that sprouting of seeds reduce anti-nutritional factors. Tannins are known to be responsible for reduced growth rate, protein digestibility and feed efficiency poultry and ruminant animals [33]. In

addition to this result, other antinutritional factors such as flavonoids, phenol, alkaloids, cardiac glycoside, phlobatannin and steroids follows the same trend as reported for other antinutritional factor showing the significant effect of sprouting and dehulling.

### 3.6 Fatty Acid Profile of Sprouted and Unsprouted Watermelon Seeds

The composition of fatty acid oil have been reported to be used in evaluating nutritional value of oil because it gives an indication of stability and rate of degradation of oil. Table 7 represents the fatty acid profile for sprouted and unsprouted oil samples of watermelon seeds. Findings from the study revealed that linoleic acid is the major fatty acid in both oils with sprouted sample having a higher value of 68.680% and a value of 65.294% for unsprouted sample. The high linoleic acid values is similar to those found in white and black seeds of watermelon which was 68% and 66% respectively reported by Sabahelkhier et al., (2011) and lower than 76.24% reported by Garba et al., (2014) for *Citrullus vulgaris* seed oil. Linoleic acid is a component of essential fatty acids that must made available in food which may produce oleic acid from stearic acid during synthesis of unsaturated fatty acids [34]. Although, linoleic acid may produce alpha-linolenic acid in plants and gamma-linolenic acid in animal through a process called desaturation which makes linoleic acid an essential component of human diet. In contrast, palmitic acid accounted for 14.07% for sprouted sample which compared with that

**Table 4. Mineral and vitamin content of sprouted and unsprouted watermelon seed flour mg/100 g**

Parameter		Unsprouted watermelon seed	Sprouted watermelon flour
Sodium	Na	32.55±0.24 <sup>a</sup>	68.24±0.58 <sup>b</sup>
Potassium	K	65.83±0.22 <sup>a</sup>	95.27±0.21 <sup>b</sup>
Calcium	Ca	26.24±0.01 <sup>a</sup>	41.08±0.11 <sup>b</sup>
Phosphorus	P	18.02±0.21 <sup>a</sup>	24.88±0.11 <sup>b</sup>
Magnesium	Mg	42.32±0.14 <sup>a</sup>	78.54±0.50 <sup>b</sup>
Iron	Fe	4.02±0.06 <sup>a</sup>	12.02±0.50 <sup>b</sup>
Copper	Cu	0.14±0.50 <sup>a</sup>	0.298±0.33 <sup>b</sup>
Manganese	Mn	0.13±0.11 <sup>a</sup>	0.333±0.00 <sup>b</sup>
Zinc	Zn	14.80±0.10 <sup>a</sup>	22.08±0.22 <sup>b</sup>
Na/K		0.49	0.72
Ca/P		1.47	1.71
Vitamin B <sub>2</sub>		5.33±0.04 <sup>a</sup>	48.43±0.84 <sup>b</sup>
Vitamin B <sub>3</sub>		3.35±0.02 <sup>a</sup>	15.45±0.51 <sup>b</sup>
Vitamin B <sub>6</sub>		4.53±0.08 <sup>a</sup>	16.48±0.81 <sup>b</sup>
Vitamin C		24.23±0.51 <sup>a</sup>	38.48±0.53 <sup>b</sup>

**Table 5. Phytochemicals composition of flour from watermelon seeds**

Parameters	Samples			
	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>
Flavonoid (mg/100 g)	3.23 <sup>a</sup> ±0.06	2.50 <sup>a</sup> ±0.06	23.39 <sup>c</sup> ±0.06	12.81 <sup>b</sup> ±0.13
Tannin (mg/100 g)	14.37 <sup>a</sup> ±0.16	19.94 <sup>b</sup> ±0.08	31.83 <sup>c</sup> ±0.12	31.69 <sup>c</sup> ±0.40
Saponin (mg/100 g)	40.13 <sup>a</sup> ±0.27	45.20 <sup>b</sup> ±0.38	52.22 <sup>c</sup> ±0.18	55.13 <sup>d</sup> ±0.54
Alkaloid (mg/100 g)	25.67 <sup>a</sup> ±0.12	28.59 <sup>b</sup> ±0.24	34.12 <sup>d</sup> ±0.19	30.93 <sup>c</sup> ±0.18
Terpenoid (mg/100 g)	48.00 <sup>a</sup> ±0.18	47.88 <sup>a</sup> ±0.23	51.93 <sup>b</sup> ±0.18	54.79 <sup>c</sup> ±0.18
Steroid (mg/100 g)	28.11 <sup>a</sup> ±0.29	27.50 <sup>a</sup> ±0.23	43.30 <sup>b</sup> ±0.23	49.84 <sup>c</sup> ±0.12
Phlobatanin (mg/100 g)	11.26 <sup>b</sup> ±0.17	9.34 <sup>a</sup> ±0.23	18.47 <sup>c</sup> ±0.64	20.19 <sup>c</sup> ±0.64
Cardiac glycoside (mg/100 g)	26.72 <sup>a</sup> ±0.12	25.04 <sup>a</sup> ±0.06	32.97 <sup>b</sup> ±0.18	30.19 <sup>b</sup> ±0.17
Oxalate (mg/100 g)	14.37 <sup>a</sup> ±0.16	19.94 <sup>b</sup> ±0.08	31.83 <sup>c</sup> ±0.12	31.69 <sup>c</sup> ±0.40
Phenol (mg/100 g)	12.69 <sup>a</sup> ±0.16	24.90 <sup>b</sup> ±0.11	33.30 <sup>c</sup> ±0.16	26.04 <sup>b</sup> ±0.16

