Adegunwa et al., *Cogent Food & Agriculture* (2019), 5: 1631582
https://doi.org/10.1080/23311932.2019.1631582

cogent food & agriculture

Received: 21 May 2019
Accepted: 11 June 2019
First Published: 07 July 2019

*Corresponding author: M. O. Adegunwa, Department of Hospitality and Tourism, Federal University of Agriculture, Abeokuta, Nigeria
E-mail: moadegunwa@gmail.com

Reviewing editor:
Fatih Yildiz, Food Engineering and Biotechnology, Middle East Technical University, Turkey

Additional information is available at the end of the article

FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Quality attribute of plantain (*Musa paradisiaca*) sponge-cake supplemented with watermelon *(Citrullus lanatus)* rind flour

M. O. Adegunwa[1]*, I. O. Oloyede[1], L. A. Adebanjo[1] and E. O. Alamu[2]

Abstract: This study is aimed at supplementing Watermelon rind flour (WF) into cakes production with Plantain Flour (PF). Six cake samples were produced from the composite mixture of PF and WF in varying proportions of 100:0, 90:10, 80:20,70:30, 60:40 and 50:50. The composite flour of plantain-watermelon rind was evaluated for proximate, functional and pasting properties while the cakes were assessed for proximate, texture and sensory qualities using laboratory standard methods. The water absorption capacity (WAC) of the composite flours has a significant ($P < 0.05$) increase as the volume of WF increases from 0 to 50%. Cake produced from PF substituted with 50% WF has the highest value of protein (10.58%). The substitution of 10% of WF showed the highest score rating by the panelist in overall acceptability (7.60). This study has provided the recipe for the formulation of quality cake with PF and WF that could be acceptable by consumers.

Subjects: Food Additives & Ingredients; Sensory Science; Food Analysis;

Keywords: plantain flour; watermelon rind flour; cake; proximate; texture properties

ABOUT THE AUTHOR

M. O. Adegunwa (PhD) is a Senior Lecturer in the Department of Hospitality and Tourism, Federal University of Agriculture, Abeokuta, Nigeria. E-mail: moadegunwa@gmail.com ORCID ID: http://orcid.org/0000-0003-4392-8995
O. I. Oloyede is a Graduate Student in the Department of Hospitality and Tourism, Federal University of Agriculture, Abeokuta, Nigeria. E-mail: itunesjay16@gmail.com
L .A. Adebanjo is an Assistant Lecturer in the Department of Hospitality and Tourism, Federal University of Agriculture, Abeokuta, Nigeria. E-mail: lukaadebanjo@gmail.com
E .A. Alamu (PhD) is an Associate Scientist at Food and Nutrition Sciences Laboratory, International Institute of Tropical Agriculture (IITA), Southern Africa Research and Administration Hub (SARAH), P.O. Box 310142, Chelston, Lusaka, Zambia. E-mail: oalamu@cgiar.org ORCID ID: http://orcid.org/0000-0001-6263-1359

PUBLIC INTEREST STATEMENT

Our study explores the potentials of plantain and Watermelon rind flour in producing cakes with acceptable functional and sensory qualities. This study provided some basic information on nutrient composition and value addition via watermelon rind flour, which is regarded as a waste. Creating wealth from waste, enriching the nutrient-minerals and vitamins addition is necessary for the consumer of the final products.

1. Introduction

In the past few years, there has been an increasing consumer interest and awareness in the field of food nutrition as a result of incidence of some diet related-health problems such as obesity, high blood pressure, diabetes, cancer of colon, gastrointestinal disease and cardiovascular disease, (Chen, 2011; Mendis & Kim, 2011). This has given rise to increased demand for health oriented and functional food products such as sugar-free, low calorie, low cholesterol and high fiber products. In view of these, development of high fiber products is one of the approaches that can be used to tackle these health problems.

Fruit consumption has increased worldwide because of taste, disease prevention and health benefits due to the presence of nutrients such as vitamins, minerals, fiber and other bioactive compounds needed by the human body for a healthy life (Hossain & Rahman, 2011). Dietary fiber is the remnants of the edible part of plant and analogous carbohydrates which includes polysaccharides, oligosaccharides, lignin and associated substances that are resistant to digestion and absorption in the human small intestines with complete or partial fermentation in the human large intestines (de Vries, 2010). Dietary fiber has been shown to have important health implications in the prevention for risk of chronic diseases such as cancer, cardiovascular diseases and diabetes mellitus (Trinidad et al., 2006). Recent studies indicated that dietary fiber (soluble and insoluble) helps in preventing cardiovascular diseases, colon cancer and reducing cholesterol (Ajila & Prasadarao, 2013; O'shea, Arendt, & Gallagher, 2012). Fiber-rich foods are produced by adding functional fiber or using basic ingredients with high dietary fiber content. Interest in fiber enhanced foods has resulted in the use of wheat bran, refined cellulose, fruits and vegetable skins to enrich target foods such as baked foods, breakfast cereals etc. consequently; development of market for fiber-rich products and ingredients has been on the increase (Ajila & Prasadarao, 2013; Drzikova & Dongowski, 2005; O'Shea et al., 2012)

The bakery industries are one of the largest organized food industries all over the world and particularly cakes are one of the most popular products (Sindhuja, Sudha., & Rahim, 2005). Bakery products are generally used as a source for incorporation of different nutritionally rich ingredients for their diversification (Sudha, Vetrimani, & Leelavathi, 2007). Cake is one of the relished and palatable baked products prepared from flour, sugar, shortening, baking powder, egg, essence as principal ingredients. Cake is consumed daily by many people and contains 10–20% fat and 27–42% sugar (FSANZ, 2006). Baking of cake consist of three different steps. In the initial step, batter expansion and moisture loss occur which is followed by further moisture loss and volume rise reaching to a maximum final step where air pockets are captured inside a cake. The tiny air bubbles in the batter will only be released into the aqueous phase when fat melts during baking. These air bubbles will grow when the leavening gas is released during baking from the decomposing baking powder. This leavens the product until its structure is set when the starch in the batter gelatinizes and forms a starch gel (Sahi & Alava, 2003; Sakiyan, Sumnu, Sahin, & Bayram, 2004). Baked products provide an excellent opportunity to incorporate food-grade fractions from grains, legumes or other indigenous food sources. High cost of wheat flour in non-wheat producing countries such as Nigeria poses a problem to bakery industries and consumers of baked products (Chinma, Abu, & Adani, 2012). Nigeria is currently one of the world's largest importers of wheat flour (United States Department of Agriculture, 2014). The present high cost of baked products in Nigeria presents the need to further study on incorporation of indigenous food sources for baking, as this will help reduce total dependence on wheat flour.

Plantain (*Musa paradisiaca*) is an important staple food in Central and West Africa, which along with bananas provides 60 million people with 25% of their calories. According to FAO (2004), over 2.11 million metric tons of plantains are produced in Nigeria annually. The unripe plantain has been documented as hypoglycemic plant, as it has been noted for its low sugar, as such used in the management of diabetic complications. Plantains are also reported to be a great source of calcium, vitamins A, B1, B2, B3, B6, C and minerals such as potassium and phosphorus (Egbebi & Bademosi, 2011). When processed into flour it is used traditionally for preparation of gruel, which is made by mixing the flour with appropriate quantities of boiling water to form a thick paste (Mepba, Eboh, & Nwaojigwa, 2007). The use of PF for production of baked goods if feasible would help to lessen our total dependence on imported wheat.

