cogent food & agriculture

FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Quality evaluation of snack produced from black pepper (*Piper nigrum L.*), plantain (*Musa paradisiaca L.*), and tigernut (*Cyperus esculentus L.*) flour blends

Ebenezer Oluwaseun Adelekan, Mojisola Olanike Adegunwa, Abdulrasaq Adesola Adebowale, Henri Adegoke Bakare and Emmanuel Oladeji Alamu

Cogent Food & Agriculture (2019), 5: 1614285

cogent • oa

cogent food & agriculture

Received: 03 April 2019
Accepted: 26 April 2019
First Published: 06 May 2019

*Corresponding author: Emmanuel Oladeji Alamu, International Institute of Tropical Agriculture (IITA), IITA Ltd 7th Floor, Optivo House, 125 High Street, Croydon CRO 9XP, UK
E-mail: o.alamu@cgiar.org

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

Additional information is available at the end of the article

FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Quality evaluation of snack produced from black pepper (*Piper nigrum L.*), plantain (*Musa paradisiaca L.*), and tigernut (*Cyperus esculentus L.*) flour blends

Ebenezer Oluwaseun Adelekan[1], Mojisola Olanike Adegunwa[2], Abdulrasaq Adesola Adebowale[2], Henri Adegoke Bakare[3] and Emmanuel Oladeji Alamu*[3]

Abstract: Chin-chin has been identified to be one the favored food items and a much-relished pastry which has been eaten as dessert or snack. This study aimed at evaluating the nutritional quality and organoleptic properties of black-pepper enriched chin-chin produced from plantain-tigernuts composite flour. Matured plantains (Musa paradisiaca), tigernuts (Cyperus esculentus), and black pepper were processed into flour. Chin-chin was processed from different blends of plantain and tigernuts composite flour at the ratio of 100:0, 70:30, 60:40, 50:50, 40:60, 30:70, and 0:100 for plantain and tigernuts, respectively. Five percent (5%) black pepper spice was added to each of the samples for chin-chin production. Proximate, mineral and vitamin, compositions were determined using standard methods. The results of proximate composition of the different snack samples showed significant differences ($P < 0.05$) with values ranging from 6.50% to 10.00%, 4.45% to 6.75%, 2.25% to 32.75%, 1.33% to 2.00%, 3.50% to 6.13%, and 46.07% to 78.48% for moisture, protein, fat, ash, crude fibre, and carbohydrate contents, respectively. There was significant difference ($P < 0.05$) in the minerals and vitamins contents, and

ABOUT THE AUTHORS

Mojisola Olanike Adegunwa is a Senior Lecturer at the Federal University of Agriculture, Abeokuta, Ogun-State, Nigeria. She has PhD in Food Quality Control and Assurance and has 65 journal articles published in reputable local and foreign journals. Her research and contribution to knowledge focused on evaluating quality of foods using appropriate processing, fortification, and enrichment of foods especially roots and tuber crops and underutilized crops as well as nutritional enhancement of some traditional local foods in Nigeria.

Emmanuel Oladeji Alamu a Nigerian, is an Associate Scientist/Food Science and Technology at International Institute of Tropical of Agriculture (IITA), Zambia. He holds a doctorate degree in Food Chemistry with over 12 years of research experience and strong analytical skills in food science and nutrition and experienced in carrying out nutrition-sensitive agricultural research using different tools and techniques. He has many publications in local and foreign journals to his credit.

PUBLIC INTEREST STATEMENT

Our study adds value to the current food science and nutrition research that gave information on the nutritional and sensory properties of novel snack product from plantain-tigernuts flours spiced with black pepper. Recently, natural anti-oxidants are of special interest to scientists to cure cellular degeneration. Successful incorporation of black pepper into chin-chin production is expected to give a reasonable amount of antioxidant in the diets of its consumers. For a quick understanding of the importance of this study, the following results obtained have shown that:

Addition of tigernuts flour improved the proximate composition of the fried chin-chin.As the level of tigernuts flour substitution increases, the mineral and vitamin contents increase. This showed that tigernuts flour is richer in vitamins and mineral elements could, therefore, be considered a good supplement for plantain flour.Chin-chin of acceptable quality could be obtained from plantain-tigernuts composite flour.Black pepper could be successfully incorporated into the recipes as a spice.