Values are expressed as Mean ±SD, different letters within the same column are significantly different ( $p < 0.05$ ) T<sub>1</sub> = Sprouted aqueous; T<sub>2</sub> = Sprouted ethanol; T<sub>3</sub> = Unsprouted aqueous; T<sub>4</sub> = Unsprouted ethanol

obtained by Garba et al., (2014) which was 14.42% for *Citrullus vulgaris* seed oil and 13% for white seeds of watermelon by Sabahelkhier et al., (2011). However, the unsprouted sample had 15.38% which was similar to 15% for black seeds of watermelon reported by Sabahelkhier et al., (2011). The values for oleic acid are 10.69% and 10.49% for Sprouted and unsprouted samples respectively. The results from this study is in agreement with the value of 11% given by Sabahelkhier et al.,(2011) for both white and black seeds of watermelon and greatly higher than 0.33% obtained Garba et al., (2014) for *Citrullus vulgaris* seed oil. Stearic acid accounted for lower values of 3.78 and 4.41% for sprouted and unsprouted sample respectively. The results were found to be much higher compared to 9.01% for *Citrullus vulgaris* seed oil gotten by Garba et al., (2014) and 10.2% for melon seed oil by Mirjana and Ksenija, (2005). The oleic acid (monounsaturated) confers greater resistance to degradation or thermal action in edible oils. In addition, free fatty acids oxidize at a higher speed than its esters; therefore, they are considered as pro-oxidants. However, when they are present in small quantities, does not significantly act on oxidative stability. The result obtained from this study have shown that the quantity of unsaturated fatty acid oil is higher than the quantity obtained for saturated fatty acid oil for both sprouted and unsprouted watermelon seed. Saturated fat is known to be responsible for the production high content of cholesterol in the body which in turn decreases insulin sensitivity. The study have also shown high content of unsaturated fatty acid which is 68.68% for linoleic acid showing that watermelon seed flour could be beneficial for consumption and food supplementation. Linoleic acid is also very

useful in blood lipids and reduction of blood pressure and serum cholesterol [34,35].

### 3.7 Amino Acid Profile for Sprouted and Unsprouted Flour from the Germinated Watermelon Seeds

Amino acid composition for sprouted and unsprouted watermelon seed flour as revealed in Table 8 showed the following amino acids which includes; glycine, alanine, serine, proline, valine, threonine, isoleucine, leucine, asparatate, lysine, methionine, glutamate, phenylalanine, histidine, arginine, tyrosine, and cystine. Both the sprouted and unsprouted watermelon seed flour contains eight (8) essential amino acids which are phenylalanine, valine, threonine, methionine, leucine, isoleucine, lysine, histidine, and tryptophan. The Table revealed that the two samples were both high in aspartate with values of 11.95 mg/100 g and 11.87 mg/100 g for sprouted and unsprouted samples respectively; followed by glutamate having 11.506 mg/100 g for the unsprouted which compared well with that obtained by Egbonu, 2015 (11.43 mg/100 g) and found to be higher than 10.88 mg/100 g for that of sprouted sample. Also, cystine, leucine, tryptophan, lysine, alanine and arginine for both sprouted and unsprouted samples were found to be (8.56 mg/100 g, 7.16 mg/100 g, 6.27 mg/100 g, 5.78 mg/100 g, 5.05 mg/100 g, 5.14 mg/100 g) and (8.43 mg/100 g, 6.44 mg/100 g, 6.17mg/100 g, 5.72 mg/100 g, 5.31 mg/100 g, 5.09 mg/100 g) respectively. However, four of the amino acids of the sprouted were slightly higher than that of the unsprouted sample except for alanine. Amino acids have been reported to be involved in the synthesis of protein, regulation of hormones and transmission of neuron in human body [36,37].