Watermelon (*Citrullus lanatus*) is a quintessential summer snack that is fat free, very low in sodium. The red flesh of watermelon is high in lycopene, a powerful antioxidant that protect your body from certain types of cancer and heart disease. Lycopene is characterized by its distinctive red color in fruits and vegetable (Mutanen & Pajari, 2011).

Watermelon is a very rich source of vitamins and serves as a good source of phytochemicals (Perkins-Veazie & Collins, 2004). Besides vitamins (A, B, C and E), mineral salts (K, Mg, Ca and Fe), and specific amino acids (citrulline and arginine), watermelon provides a wide variety of dietary antioxidants such as carotenoids and phenolics (Perkins-Veazie, Collins, & Clevidence, 2007). Watermelon rind prevents the sweeter flesh from spoiling and contains additional Vitamin C, fiber, potassium and a small amount of vitamin B.

Watermelon rinds are edible and contain many hidden nutrients, but most people avoid eating them due to their unappealing flavor. They are sometimes used as vegetable. In China, they are stir-fried, stewed or more often pickled. Pickled watermelon rind is commonly consumed in the Southern US (Rattray And Diana, 2012). Eating the rind allows us to use all the edible part of the watermelon, and it reduces food waste. Watermelon rind seen as waste can be converted to flour by cutting thick slices of the rind from the watermelon fruit, drying and milling it to powdery form. The flour can then be incorporated into bakery products to make diverse nutritionally enhance baked foods. The objective of the study is to process watermelon rind into flour by drying and milling it, and then incorporating it into PF to produce high-fiber cake.

2. Material and methods

2.1. Collection of samples
Matured green plantain fruit (*Musa paradisiaca*) was purchased from Osiele market, Abeokuta, Ogun state, Nigeria. Watermelon fruits were purchased from Asero market, Abeokuta, Ogun state, Nigeria. Cake ingredients such as sugar, margarine, baking powder, vanilla extract and eggs were gotten from a catering store at Camp, Abeokuta, Ogun state, Nigeria.

2.2. PF preparation
The matured green plantain fruits bunch was cut into individual fruits, defingered and weighed. The plantain was washed, peeled and cut round slices using a manual slicer. About 5 g of Sodium Metabisulfite ($Na_2S_2O_5$) was dissolved in 5 l of water, the plantain slices were poured into the prepared Sodium metabisulfite for 5 min. The sulfited slices was then drained with a sieve and then packed into a muslin bag. A hot water bath was heated to 60°C and the muslin bag containing the sulfited pulp was blanched in hot water for 1 min. The blanched plantain pulp was then dried in the hot air oven at 60°C for 24 h to obtain dry chips, the dried chips was milled using the milling machine.

2.3. WF preparation
The watermelon fruit was thoroughly washed to remove sand particles after which it was sliced using a home choice knife. The pulp was carefully scraped off to obtain the rind, which was sliced into small chips with a manual slicer. The rind chips were weighed and dried with Genlab Drying Cabinet at 60°C for 48 hr. After drying, the dried watermelon chips were weighed before milling into powdered flour.

2.4. Processing of cake samples
The proportion of ingredients used consists of flour (100 g), egg (100 g), sugar (100 g), vanilla (three drops), baking powder (1.7 g), water (80 ml) and margarine (80 g). The baking procedure

described by Ceserani, Kinkton, and Foskett (1995) was adopted. The flour was made of a composite mixture of PF and WF in varying proportions (100% Plantain flour, 90:10, 80:20, 70:30, 60:40 and 50:50; Plantain: Watermelon rind flour). The dry ingredients were weighed and mixed thoroughly. The vanilla extract and water were added, and all ingredients was incorporated together thoroughly. The dough was cut out and baked in greased pans in the oven at 160°C for 1 hr.

2.5. Proximate determination of the flour

The proximate compositions of the flour were determined using the procedure of (AOAC, 2006). Moisture content, protein, crude fat, ash and crude fiber. Total carbohydrate was determined by the difference.

2.6. Pasting properties of the flour

It was determined using the Rapid Visco Analyzer (Newport scientific). About 3.5 g of the sample was weighed to the nearest 0.01 g into a weighing vessel prior to transfer into the text canister. About 2.5 of distilled water was dispensed into test canister. The sample was transferred onto the water surface in the canister. A paddle was placed into the canister and its blade was rigorously jogged through the sample up and down 10 times. Jogging was repeated, to ensure that the samples remaining on the water surface or on the paddle were well dissolved. The paddle and canister assembly were inserted firmly into the paddle coupling so that the paddle is properly centered. The measurement cycle was initiated by depressing after initiation and terminated automatically.

From the recorded viscosity, the following parameters was read: peak viscosity through holding Strength breakdown set back final viscosity, peak time and pasting temperature.

3. Functional properties determination of plantain and watermelon flour blends

3.1. Bulk density determination

This was determined using the method described by Wang and Kinsella (1976). About 10 g of the samples was weighed into a 50 ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top for several times until there was no more decrease in volume. The volume of the compacted sample was recorded, and the bulk density was calculated as follows:

Calculation:

$$\text{Bulk density } (\text{g/mg or g/cm3}) = \frac{\text{weight of sample}}{\text{Volume of sample after tapping}}$$

3.2. Swelling power and solubility

This was determined using the method described by Leach, Mccowan, and Schoch (1957). One gram of sample was weighed into a 100 ml conical flask; 15 ml of distilled water was added and mixed gently at low speed for 5 min. The slurry was heated in a thermostat water bath at 40 min. During heating, the slurry was stirred gently to prevent lumps forming in the starch. The content was then transferred into pre-weighed centrifuge tubes and 7.5 ml distilled water was added. The tube containing the paste was centrifuged at 2,200 rpm for 20 min using SORVALL GLC—1 centrifuge (model 06470, USA). The supernatant was decanted immediately after centrifuging into a pre—weighed can and dried at 100°C to constant weight. The weight of the sediment was taken and recorded.

Calculation:

$$\text{Swelling power} = \frac{\text{weight of sediment}}{\text{Sample weight} - \text{weight of soluble}}$$

$$\text{Solubility index } (\%) = \frac{\text{weight of soluble}}{\text{Weight of sample}} \times 100$$

3.3. Water absorption capacity (WAC)

This was determined using the method described by Sosulski (1962). To 1 g of the sample, 15 ml of distilled water was added in a pre-weighed centrifuge tube. The tube with its content was agitated on a flask Gallenkamp shaker for 2 min and centrifuged at 4,000 rpm for 20 min on a SORVALL GLC-1 centrifuge (Model 06470, USA). The clear supernatant was discarded, and the centrifuge tube weighed with the sediment. The amount of water bound by the sample was determined by difference and expressed as the weight of water bound by 100 g dry of flour.