© 2019 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

cogent • food & agriculture

organoleptic properties of the black pepper chin-chin samples. In conclusion, chin-chin of improved and acceptable nutritional and organoleptic properties could be obtained using plantain-tigernuts composite flour and black pepper spice for improved nutrition. This product could add to range of snacks available for those with special dietary needs.

Subjects: Food Additives & Ingredients; Food Chemistry; Chemistry

Keywords: Plantain flour; tiger-nut flour; black pepper; spiced-chin-chin; proximate composition

1. Introduction

In Africa, plantains and bananas provide more than 25% of the carbohydrate requirements for over 70 million people (UNCST, 2007). Nigeria is one of the largest plantain producing countries in the world (FAO, 2006). Plantains can be used for cooking at any stage of ripeness, and ripe plantain can be eaten raw. Green plantains are firm and starchy, and resemble potatoes in flavor. They can also be boiled, baked, micro waved, or grilled over charcoal, peeled or still in the peel. An average plantain has about 220 calories and is a good source of potassium and dietary fiber. Unripe plantain is traditionally processed into flour in Nigeria and in other west and central African countries (Ukhum & Ukpebor, 1991). The flour produced is mixed with boiling water to prepare an elastic pastry ("amala" in Nigeria and foufou or fufu in Cameroon) which is eaten with various sauces. Plantain flour is however gradually finding applications in weaning food formulation and composite flour preparations (Mepba, Eboh, & Nwaojigwa, 2007; Olaoye, Onilude, & Idowu, 2006).

Tigernut (*Cyperus esculentus*) is an underutilized crop in the family of Cyperaceae, which produces rhizomes from the base and tubers that are somewhat spherical. It has been reported to be high in dietary fiber content (Anderson, Smith, & Gustafson, 1994) and it has been demonstrated to be a rich source of quality oil and contains moderate amount of protein. It is also an excellent source of some useful minerals such as iron and calcium (Oladele & Aina, 2007) and rich in vitamins E and C (Rita, 2009; Adegunwa, Adelekan, Adebowale, Bakare, & Alamu, 2017). It also contains a reasonable amount of methionine lacking in plantain, making it a good supplement for plantain (Ogazi et al., 1996; Adegunwa et al., 2017). Different kinds of products are obtained from tigernut which includes; tigernut flour, tigernut oil, tigernut milk, "Dakuwa" and "kunu" and some of them can be eaten as snack (Gambo & Da'u, 2014). Tigernut flour is considered good flour or additive for the bakery industry, as its natural sugar content is high, avoiding the necessity of adding too much extra sugar (Anderson et al., 1994). Although, many researchers have worked on tigernut (De Vries, 1991; Cortes, Esteve, Frigola, & Torregrosa, 2005; Bamigbola, Awolu, & Oluwalana, 2016; Adegunwa et al., 2017), yet there is need for increased utilization and awareness about its health benefits.