Moreover, high content of these amino acids in watermelon seed flour may be very useful in nutritional studies and may required for further investigation. Likewise, glycine, phenylalanine, threonine, tyrosine, isoleucine, methionine, valine, histidine, proline, serine was found to be low in sprouted and unsprouted samples which were all tested at 5% level of significance.

**Table 6. Fatty acid profile for sprouted sample**

Compound name	Sprouted watermelon seed flour (%)	Unsprouted watermelon seed flour (%)
Myristic acid (C14:0)	0.19±0.01 <sup>a</sup>	0.17±0.01 <sup>b</sup>
Palmitic acid (C16:0)	14.07±0.02 <sup>a</sup>	15.38±0.06 <sup>b</sup>
Margaric acid (C17:0)	0.19±0.01 <sup>a</sup>	0.42±0.02 <sup>b</sup>
Stearic acid (C18:0)	3.78±0.00 <sup>a</sup>	4.41±0.03 <sup>b</sup>
Arachidic acid (C20:0)	0.43±0.04 <sup>a</sup>	0.42±0.01 <sup>b</sup>
Behenic acid (C22:0)	0.26±0.05 <sup>a</sup>	0.19±0.04 <sup>b</sup>
Lignoceric acid (C24:0)	0.42±0.02 <sup>a</sup>	0.93±0.02 <sup>b</sup>
Total Saturated fatty acids	18.95	21.99
Palmitoleic acid (C16:1)	0.39±0.02 <sup>a</sup>	0.49±0.02 <sup>b</sup>
Oleic acid (C18:1)	10.69±0.01 <sup>a</sup>	10.49±0.01 <sup>b</sup>
Erucic acid (C22:1)	0.43±0.02 <sup>a</sup>	0.19±0.04 <sup>b</sup>
Total Monounsaturated fatty acid	11.51	11.61
Linoleic acid (C18:2)	68.68±0.07 <sup>a</sup>	65.29±0.02 <sup>b</sup>
Linolenic acid (C18:3)	0.68±0.05 <sup>a</sup>	1.00±0.01 <sup>b</sup>
Arachidonic acid (C20:4)	0.03±0.01 <sup>a</sup>	0.07±0.07 <sup>b</sup>
Total Polyunsaturated fatty acid	69.39	66.39
Total Unsaturated fatty acid	80.90	68.00
TST/TUS	0.23	0.32
oleic acid/linoleic acid	0.16	0.16
Essential fatty acid (C18:2+C18:3)	79.37	67.32

**Table 7. Amino acid profile for sprouted sample of flour from the germinated watermelon seeds**

Compound name	Sprouted watermelon seed flour (mg/100 g of protein)	Unsprouted watermelon seed flour (mg/100 g of protein)
Glycine	4.89±0.01 <sup>a</sup>	5.02±0.01 <sup>b</sup>
Alanine	5.05±0.02 <sup>a</sup>	5.31±0.02 <sup>b</sup>
Serine	2.25±0.00 <sup>a</sup>	2.64±0.04 <sup>b</sup>
Proline	2.38±0.04 <sup>a</sup>	2.24±0.07 <sup>b</sup>
Valine	2.56±0.00 <sup>a</sup>	2.49±0.03 <sup>b</sup>
Threonine	3.79±0.02 <sup>a</sup>	3.69±0.02 <sup>b</sup>
Isoleucine	3.61±0.02 <sup>a</sup>	4.42±0.05 <sup>b</sup>
Leucine	7.16±0.01 <sup>a</sup>	6.44±0.05 <sup>b</sup>
Aspartate	11.95±0.05 <sup>a</sup>	11.87±0.02 <sup>b</sup>
Lysine	5.78±0.00 <sup>a</sup>	5.73±0.05 <sup>b</sup>
Methionine	3.33±0.00 <sup>a</sup>	3.29±0.03 <sup>b</sup>
Glutamate	10.88±0.01 <sup>a</sup>	11.51±0.01 <sup>b</sup>
Phenylalanine	4.62±0.03 <sup>a</sup>	4.55±0.02 <sup>b</sup>
Histidine	2.39±0.02 <sup>a</sup>	2.55±0.01 <sup>b</sup>
Arginine	5.14±0.00 <sup>a</sup>	5.09±0.01 <sup>b</sup>
Tyrosine	3.77±0.05 <sup>a</sup>	3.72±0.03 <sup>b</sup>
Tryptophan	6.27±0.05 <sup>a</sup>	6.17±0.02 <sup>b</sup>
Cystine	8.56±0.07 <sup>a</sup>	8.43±0.02 <sup>b</sup>