Calculation:

$$\% \text{ water absorption capacity } = \frac{\text{final weight} - \text{initial weight of sample}}{\text{Weight of sample}} \times 100$$

3.4. Dispersibility

This was determined by the method described by Kulkarni, Kulkarni, and Ingle (1991). About 10 g of flour was suspended in 100 ml measuring cylinder and distilled water was added to reach a volume of 100 ml, the set up was stirred vigorously and allowed to settle for 3 h. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage Dispersibility.

$$\text{Dispersibility } (\%) = 100 - \text{volume of settled particle}$$

3.5. Texture profile analysis of the cake

The texture profile analysis of cake samples (2.5 cm) from the midsection of the cakes was performed using a texture analyzer (TexVol, TVT-300XPH, Perten Instru) with a 36 mm diameter cylindrical probe, 50% compressing and a test speed of 1.0 mm s^{-1}. The crust of cake samples was removed in cake texture determination. A double cycle was programmed, and the texture profile was determined using Texture Expert 1.05 software. Other parameters were defined as: pre-test speed 2.0 mm s^{-1}, post-test speed 2.0 mm s^{-1} and trigger force 5 g. The texture parameters recorded were Stringiness, cohesiveness, adhesiveness, springiness, resilience, gumminess and chewiness, and the texture parameter of cake was averaged from two replications.

3.6. Color determination of the cake

To measure the color of samples a Konica Minolta colorimeter was used based on (CIE) L*, a*, b* scale. After calibrating the instrument by covering a zero-calibration mask (CM-A124) followed by white calibration plate (CM-A120), samples were analyzed by placing it on the petri dish (CM-A128) and covered with a black container. The color attributes, that is Hunter lightness (L*), redness (a*) yellowness (b*), hue angle and chroma values was recorded by using the Spectro magic software version V.3.61G (Minolta Co., Ltd, CyberChrome, Inc). The hue angle ranged 0–360, where 0° indicates as red, 90° indicated yellow, 180°indicates green and 270° indicates blue color.

3.7. Sensory evaluation of high fiber cake

Cake samples were subjected to sensory evaluation. The produced cake was subjected to sensory evaluation by 25 untrained panelists consisting students of the College of Food Science and Human Ecology, Federal University of Agriculture, Abeokuta. The evaluation was conducted in a sensory laboratory under fluorescent light and ambient temperature using a 9-point hedonic scale as described by (Iwe, 2002). Panelists evaluated the sensory properties of the cake samples based on their degree of like (scale of 1–9) where 1 = dislike extremely, 2 = dislike very much, 3 = dislike moderately, 4 = dislike slightly, 5 = neither like nor dislike, 6 = like slightly, 7 = like moderately, 8 = like very much, 9 = like extremely (Wichchukit & O'Mahony, 2014). The sensory attributes evaluated are color, appearance, taste, sweetness, texture and overall acceptability

3.8. Statistical analysis
The data generated was analyzed using the analysis of variance (ANOVA). Least significant difference (LSD) and Duncan separation was used to separate the mean at $P < 0.05$.

4. Results and discussion

4.1. Proximate composition of plantain and watermelon rind composite flour
Table 1 gives the changing in characteristics of PF when varying degree of WF is added. Moisture is an important parameter to be measured for the bakery products as it significantly affects their textural quality, chemical and biochemical reactions, and microbiological spoilage. The moisture content increases as the percentage of WF increases from 0 to 50%. This ranged from 6.66 to 10.21%. Moisture content has implication on the shelf stability of food products, therefore, the sample 50% PF and 50% WF with the highest moisture content will therefore be more susceptible to deteriorative changes during storage. The dry matter content decreases significantly from 93.35 to 89.80%. This goes in line with the result of the level of moisture content as WF increases. This shows that there is more moisture in watermelon rind flour. The decrease in dry matter content also signifies that there will be decrease in the volume of the flour that will be gotten as more volume of WF is added to plantain flour. There was an increase in crude protein (2.20–15.14%) which helps to improve the nutritional quality of the cakes, fat (1.44–2.63%), and a decrease in carbohydrate (83.69–66.64%) showing the WF has low carbohydrate content. There was a decrease in crude fiber as the substitution of watermelon rind increased from 0 to 50% (4.64–2.95%), this indicates that the composite flour of plantain and WF is low in fiber as compare with previous studies. The result observed in the present study was in accordance with the study done by Asif-Ul-Alam, Islam, Hoque, and Monalisa (2014). Ash is the mineral material in flour, ash ranged from 1.36 to 2.44%, the result of the sample 100:0 (1.36%) goes in line with the results of (Ahenkora, Kyei, Marfo, & Banful, 1998; Ketiku, 1973) who reported that plantains contain low quantities of minerals. However, the ash does not affect baking performance of flour.

4.2. Functional properties of plantain and watermelon rind composite flour
Functional properties are those characteristics that govern the behavior of nutrients in food during processing, storage and preparation as they affect food quality and acceptability (Onwuka, 2005). The functional properties of the composite flour of plantain and WF are presented in Table 2. The water absorption capacity has a significant ($P < 0.05$) increase as the volume of WF increases from 0 to 50%. The values ranged from 2.15 to 2.93%. This means, as more WF is being added to plantain flour, there is increase in their water absorption capacity. The water absorption capacity is a function of water holding ability of the flour sample. Water absorption capacity is important in bulking and consistency of products as well as in baking applications. Niba, Bokanga, Jackson, Schlimme, and Li (2001) further described water absorption capacity as an important processing parameter that has implication for viscosity. Adebowale, Olu-Owolabi, Olayinka, and Olayide (2005), reported that at higher temperature, starch expands rapidly especially in the amorphous region. Expansion of the starch enables more water to be absorbed in the amorphous space of starch, which leads to a swelling phenomenon. Flours with high WAC find useful applications as functional ingredients in bakery products as this could prevent staling by reducing moisture loss (Obatolu, Fasoyiro, & Ogunsunmi, 2007). WAC is also important in the development of ready-to-eat foods and a high absorption capacity may assure product cohesiveness as reported by Houson and Ayenor (2002).

High bulk density is desirable for reducing shipping and packaging costs as it implied that lesser packaging material would be required, as bulk density gives an indication of the relative volume of packaging material required (Dairy Products Technology Center, 2001). There was no significance change in the bulkiness of the mixture. The values for the bulk density of the composite flour ranged

Table 1. Proximate composition of plantain and watermelon rind composite flour

PF:WF %	Moisture Content (%)	Dry Matter (%)	Fat (%)	Ash (%)	Crude Fiber (%)	Crude Protein (%)	Carbohydrate Content (%)
100:0	6.66^{a}	93.35^{c}	1.44^{a}	1.36^{a}	4.64^{f}	2.20^{a}	83.69^{f}
90:10	7.27^{a}	92.74^{c}	1.70^{b}	1.44^{b}	4.20^{e}	7.49^{b}	77.91^{e}
80:20	8.48^{b}	91.53^{b}	1.90^{c}	1.71^{c}	4.03^{d}	9.33^{c}	74.57^{d}
70:30	8.91^{b}	90.60^{ab}	2.24^{d}	2.05^{d}	3.82^{c}	11.98^{d}	70.52^{c}
60:40	10.17^{c}	89.83^{a}	2.41^{e}	2.22^{e}	3.59^{b}	12.77^{e}	68.85^{b}
50:50	10.21^{c}	89.80^{a}	2.63^{f}	2.44^{f}	2.95^{a}	15.14^{f}	66.64^{a}

Mean values with different superscript letter(s) within the same column are significantly different ($P < 0.05$). PF = Plantain Flour and WF = Watermelon rind flour.