Black pepper (*Piper nigrum*) is famous as the spices king due to its pungent quality (Srinivasan, 2007). It is a member of family *Piperaceae* (Abbasi et al., 2010; Ahmad et al., 2010). The genus piper has more than 1000 species but the most well-known species are *P. nigrum, P. longum*, and *P. betle. P. nigrum* fruits are also used to produce white pepper and green pepper and are valued due to the presence of piperine including its different isomers (Zaveri, Khandhar, Patel, & Patel, 2010). Black pepper can be used for different purposes such as human dietaries as medicine, as preservatives, as biocontrol agents (Srinivasan, 2007; Awen, Ganapati, & Chandu, 2010; Hussain, Naz, Nazir, & Shinwari, 2011). This plant and its active component piperine can stimulate the digestive enzymes of pancreas and intestines and increases biliary bile acid secretion when orally administered (Tiwari & Singh, 2008). *P. nigrum* possesses antioxidant activity which is probably due to the presence of flavonoids and phenolic contents (Ahmad et al., 2010). Black pepper is antimicrobial (Wongpa, Himakoun, Soontornchai, & Temcharoen, 2007). The effect of intake of peppercorn in food items and oral administration of active compounds of genus piper such as piperine, piperamides, piperamines, and pipene on the enzyme's activation of pancreas, liver, and the terminal digestive enzymes of the small intestinal mucosa has been reported (Awen et al., 2010; Tiwari & Singh, 2008). Addition of piperine to food substances as food additives increases lipase activity, pancreatic amylase activity, chymotrypsin activation, and protease activity (Srinivasan, 2007).

Wheat flour has been solely used to produce deep fat fried and baked products such as bread, cakes, buns, doughnuts, chin-chin, and biscuit. This is because of the nature and functional properties of the wheat flour proteins. But, local climatic conditions in tropical countries such as Nigeria are not suitable for profitable wheat production. Since 1960, much research aimed at incorporating nonwheat materials of local origin on bread and other flour product was undertaken to limit wheat import (Gomez, House, Rooney, & Dendy, 1992). The difficulties in the use of nonwheat flour to produce baked goods due to the deficiency of gluten a viscoelastic protein necessitate the search for products which do not require the leavening action of gluten. Such products are mostly deep fat fried products like buns and chin-chin (Opara, Edem, & Anierobi, 2013). Chin-chin is a fried snack popular in West Africa. It is sweet, hard, doughnut-like baked or fried dough of wheat flour, and other customary baking items. Chin-chin may also contain cowpeas (Akubor, 2004). Many people also bake it with ground nutmeg for flavor. It is usually kneaded and cut into small squares of 1 square inch or so, about a quarter of an inch thick, before frying (Mepba et al., 2007). As such chin-chin is easily one of the most favored food item, a much-relished African pastry which could serve as a dessert, snack, and as a popular street food. In fact, it enjoys a very special place in the heart as well as stomachs of West African population (Mepba et al., 2007). Recently, natural antioxidants are of special interest to scientists to cure cellular degeneration (Ahmad, Fazal, Ayaz, Mohammad, & Fazal, 2011; Obinna, Nwodo, Olayinka, Chinwe, & Kehinde, 2009). Successful incorporation of black pepper into chin-chin production is expected to provide a reasonable amount of antioxidant in the diets of its consumers. This study therefore aimed at determining the acceptability of black pepper incorporated chin-chin as well as to evaluate some quality attributes of chin-chin produced from plantain-tigernuts composite flour.

2. Materials and methods

Tigernuts (*Cyperus esculentus*) yellow variety, black pepper and matured green ripe and wholesome fruits of plantain, was purchased from Kuto market, Abeokuta. Ingredients of chin-chin such as margarine, sugar, salt, nutmeg, egg, and vegetable oil were also purchased from the same market.

3. Tigernut and plantain flours processing

The method described by Adegunwa et al. (2017) was used in the preparation of tigernut and plantain flours. The dried tigernuts and plantain were milled and sieved through 600 µm mesh size sieve. The resultant flour was packed and sealed in polythene bags.

4. Black pepper flour processing

Black pepper flour was prepared from fresh fruits of fully ripe black pepper (*P. nigrum*) by water steeping and retting technique described by Omafuvbe and Kolawole (2004) with slight modification. Essentially, ripe pepper berries were washed with tap water, packed in muslin bags, and soaked in a basin of water for 7 days with daily changes of the steeping water. Retted pepper berries were de-skinned by rubbing with hands and washed in running water. De-skinned berries were dried in the oven at 40°C until a moisture content of 10–12% was achieved (Purseglove, Brown, Green, & Robbins, 1981). The dried nuts were milled and sieved through 250 µm aperture size. The resultant flour was packed and sealed in polythene bags.