**Table 8. Sensory qualities of akara-analogue from sprouted and non-sprouted watermelon flour**

Sample	Unsprouted akara-analogue	Sprouted akara-analogue	Control
Taste	6.95 ± 1.67 <sup>a</sup>	5.35 ± 1.51 <sup>b</sup>	7.35 ± 1.87 <sup>a</sup>
Colour	7.65 ± 1.04 <sup>a</sup>	5.90 ± 2.11 <sup>b</sup>	7.35 ± 0.93 <sup>a</sup>
Aroma	6.65 ± 1.42 <sup>b</sup>	4.60 ± 1.64 <sup>c</sup>	7.60 ± 0.82 <sup>a</sup>
Mouth-feel	6.15 ± 1.98 <sup>a</sup>	3.25 ± 1.97 <sup>b</sup>	6.85 ± 1.42 <sup>a</sup>
Aftertaste	5.75 ± 2.07 <sup>a</sup>	4.90 ± 1.25 <sup>b</sup>	6.75 ± 1.41 <sup>a</sup>
Overall acceptability	6.55 ± 1.82 <sup>a</sup>	5.95 ± 1.64 <sup>b</sup>	7.50 ± 1.54 <sup>a</sup>

Means with different letters in the same row are significantly different ( $p < 0.05$ ). while those with the same letters has no significant different ( $p > 0.05$ )

**Table 9. Sensory qualities of akara-analogue from sprouted and non-sprouted watermelon flour**

Sample	Non-sprouted akara-analogue	Sprouted akara-analogue	Control
Taste	6.95 ± 1.67 <sup>a</sup>	5.35 ± 1.51 <sup>b</sup>	7.35 ± 1.87 <sup>a</sup>
Colour	7.65 ± 1.04 <sup>a</sup>	5.90 ± 2.11 <sup>b</sup>	7.35 ± 0.93 <sup>a</sup>
Aroma	6.65 ± 1.42 <sup>b</sup>	4.60 ± 1.64 <sup>c</sup>	7.60 ± 0.82 <sup>a</sup>
Mouth-feel	6.15 ± 1.98 <sup>a</sup>	3.25 ± 1.97 <sup>b</sup>	6.85 ± 1.42 <sup>a</sup>
Aftertaste	5.75 ± 2.07 <sup>a</sup>	4.90 ± 1.25 <sup>b</sup>	6.75 ± 1.41 <sup>a</sup>
Overall acceptability	6.55 ± 1.82 <sup>a</sup>	5.95 ± 1.64 <sup>b</sup>	7.50 ± 1.54 <sup>a</sup>

Means with different letters in the same row are significantly different ( $p < 0.05$ ). while those with the same letters has no significant different ( $p > 0.05$ )

### 3.8 Sensory Qualities of Akara-analogue Produced from Sprouted and Unsprouted Watermelon Flour

Hedonic test is a known test used to evaluate the level of acceptance of a product. The akara produced using sprouted and unsprouted watermelon were evaluated and compared with the control akara with 100% cowpea flour. Mean sensory attributes scores of the akara-analogue made from sprouted, unsprouted and the control is presented in Table 9. Sensory attributes of akara-analogue showed that the control had the highest score for taste (7.35) and aroma (7.60) which are significantly different ( $p < 0.05$ ) when compared with unsprouted and sprouted samples in terms of aroma. Control samples and unsprouted samples are equally accepted in terms of colour, mouth feel and after-taste which means there was no significant different among the samples at  $p < 0.05$ . The colour of akara made from unsprouted watermelon flour was preferred than that of control sample which recorded a value of 7.60. Sprouted sample is significantly different ( $p < 0.05$ ) from other samples having the least score in all the attributes measured. But on individual rating, samples from unsprouted watermelon samples was most preferred in terms of overall acceptability and there was no significant differences among the samples at  $p < 0.05$ . The

effect of sprouting is significant in sprouted akara-analogue with the panelist rating very low.

### 4. CONCLUSION

In this study, the replacement of cowpea flour by watermelon flour in akara production to improve nutritional values and development of new recipes to make good quality akara watermelon were successful. This study revealed that both the sprouted and non-sprouted watermelon seeds flour is very high in protein and can complement protein from cereal based plant foods in the diets of Nigerians. Sprouting has also shown the potentials of watermelon seed to be used in protein food supplementation and as a functional ingredient in the development of new food product. The result of this study therefore demonstrate that a great potential exists for sprouted watermelon seeds from the nutritional point of view and can also be explored as an alternate protein source to alleviate protein-energy-malnutrition among economically weaker sections of peoples in developing countries in production of several food products. The successful utilization rather than discarding the seeds after consuming the fruit which will improve and encourage the production, acceptance and consumption of watermelon seed flour.

## ACKNOWLEDGEMENT

The author appreciates the support received from the technical assistant from Mr. Sunday Adenekan of the Department of Biochemistry, University of Lagos, Idi-Araba, Nigeria.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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