Table 2. Functional properties of plantain and watermelon rind composite flour

PF:WF %	WAC (%)	BD (g/m)	D (%)	SI (%)	SP (70°C) %	SP (80°C) %	SP (90°C) %	SP (100°C) %
100:0	2.15^{a}	0.69^{a}	0.89^{a}	27.49^{f}	5.92^{a}	12.59^{a}	15.63^{a}	18.64^{a}
90:10	2.34^{b}	0.73^{a}	1.11^{b}	25.87^{e}	9.13^{ab}	12.94^{ab}	16.31^{b}	19.57^{ab}
80:20	2.50^{c}	0.74^{a}	1.30^{c}	25.14^{d}	9.47^{ab}	13.18^{abc}	16.50^{bc}	19.83^{bc}
70:30	2.61^{d}	0.75^{a}	1.41^{d}	24.79^{c}	9.89^{b}	13.50^{bcd}	16.90^{bc}	20.35^{bcd}
60:40	2.77^{e}	0.52^{a}	1.48^{e}	24.25^{b}	10.17^{b}	13.81^{cd}	17.11^{c}	20.84^{cd}
50:50	2.93^{f}	0.70^{a}	1.70^{f}	22.85^{a}	11.37^{b}	14.14^{d}	18.18^{d}	21.43^{d}

Mean values with different superscript letter(s) within the same column are significantly different ($P < 0.05$). PF = Plantain Flour and WF = Watermelon rind flour.

WAC = Water Absorption Capacity, BD = Bulk Density, D = Dispersibility, SI = Solubility Index, SP70 = Swelling Power at 70°C, SP80 = Swelling Power at 80°C, SP90 = Swelling Power at 90°C and SP100 = Swelling Power at 100°C.

from 0.52 to 0.75%. The bulk densities reported in this study are like those reported (0.83–0.85 g/ml) for cowpea-plantain-wheat flour blends (Akubor, Adamolekun, Oba, Obari, & Abudu 2003). Water solubility index measures the number of free molecules leached out from the starch granule in addition to excess water and thus reflects the extent of starch degradation (Onwuka, 2005). Dispersibility and Solubility Index were significant at $P < 0.05$. While dispersibility increases as the level of WF increases from 0.89 to 1.70%, the Solubility Index decreases from 27.49 to 22.85%. This means that increase in the substitution of PF with watermelon rind flour, increase the rate in which it can be dispersed by air/wind, while its solubility in water decreases as the substitution increases from 0 to 50%.

Baking flour is known for its swelling ability after being mixed with water and other ingredients. The table showed the swelling power at varying degree of substitution and at different degrees. Swelling power indicate the degree of exposure of the internal structure of starch granules to action of water, that is a measure of hydration capacity (Raules, Valencia, & Nair, 1993); this may indicate that the different drying methods tend to cause slight aggregation of starch granules to different degrees and subsequently affect the level of its exposure to water and its swelling power. The swelling power though increased as the level of watermelon increases from 0–50% at 70°C, the increase was not significantly different at $P < 0.05$. At 80°C and 100°C there were increase in the swelling power as the level of WF substitution increases from 0 to 50% and both were significantly different at $P < 0.05$. The swelling power increases from 12.59 to 14.14% and 18.64 to 21.43% at 80°C and 100°C, respectively. At 90°C, a substitution of PF with WF by 20% and 30% does not have any significant difference while substitutions at 10%, 40% and 50% were significantly different at $P < 0.05$.

4.3. Pasting properties of plantain and watermelon rind composite flour

The pasting properties of PF and WF are presented in Table 3. These properties of starch are used in assessing the suitability of its application as functional ingredients in food and other industrial products whereby the most important pasting characteristics is amylographic viscosity (Aviara, Onuh, & Ehiabhi, 2010). The pasting temperature ranged between 81.05 and 83.60°C with the lowest pasting temperature of 81.05°C for 100% Plantain flour. Pasting temperature is a measure of the least temperature required for cooking (Arisa, Adelekan, Alamu, & Ogunfowora, 2013), which can impact the stability of other components in a formula and energy cost. The measure of cooking time is also known as peak time. PF substituted with 10% WF had the lowest peak time (4.94 min) while the one substituted with 50% WF had the highest peak time (5.24 min). The pasting temperature and peak time were not significant at $P < 0.05$.

The maximum viscosity (peak viscosity) developed during or soon after the heating portion of the pasting test is lowest (195.79 RVU) in PF substituted with 50% WF and highest (453.63 RVU) in the

Table 3. Pasting properties of plantain and watermelon rind composite flour

PF:WF %	Peak Viscosity (RVU)	Trough (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Peak Time (min)	Pasting Temp (°C)
100:0	453.63^{d}	312.00^{d}	141.67^{a}	474.30^{d}	162.33^{b}	5.07^{ab}	81.05^{a}
90:10	428.75^{cd}	292.46^{cd}	136.30^{a}	443.00^{cd}	150.54^{ab}	4.94^{a}	81.95^{a}
80:20	367.13^{bc}	253.38^{cd}	113.75^{a}	393.05^{bc}	139.67^{ab}	5.00^{ab}	82.85^{a}
70:30	326.75^{b}	235.50^{bc}	91.25^{a}	373.09^{b}	137.59^{ab}	5.03^{ab}	83.15^{a}
60:40	239.00^{a}	171.50^{ab}	67.50^{a}	297.67^{a}	126.17^{ab}	5.07^{ab}	82.35^{a}
50:50	195.79^{a}	156.92^{a}	241.00^{a}	263.63^{a}	106.71^{a}	5.24^{b}	83.60^{a}

Mean values with different superscript letter(s) within the same column are significantly different ($P < 0.05$). PF = Plantain Flour and WF = Watermelon rind flour.

control sample (plantain flour). The peak viscosity is correlated with the final product quality and it is an indication of the viscous load likely to be encountered during mixing (Maziya-Dixon, Dixon, & Adebowale, 2004). Peak viscosity could be known through higher swelling index. The PF (control), PF substituted with 10%, 20% and 30% WF were significantly different ($P < 0.05$) but those substituted with 40% and 50% WF are not significant at $P < 0.05$. Trough, holding strength or hot paste viscosity is due to the accompanied breakdown in viscosity that is when the samples were subjected to a period of constant temperature (usually 95°C) and mechanical shear stress. The control (plantain flour) had the highest value of holding strength of 312 RVU while the PF substituted with 50% WF had the lowest value of 156.92 RVU. The trough values ranged between 156.92 and 312 RVU. All the values except those substituted with 10% and 20% WF are significant at $P < 0.05$.

The breakdown viscosity is an indication of breakdown or stability of the starch gel during cooking and lower values depict stability of the starch gel and it is the degree of disintegration of granules. The breakdown viscosities ranged between 67.50 and 241 RVU and the PF substituted with 40% WF had the lowest breakdown viscosity value of 67.50 RVU. Breakdown viscosities are not significantly different at $P < 0.05$ for all samples. The setback viscosity is the viscosity after 50°C cooling and it is the stage where retrogradation or reordering of starch molecules occurs. It has effect on digestibility (Arisa et al., 2013). The setback value for the control (plantain flour) is 162.33 RVU. The setback values range between 106.71 and 162.33 RVU with the lowest value being recorded in the PF substituted with 50% watermelon rind flour. Only the control and 50% WF are significantly different ($P < 0.05$). The final viscosity of the control had the highest value of 474.30 RVU and the PF substituted with 50% WF had the lowest value of 263.63 RVU. PF substituted with 40% and 50% WF are not statistically significant at $P < 0.05$ while the remaining four samples under final viscosity are significantly different ($P < 0.05$).