5. Composite flour preparation

Plantain flour (PF) and tigernut flour (TF) were blended with different combination manually (Table 1).

6. Processing of chin-chin

Table 2 shows the ingredients composition for the production of chin-chin. Flour and salt were sieved first into a bowl. Then margarine was mixed together with flour evenly. Egg, sugar, and other ingredients were added to make stiff dough. The stiff dough was rolled tightly to 1 cm thickness on a board and cut into cubes. Cut dough was fried in deep hot vegetable oil until golden brown coloration was obtained. The fried chin-chin were drained, cooled, and packaged.

7. Determination of proximate composition

Proximate composition: protein, ash, moisture content, crude fat, crude fiber, and carbohydrate were determined according to the official method of analysis described by the Association of Official and Analytical Chemist (A.O.A.C., 2005).

8. Mineral analysis

Five grams (5 g) of each sample was heated gently over a Bunsen burner flame until most of the organic matter was destroyed. This was further heated strongly in a muffle furnace for several hours until white-gray ash was obtained. The ash material was cooled. About 20 ml of distilled water and 10 ml of dilute hydrochloric acid was added to the ashed material. This mixture was boiled, filtered into a 250 ml volumetric flask, washed thoroughly with hot water, cooled and made up to volume. Mineral content of each sample was analyzed using Atomic Absorption Spectrophotometer (PYE Unicon, UK, model SP9) (A.O.A.C., 1995). Some mineral elements determined include: potassium, magnesium, phosphorus, calcium, and iron.

9. Vitamin analyses

Vitamins A (Retinol) and B1 (Thiamine) were determined using A.O.A.C. (2005) method and described by Adegunwa et al. (2017), while Vitamin E (Tocopherol) was determined using A.O.A.C. (1995) method.

10. Ascorbic acid (vitamin C)

Ascorbic acid was determined by dyestuff titration method Oladeji, Akanbi, and Gbadamosi (2013). Sample (5 g) was digested by 0.4% oxalic acid. The aliquot was titrated against dyestuff, which was previously standardized by standard ascorbic acid solution, and the ascorbic acid content was calculated using the following expression.

$$\text{Vitamin C (mg/100g)} = \frac{\text{Titre value X 0.606 X 100}}{\text{Weight of Sample}}$$

11. Sensory attributes of the chin-chin

The sensory attributes of the chin-chin were obtained by using simple hedonic tests as described by Larmond (1991). This was done using a 20-member panel comprising of students of the Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, who were familiar with the sensory attributes of chin-chin. Evaluation indexes include Appearance, crispness, crunchiness, taste, color, flavor, and overall acceptance. Each panellist was asked to score each attribute on a 9-point hedonic scale where 9 and 1 represent "like extremely" and "dislike extremely", respectively.

12. Statistical analysis

The mean ± standard deviation of the result data from the experiment was calculated and analyzed using single factor ANOVA in the statistical package for social science software (SPSS version 17.0 for windows). The Duncan multiple range test was used to separate the differences in the mean scores at significant level of $P = 0.05$. Pearson correlation analysis was carried out on the functional properties of the flour and the sensory properties of the fried chin-chin.