4.4. Proximate compositions of cake made from composite flour of plantain and watermelon rind

The proximate composition of cake made from composite flour of plantain and WF is presented in Table 4. The result depicts that there is significant difference ($P < 0.05$) in crude protein content for all the cakes. Proteins are building blocks of the body and foods that are rich in protein are known to reduce protein energy malnutrition. The cake produced from PF substituted with 50% WF has the highest value of protein (10.58%) and it is in line with the findings of Arisa et al. (2013) where the wheat biscuit had the highest value of protein (11.88%). These results are also close to the result of protein values for biscuits made from 100% millet by (Eneche, 1999) and within the results obtained by of Chinma and Gernah (2007) who reported protein contents (6.83–16.60%) of cookies produced from cassava/soybean/mango composite flours. The moisture content in the cake samples were only significantly different ($P < 0.05$) for 20% and 50% substitution of PF with watermelon rind flour. The moisture content values of the cake produced ranged between 30.23 and 44.69%. Results obtained in this study were not in line with the findings from Al-Sayed and Ahmed (2013). The authors reported that cake containing watermelon rind powder showed lower moisture content (23.26–25.24%) than the cake without addition of watermelon rind powder (27.04%). The ash content of the cake was significantly different ($P < 0.05$) for the control (plantain flour), 10%, 30% and 50% WF substitution respectively. It has the highest values of ash content (1.64%) at 50% level of substitution. The ash content may be associated with the presence of greater ash in the WF (13.09–19.13%), (Ho, Suhaimi, Ismail, & Mustafa, 2016) than in the plain flour or wheat flour (1.42%) (Noor Aziah, Lee Min, & Bhat, 2011). The high ash content of steamed cupcakes containing WF was also corresponded with the presence of a high mineral content (Omotoso & Adedire, 2007) in watermelon rind due to the minerals are less sensitive to heat and has less volatile properties. Fat plays a major role in determining the shelf life of foods. The fat content of the cake was not significantly different at $P < 0.05$ across all the samples. The fat values ranged between 5.77 and 7.58%. Hanan, Al-Sayed, and Abdelrahman (2013) reported that the fat content of cake samples was not significantly affected by substituting the flour with watermelon rind and Sherlyn melon peel powder. These results agree with (Hanaa & Eman, 2010). There was a significant difference ($P < 0.05$) in crude fiber of 50% substitution of PF with WF, which has the lowest value of 3.89%. According to Sengkhamparn, Chanshotikul, Assawajitpukdee, and Khamjae

Table 4. Proximate compositions of cake made from composite flour of plantain and watermelon rind

PF:WF %	Moisture Content (%)	Dry Matter (%)	Fat (%)	Ash (%)	Crude Fiber (%)	Crude Protein (%)	Carbohydrate (%)
100:0	36.78^{ab}	63.22^{ab}	6.55^{a}	1.12^{a}	4.52^{c}	1.81^{a}	49.23^{b}
90:10	31.75^{ab}	68.26^{ab}	7.58^{b}	1.29^{b}	4.27^{bc}	4.47^{b}	50.65^{b}
80:20	30.23^{a}	69.78^{b}	7.47^{b}	1.45^{c}	4.52^{c}	7.66^{c}	48.66^{b}
70:30	38.61^{ab}	61.39^{ab}	6.28^{a}	1.40^{bc}	4.10^{ab}	8.58^{cd}	41.04^{ab}
60:40	38.69^{ab}	61.31^{ab}	6.49^{a}	1.51^{c}	4.02^{ab}	9.38^{d}	39.93^{ab}
50:50	44.69^{b}	55.31^{a}	5.77^{a}	1.64^{d}	3.89^{a}	10.58^{e}	33.19^{a}

Mean values with different superscript letter(s) within the same column are significantly different ($P < 0.05$). PF = Plantain Flour and WF = Watermelon rind flour.

(2013), the degradation of pectin or other fiber (i.e., cellulose or hemicelluloses) occurred during drying process and hence reduced the crude fiber content of dried sample. The result observed in the present study was in accordance with the study done by Asif-Ul-Alam et al. (2014). The dry matter content decreases as more PF is being substituted with WF except for 10% and 20% levels of substitution. About 50% level of substitution was significantly different at $P < 0.05$ and had the least dry matter content level (55.31%). The higher the moisture content the lower the amount of dry solids in flour (A. O.A.C, 2005). Carbohydrate content is not significantly different at $P < 0.05$ except the sample with 50% substitution of PF with watermelon rind flour. Values observed for the carbohydrate content of the cookies in this study are similar to those reported by Falola, Olatidoye, Balogun, and Opeifa (2011), for cookies produced using cassava flour and cucurbitamixta seed flour blends. Generally, it could be concluded that cakes containing the WF had a good chemical composition, that is ash and protein.

4.5. Texture analysis of cakes produced from composite flour of plantain and watermelon rind

In texture profile analysis (Table 5), the hardness (peak force) of the samples measured showed fluctuation with increase in substitution of PF with WF from 0 to 50%. The hardness of the cakes was directly related to the density and indirectly to its volume. The peak force is not statistically significant at $P < 0.05$. Noor Aziah et al. (2011) reported that texture is likely to be associated to product volume, whereby, the firmness is inversely proportional to volume of the products. These results were on par with the specific volume results, with higher specific volume producing a softer crumb texture. The weight of samples was not significantly different among any of the cakes in this study. Thus, the increase in hardness was mainly related to the volume of these cakes. Resilience is the ratio of recoverable energy as the first compression is relieved. It ranged from 0.21 to 0.39. The results shown are not significantly different in the cake resilience value. Springiness measures elasticity by determining the extent of recovery between the first and second compression. The springiness values of plantain cake with watermelon rind substitution were in the range of 0.71–0.85. Springiness of the cake samples significantly were reduced by addition of WF in their formulation. The springiness of cake was not significantly different ($P < 0.05$) except at 50:50 substitution. Chewiness is the product of gumminess and springiness and it is the amount of energy need to dismantle a food for swallowing. According to Henriques, Guiné, and Barroca (2012), the chewiness is strongly related to the hardness of the sample. The firmed the crumb texture, the longer time it needs to chew the food. These findings are in line with results of Hosseini, Seyedain Ardabili, and Kashaninejad (2018). The result showed inconsistent trend and are not statistically significant ($P < 0.05$) except those substituted with 50% WF which is significantly different ($P < 0.05$). It ranged from 377.00 to 969.00

Cohesiveness measures the internal resistance of food structure. Cohesiveness is the ability of a material to stick to itself (Hosseini et al., 2018). The cohesiveness value ranges from 0.35 to 0.75 and are statistically significant at $P < 0.05$. Adhesiveness is the ability to glue or cement to a surface. The values range between 1.19 and 482.92 and are not significantly different ($P < 0.05$). Gumminess is determined by hardness multiplied by cohesiveness. The gumminess values were between 544.00 and 1048.00. The results also showed that the increase in substitution of PF with watermelon rind flour, the decrease in its stickiness. Cake samples substituted with WF were not significantly different at ($P < 0.05$) except at 40% and 50% substitution. A report by Wang, Zhang, and Adhikari (2015) also showed similar trend for breads with addition of fibers since they caused an increase in gumminess and chewiness of tested breads. Overall, while stickiness, springiness and cohesiveness decrease with increase substitution, other textural properties showed inconsistent values.

4.6. Color analysis of cakes produced from composite flour of plantain and watermelon rind

The results of color analysis of cake produced from PF and WF are presented in Table 6. The color is being affected as the PF is being replaced by the watermelon rind flour. The control (plantain flour) had the lightest, the most reddish and yellowish color with values of 33.62, 11.13 and 14.03 respectively. As the substitution of WF increases, the values decrease indicating a darker, reduced redness and

https://doi.org/10.1080/23311932.2019.1631582

Table 5. Texture analysis of cakes produced from composite flour of Plantain and watermelon rind

PF:WF %	Peak Force	Stringiness	Chewiness (g)	Resilience	Adhesiveness	Peak time (min)	Gumminess (g)	Stickiness	Springiness	Cohesiveness
100:0	1358.50^{a}	1.10^{a}	898.50^{b}	0.39^{a}	1.19^{a}	6.92^{a}	1004.00^{ab}	−4.00^{a}	0.85^{b}	0.75^{d}
90:10	1600.50^{a}	0.80^{a}	891.50^{b}	0.30^{a}	1.19^{a}	6.71^{a}	1048.50^{ab}	−5.50^{a}	0.85^{b}	0.66^{bcd}
80:20	1426.50^{a}	2.43^{ab}	815.00^{b}	0.32^{a}	10.45^{a}	6.88^{a}	948.00^{ab}	−10.00^{a}	0.85^{b}	0.67^{cd}
70:30	1673.00^{a}	4.57^{b}	823.50^{b}	0.26^{a}	160.33^{a}	6.79^{a}	1010.50^{ab}	−52.50^{a}	0.83^{ab}	0.61^{bc}
60:40	2324.00^{a}	2.34^{ab}	969.00^{b}	0.21^{a}	4.85^{a}	6.16^{a}	1229.50^{b}	−17.00^{a}	0.79^{ab}	0.53^{b}
50:50	1506.50^{a}	7.90^{c}	377.00^{a}	0.33^{a}	482.92^{a}	6.30^{a}	544.00^{a}	−77.50^{a}	0.71^{a}	0.35^{a}

Mean values with different superscript letter(s) within the same column are significantly different ($P < 0.05$). PF = Plantain Flour and WF = Watermelon rind flour.

Table 6. Color analysis of cakes produced from composite flour of plantain and watermelon rind

PF:WF %	L*	a*	b*
100:0	33.62^{d}	11.13^{f}	14.03^{f}
90:10	31.73^{c}	8.89^{e}	13.32^{e}
80:20	29.36^{b}	7.92^{d}	10.36^{d}
70:30	28.89^{a}	7.18^{c}	8.55^{c}
60:40	28.79^{a}	6.41^{b}	7.61^{b}
50:50	28.99^{a}	5.49^{a}	7.39^{a}

Mean values with different superscript letter(s) within the same column are significantly different ($P < 0.05$). PF = Plantain Flour and WF = Watermelon rind flour.

L* = Degree of lightness

a* = Degree of redness

b* = Degree of yellowness

reduced yellowness of the cake. This is in alienation with the study of Hosseini et al. (2018) who posited that for crumb color, as the level of pumpkin powder increased, the *L** value decreased but the *a** and *b** value increased, indicating that a darker, redder and yellow crumb was obtained because of pumpkin powder substitution. Redness and yellowness levels are significantly different at $P < 0.05$ while the control, 10% and 20% substitution of PF with WF were significant ($P < 0.05$) for the degree of lightness.

In general, the substitution of PF with WF leads to reduction in degree of lightness, redness and yellowness of the cake.

4.7. Sensory analysis of cakes produced from composite flour of plantain and watermelon rind

The results of sensory evaluation are presented in Table 7. The cakes sensory properties observed were color, texture, appearance, sweetness, flavor and overall acceptability. To provide both reliable and valid results for sensory attributes measurements, an, hedonic scale is a unique scale for measuring product liking and preference (Hosseini et al., 2018). The appearance of the cake produced from PF and WF was not significant at $P < 0.05$. The control (plantain flour) was significantly different ($P < 0.05$) in cake color, the 10%, 40% and 50% substitution of PF with WF were significantly different ($P < 0.05$) in color. The cake produced from PF and 10% substitution was the highest rated among the panelist and statistically significant ($P < 0.05$) in terms of flavor. Those substituted with 40% and 50% WF were also statistically significant at $P < 0.05$ but lowly rated by the consumers.

There was no significant difference ($P < 0.05$) in texture for the control, 20% and 30% substitution of PF with watermelon flour respectively. The plantain cake substituted with 10%, 40% and 50% were significantly different at $P < 0.05$ for texture. Sweetness of the cake were statistically significant ($P < 0.05$) in plantain cake substituted with 10%, 40% and 50% WF respectively. There was significant difference ($P < 0.05$) in terms of overall acceptability for 10%, 30% 40% and 50% PF substituted with WF respectively. This is in line with the findings of Arisa et al. (2013). Cakes produced from 90:10% substitution had higher mean score for all attributes when compared to other samples.

The substitution of 10% of WF showed the highest score rating by the panelist in overall acceptability (7.60) compared to all WF-incorporated cakes, although all formulated cakes were acceptable, since they received scores higher than 4, ranging from 5.20 to 7.60. It could be concluded that WF can be supplemented (up to 10%) during preparation of cakes. Knuckles, Hudson, Chiu, and Sayre (1997) reported that in sensory evaluation, products with score value of more than five, on 9-point hedonic scale, for overall acceptability can be considered as a good quality product.

Table 7. Sensory analysis of cakes produced from composite flour of plantain and watermelon rind

PF:WF %	Color	Texture	Appearance	Sweetness	Flavor	Overall Acceptability
100:0	6.80^{b}	7.04^{bc}	6.72^{ab}	6.80^{bc}	6.92^{bc}	7.28^{cd}
90:10	7.72^{c}	7.28^{c}	7.40^{b}	7.20^{c}	7.00^{c}	7.60^{d}
80:20	7.12^{bc}	6.88^{bc}	7.36^{b}	6.88^{bc}	6.80^{bc}	6.96^{cd}
70:30	6.92^{bc}	6.68^{bc}	6.84^{ab}	6.28^{bc}	6.24^{bc}	6.52^{bc}
60:40	6.28^{ab}	6.12^{ab}	6.28^{a}	5.92^{ab}	5.84^{b}	5.88^{ab}
50:50	5.80^{a}	5.56^{a}	5.96^{a}	4.96^{a}	4.72^{a}	5.20^{a}

Mean values with different superscript letter(s) within the same column are significantly different ($P < 0.05$). PF = Plantain Flour and WF = Watermelon rind flour.

5. Conclusion

This study provided the recipe for the formulation of cake with PF and WF that could be acceptable by consumers. The sensory characteristics revealed that substitution of 10% WF with PF for cake production was satisfactory because it has the highest rating by panelist in terms of color, texture, appearance, sweetness, flavor and overall acceptability. The substitution of WF has caused the increased to crude protein and ash contents of the cakes. but the stickiness, springiness and cohesiveness properties decreased However, The color analysis indicated that as the level of WF increased, the L*, a*and b* values decreased, indicating that a darker, redder and yellow crumb color was obtained because of watermelon rind substitution This made the cakes from composite flours to be more nutritious and acceptable than the 100% PF cake.