13. Results and discussions

Table 3 shows the results of the chemical composition of fried chin-chin. Significant ($P < 0.05$) differences existed in the moisture, ash, protein, fat, and total carbohydrate contents of the fried chin-chin. As expected, the ash, protein, fat, and crude fiber content increased as the percentage of tigernuts flour substitution increases, while moisture and carbohydrate increased with increase in plantain flour substitution. The ash content of the fried chin-chin ranged between 1.67% ±

Table 1. Different treatment for composite flour preparation

Treatment	Plantain flour (%)	Tigernut flour (%)	Sample code
T1	100	0	A
T2	0	100	B
T3	70	30	C
T4	60	40	D
T5	50	50	E
T6	40	60	F
T7	30	70	G

Table 2. Ingredients composition for chin-chin production

Ingredients	Weight
Flour	200 g
Fat	4 g
Sugar	40 g
Salt	2 g
Sodium bicarbonate	2 g
Egg	50 g
Water	20 ml
Nutmeg	4 g
Black pepper spice	10 g

Source: Evelyn (2007) with slight modification.

Table 3. Proximate composition of plantain-tigernut black pepper spiced chin-chin

Sample moisture (%)	Crude protein (%)	Crude fat (%)	Ash (%)	Crude fiber (%)	CHO (%)	
A	5.09 ± 0.12^{a}	5.43 ± 0.25^{d}	9.87 ± 0.06^{g}	1.67 ± 0.00^{b}	3.64 ± 0.02^{e}	74.41 ± 0.33^{a}
B	4.25 ± 0.35^{b}	7.18 ± 0.25^{c}	14.34 ± 0.56^{f}	1.70 ± 0.04^{b}	4.49 ± 0.02^{d}	68.06 ± 0.10^{b}
C	3.49 ± 0.23^{c}	7.37 ± 0.10^{bc}	19.91 ± 0.41^{e}	1.70 ± 0.04^{b}	4.56 ± 0.06^{d}	62.94 ± 0.68^{c}
D	3.17 ± 0.24^{cd}	7.44 ± 0.00^{bc}	22.62 ± 0.17^{d}	1.70 ± 0.04^{b}	4.64 ± 0.17^{d}	60.44 ± 0.06^{d}
E	3.17 ± 0.24^{cd}	7.47 ± 0.04^{bc}	25.67 ± 0.47^{c}	1.87 ± 0.28^{b}	5.29 ± 0.13^{c}	56.54 ± 1.16^{e}
F	3.09 ± 0.12^{cd}	7.64 ± 0.03^{b}	30.07 ± 0.11^{b}	1.86 ± 0.20^{b}	5.64 ± 0.09^{b}	51.71 ± 0.09^{f}
G	2.84 ± 0.23^{d}	9.57 ± 0.09^{a}	35.25 ± 0.35^{a}	2.53 ± 0.21^{a}	6.28 ± 0.11^{a}	43.55 ± 0.40^{g}

Values are means and standard deviation (±) of replicate determination. Values with different superscript in the same column are significantly different at $P < 0.05$. Sample: A: 100% plantain flour, B: 70% plantain flour and 30% tigernut flour, C: 60% plantain flour and 40% tigernut flour, D: 50% plantain flour and 50% tigernut flour, E: 40% plantain flour and 60% tigernut flour, F: 30% plantain flour and 70% tigernut flour, and G: 100% tigernut flour.

0.00% and 2.53% ± 0.21%, with chin-chin made from 100% tigernut flour having the highest mean value. Ash gives an indication of inorganic elements that are present in a food as minerals. Ash content of the chin-chin were high, indicating that the chin-chin were likely to be good sources of mineral elements. The ash contents of the chin-chin samples obtained in this study were higher compared to the value (1.16 ± 0.00) reported for chin-chin made from 100% wheat flour by Falola, Olatidoye, Adesala, and Amusan (2014).