Funding
The authors received no direct funding for this research.

Author details
M. O. Adegunwa[1]
E-mail: moadegunwa@gmail.com
I. O. Oloyede[1]
E-mail: itunesjay16@gmail.com
L. A. Adebanjo[1]
E-mail: lukaadebanjo@gmail.com
E. O. Alamu[2]
E-mail: oalamu@cgiar.org
ORCID ID: http://orcid.org/0000-0001-6263-1359
[1] Department of Hospitality and Tourism, Federal University of Agriculture, Abeokuta, Nigeria.
[2] Food and Nutrition Sciences Laboratory, International Institute of Tropical Agriculture (IITA), Southern Africa Research and Administration Hub (SARAH), P.O. Box 310142, Chelston, Lusaka, Zambia.

Citation information
Cite this article as: Quality attribute of plantain (*Musa paradisiaca*) sponge-cake supplemented with watermelon *(Citrullus lanatus)* rind flour, M. O. Adegunwa, I. O. Oloyede, L. A. Adebanjo & E. O. Alamu, *Cogent Food & Agriculture* (2019), 5: 1631582.

References

A.O.A.C. (2005). *Official methods of analysis of the association of official analytical chemist, 16th*. Virginia, USA: Published by the Association of Official Analytical Chemist Arlington.

A.O.A.C. (2006). *Official methods of analysis of the association of official analytical chemist, 18th*. Virginia, USA: Published by the Association of Official Analytical Chemist Arlington.

Adebowale, K. O., Olu-Owolabi, B. I., Olayinka, O. O., & OLAYIDE, S. L. (2005). Effect of heat moisture treatment and annealing on physicochemical properties of red sorghum starch. *African Journal of Biotechnology*, 4(9), 923–933.

Ahenkora, K., Kyei, M. A., Marfo, E. K., & Banful, B. (1998). Nutritional composition of false horn Apantuba plantain during ripening and processing. *Journal of Food Chemistry*, *1*, 455–458.

Ajila, C. M., & Prasadarao, U. J. S. (2013). Mango peel dietary fibre; Composition and associated bound phenolics. *Journal of Functional Foods*, *5*, 444–450. doi:10.1016/j.jff.2012.11.017

Akubor, P. I., Adamolekun, F. O., Oba, C. O., Obari, H., & Abudu, J. I. (2003). Chemical composition and functional properties of Cowpea and Plantain flour blends for cookies production. *Plant Foods for Human Nutrition*, *56*, 105–115.

Al-Sayed, H. M. A., & Ahmed, A. R. (2013). Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fiber and antioxidants in cake. *Annals of Agricultural Sciences*, *58*, 83–95. doi:10.1016/j.aoas.2013.01.012

Arisa, N. U., Adelekan, A. M. I. N. A. T. O., Alamu, A. D. E. D. I. R. A. N. E., & Ogunfowora, E. B. U. N. O. L. U. W. A. J. (2013). Effect of pretreatment of plantain (Musa Parasidiaca) flour on the pasting and sensory characteristics of Biscuit Product. *Pakistan Journal of Food Sciences*, *23*(1), 43–51.

Asif-Ul-Alam, S. M., Islam, M. Z., Hoque, M. M., & Monalisa, K. (2014). Effects of drying on the physicochemical and functional properties of green banana (Musa sapientum) flour and development of baked product. Ame. *Journal of Food Science and Technology*, *2*(4), 128–133.

Aviara, N. A., Onuh, O. A., & Ehiabhi, S. A. (2010). Physical properties of Mucuna flagellipes nuts. *Seed Science and Biotechnology*, *4*, 59–68.

Ceserani, V., Kinkton, R., & Foskett, D. (1995). *Practical cooking* (8th ed.). London: Holder and Stronghton.
Chen, M. F. (2011). The mediating role of subjective health complaints on willingness to use selected functional foods. *Food Quality and Preference*, *22*, 110–118.
Chinma, C. E., Abu, J. O., & Adani, O. P. (2012). Proximate composition, physical and sensory properties of non-wheat cakes from Acha and Bambara nut flour blends. *Nigerian Journal of Nutritional Sciences*, *33*(1), 711.
Chinma, C. E., & Gernah, D. I. (2007). Physicochemical and sensory properties of cookies produced from cassava/soyabean/mango composite flours. *Journal of Food Science and Technology*, *5*(3), 256–260.
Dairy Products Technology Center. (2001). *Dairy ingredients fax: Bulk density*. San Luis Obispo: California Polytechnic State University.
Devries, J. W. (2010). Validation official methodology commensurate with dietary fiber research and definitions. In J. W. van der Kamp, J. Jones, B. McCleary, & D. Topping (Eds.), *Dietary fiber: New frontiers for food and health* (pp. 29–48). The Netherlands: Wageningen Academic Publishers.
Drzikova, B., & Dongowski, G. (2005). Dietary fiber-rich oat-based products affect serum lipids, microbiota formation of short-chain fatty acids and steroids in rats. *British Journal of Nutrition*, *94*(6), 1012–1025.
Egbebi, A. O., & Bademosi, T. A. (2011). Chemical composition of ripe and unripe banana and plantain. *International Journal of Tropical Medicine and Public Health*, *3*(2), 18–22.
Eneche, H. E. (1999). Biscuit making potentials of millet/pigeon pea flour blends. *Plant Foods for Human Nutrition*, *54*, 21–27.
Falola, A. O., Olatidoye, O. P., Balogun, I. O., & Opeifa, A. O. (2011). Quality characteristics of cookies produced from composite flours of cassava and cucurbita mixta seed. *Journal of Agriculture and Veterinary Sciences*, *3*, 1–12.
FAO - Food and Agricultural Organization. (2004). *Food and agricultural indicators. FAO (2005)*. Rome: ESSA.
FSANZ. (2006). *Food standards Australia and New Zealand*. NUTTAB 2006 Online Version.
Hanaa, A. H., & Eman, F. M. (2010). Functional attribute of chick pea and defatted soybean flour blends on quality characteristics of shortening cake. *European Journal of Applied Science*, *2*(2), 44–50.
Hanan, M. A., Al-Sayed, A., & Abdelrahman, R. A. (2013). Utilization of watermelon rinds and sharlyn melon peels as a natural source of dietary fiber and antioxidants in cake. *Annals of Agricultural Science*, *58*(1), 83–95. doi:10.1016/j.aoas.2013.01.012
Henriques, F., Guiné, R. P. F., & Barroca, M. J. (2012). Influence of drying treatment on physical properties of pumpkin. *Croatian Journal of Food Technology, Biotecnology and Nutrition*, *7*(Special Issue), 53–58.
Ho, L. H., Suhaimi, M. A., Ismail, I., & Mustafa, K. A. (2016). Effect of different drying conditions on proximate compositions of red- and yellow-fleshed watermelon rind powders. *Journal of Agrobiotechnology*, *7*, 1–12.
Hossain, M. A., & Rahman, S. M. M. (2011). Total phenolics, flavonoids and antioxidant activity of tropical fruit pineapple. *Food Res. Int*, *44*, 672–676.
Hosseini, G. H. A. B. O. O. S. S. H., Seyedain Ardabili, S. M., & Kashaninejad, M. (2018). Physico-chemical, textural and sensory evaluation of sponge cake supplemented with pumpkin flour. *International Food Research Journal*, *25*(2), 854–860.
Houson, P., & Ayenor, G. S. (2002). Appropriate processing and food functional properties of maize flour. *African Journal of Science and Technology*, *3*(1), 126–131.
Iwe, M. O. (2002). *Handbook of sensory methods and analysis*. Uwani-Enugu: Rejoint communication service limited.
Ketiku, A. O. (1973). Chemical composition of unripe plantain (Musa Paradisiaca). *Journal of the Science of Food and Agriculture*, *24*, 703–707.
Knuckles, B. E., Hudson, C. A., Chiu, M. M., & Sayre, R. N. (1997). Effects of β-glucan barley fractions in high-fiber bread and pasta. *Cereal Food World*, *42*(2), 94–99.
Kulkarni, K. D., Kulkarni, D. N., & Ingle, U. M. (1991). Sorghum malted and soya bean weaning food formulations: Preparation, functional properties and nutritive value. *Food and Nutrition Bulletin*, *13*, 322–327.
Leach, H. W., Mccowan, L. D., & Schoch, T. J. (1957). Structure of the starch granule: Swelling power and solubility patterns of different starches. *Cereal Chemistry*, *36*, 534–544.
Maziya-Dixon, B., Dixon, A. G. O., & Adebowale, A. A. (2004). Targeting different end uses of cassava: Genotypic variations for cyanogenic potentials and pasting properties. A paper presented at ISTRC-AB Symposium, 31 October – 5 November 2004, Whitesands Hotel, Mombassa, Kenya.
Mendis, E., & Kim, S. K. (2011). Present and future prospects of seaweeds in developing functional foods. In K. Se-Kwon (Ed.), *Advances in food and nutrition research* (pp. p1–15). Cambridge, MA: Academic Press.
Mepba, H. D., Eboh, L., & Nwaojigwa, S. U. (2007). Chemical composition, functional and baking properties of wheat – Plantain composite flours. *African Journal of Food, Agriculture, Nutrition and Development*, *7*(1), 4–5.
Mutanen, M., & Pajari, A. M. (2011). *Vegetables, whole grains, and their derivatives in cancer prevention*. Dordrecht: Springer. (eds.). Diet and cancer, Vol. 2.
Niba, L. L., Bokanga, M., Jackson, F. I., Schlimme, D. S., & Li, B. W. (2001). Physicochemical properties and starch granular characteristics of flour from various Manihot esculenta (cassava), genotype. *Journal of Food Science*, *67*, 1701–1705. doi:10.1111/j.1365-2621.2002.tb08709.x
Noor Aziah, A. A., Lee Min, W., & Bhat, R. (2011). Nutritional and sensory quality evaluation of sponge cake prepared by incorporation of high dietary fiber containing mango (Mangifera indica var. Chokanan) pulp and peel flours. *International Journal of Food Sciences and Nutrition*, *62*(6), 559–567.
O'Shea, N., Arendt, E. K., & Gallagher, E. (2012). Dietary fiber and phytochemical characteristics of fruit and vegetables byproducts and their recent application as novel ingredients in food products. In *Innovative food science and emerging technologies 16* (Vol. 2, pp 1–10). The Netherlands: Wageningen Academic Publishers.
Obatolu, V. A., Fasoyiro, S. B., & Ogunsunmi, L. O. (2007). Processing and functional properties of yam beans (Sphenostylis sternocarpa). *Journal of Food Processing and Preservation*, *31*(2), 240–249. doi:10.1111/j.1745-4549.2007.00112.x
Omotoso, O. T., & Adedire, C. O. (2007). Nutrient composition, mineral content and the solubility of the proteins of palm weevil, Rhynchophorus phoenicis. (Coleoptera: Curculionidae). *Journal of Zhejiang University-SCIENCE B (Biomedicine and Biotechnology)*, *8*(5), 318–322.
Onwuka, G. I. (2005). Food Analysis and Instrumentation. *Theory and Practice*, *5*, 1333–1334.
Perkins-Veazie, P., & COLLINS, J. K. (2004). Flesh quality and lycopene stability of fresh-cut watermelon.

Postharvest Biology and Technology, *31*, 159–166. doi:10.1016/j.postharvbio.2003.08.005

Perkins-Veazie, P., Collins, J. K., & Clevidence, B. (2007). Watermelons and health. *Acta Horticulturae (ISHS)*, *731*, 121–128. doi:10.17660/ActaHortic.2007.731.17

RATTRAY AND DIANA. (2012). Southern U.S. cuisine: Judy's pickled watermelon rind. *Food Science and Biotechnology*, *21*, 1633–1639. https://www.Southernfood.about.com.

Raules, J., Valencia, S., & Nair, B. (1993). Effect of processing on the physicochemical characteristics of guinea flour (Chenopodium guinea Wild). *Starch*, *46* (1), 13–19.

Sahi, S. S., & Alava, J. M. (2003). Functionality of emulsifiers in sponge cake production. *Journal of the Science of Food and Agriculture*, *83*, 1419–1429.

Sakiyan, O., Sumnu, G., Sahin, S., & Bayram, G. (2004). Influence of fat content and emulsifier type on the rheological properties of cake batter. *European Food Research and Technology*, *219*, 635–638. doi:10.1007/s00217-004-1020-4

Sengkhamparn, N., Chanshotikul, N., Assawajitpukdee, C., & KHAMJAE, T. (2013). Effects of blanching and drying on fiber rich powder from pitaya (Hylocereus undatus) peel. *International Food Research Journal*, *20*(4), 1595–1600.

Sindhuja, A., Sudha, M. L., & Rahim, A. (2005). Effect of incorporation of amaranth flour on the quality of cookies. *European Food Research and Technology*, *221*(5), 597–601. doi:10.1007/s00217-005-0039-5

Sosulski, F. W. (1962). The centrifuge methods for determining flour absorption in hard red spring wheat. *Cereal Chemistry*, *39*, 344–349.

Sudha, M. L., Vetrimani, R., & Leelavathi, K. (2007). Influence of fiber from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. *Food Chemistry*, *100*(4), 1365–1370.

Trinidad, P. T., Mallillin, A. C., Valdez, D. H., Loyola, A. S., Askali-Mercado, F. C., Castillo, J. C., … Chua, M. T. (2006). Dietary fiber from coconut flour: A functional food. *Innovative Food Science and Emerging Technologies*, *7*, 309–317. doi:10.1016/j.ifset.2004.04.003

United States Department of Agriculture. (2014). *Wheat imports by country in 1000MT*. Washinton, DC.

Wang, H. C., Zhang, M., & Adhikari, B. (2015). Drying of shiitake mushroom by combining freeze-drying and mid-infrared radiation. *Food and Bioproducts Processing*, *94*, 507–517.

Wang, J. C., & Kinsella, J. E. (1976). Functional properties of novel proteins: Alfalfa leaf protein. *Journal of Food Science*, *41*, 286–289. doi:10.1111/j.1365-2621.1976.tb00602.x

Wichchukit, S., & O'Mahony, M. (2014). The 9-point hedonic scale ranking in food science: Some reappraisals and alternatives. *Journal of the Science of Food and Agriculture*, *95*, 2167–2178. doi:10.1002/jsfa.6993