The fat content of the fried chin-chin ranged from 9.87% ± 0.06% to 35.25% ± 0.35%. The increased substitution of tigernuts flour increased the fat content of the fried chin-chin, which could be of nutritional concern; however, tigernuts fat has been reported to have health benefits (Adejuyitan, 2011; Sánchez-Zapata, Fernández-López, & Pérez-Alvarez, 2012). Tigernut oil has been reported to reduce low density lipoprotein-cholesterol (LDL-C) and increases high-density lipoprotein cholesterol (HDL-C) and, hence, reduces levels of triglycerides in blood and the risk of forming bloody clots, thereby preventing arteriosclerosis (Sánchez-Zapata et al., 2012). It also stimulates the absorption of calcium in bones and the production of new bony material due to presence of short and medium chain fatty acids, oleic acid, and essential fatty acids. It has a high oleic acid and low polyunsaturated fatty acid (linoleic acid and linolenic acid) (Ezebor, Igwe, Owolabi, & Okoh, 2005). It also has higher oxidative stability than other oils, due to the presence of polyunsaturated fatty acids and gamma-tocopherol (Ezebor et al., 2005). The oil was found to contain 18% saturated (palmitic acid and stearic acid) and 82% unsaturated (oleic acid and linoleic acid) (Zhang, Hanna, Yusuf, & Nan, 1996). Tigernuts oil has a monounsaturated profile (>60% monounsaturated fatty acids [MUFA]), with a similar fatty acid (FA) profile to olive oil (Sánchez-Zapata et al., 2012). Tigernut oil was considered a generally healthier alternative.

The moisture content of the chin-chin ranged from 2.84% ± 0.23% to 5.09% ± 0.12%. Moisture provides a measure of the water content and an index of storage stability of the food. Sanni, Adebowale, and Tafa (2006) reported that the lower the moisture content of a product to be stored the better the shelf stability of such products. Hence, low moisture ensures higher shelf stability of dried product. Therefore, the low moisture content of all the fried chin-chin makes them less liable to microbial attack than the raw material (plantain and tigernuts) and would have longer shelf stability. The protein content of the fried chin-chin ranged from 5.43% ± 0.25% to 9.57% ± 0.09%. The protein content of the chin-chin samples increased as the level of tigernuts flour substitution increases. The protein content of chin-chin made from 100% tigernuts flour obtained in this study was higher than the value (9.25% ± 0.07%) reported for chin-chin made from 100% wheat flour by Falola et al. (2014).

The crude fiber content of the fried chin-chin ranged from 3.64% ± 0.02% to 6.28% ± 0.11%. The crude fiber content of the fried chin-chin increased as the level of tigernuts flour substitution increases. The result of crude fiber content for chin-chin made from 100% tigernuts flour in this study is higher that the value (5.19%) reported for chin-chin made from 100% wheat flour by Adegunwa, Adebowale, Bakare, and Ovie (2014). Nutritional claims for dietary fiber foods (Official Journal of European Commission, 2012) recommended that for a product to be labeled as "source of fiber" it must contain >3 g dietary fiber/100 g food. Since the fried chin-chin samples obtained in this study contain more than 3 g dietary fiber/100 g, the fried chin-chin can be regarded as "source of dietary fiber." The carbohydrate content of the chin-chin samples ranged from 43.55% ± 0.40% to 74.41% ± 0.33%; the chin-chin produced from 100% plantain flour had the highest mean value. The results showed that the carbohydrate content decreased with increasing level of tigernuts flour substitution. The carbohydrate content of chin-chin made from 100% plantain flour obtained in this study was higher than the value (57.41%) reported for chin-chin made from 100% wheat flour by Adegunwa et al. (2014).

The results of the mineral composition of the fried chin-chin are shown in Table 4. The results show that there is significant difference ($P < 0.05$) in the mineral composition of the fried chin-chin. The magnesium content of the fried chin-chin ranges between 21.43 ± 0.11 and 32.28 ± 0.04 mg/100 g, while the phosphorus content ranges between 26.51 ± 0.83 and 113.62 ± 2.03 mg/100 g. There is increase in magnesium and phosphorus content of the chin-chin as the level of tigernuts flour substitution increases. This implied that chin-chin produced from 100% tigernuts flour has the highest magnesium and phosphorus content, while chin-chin produced from 100% plantain flour has the lowest mean value.

The potassium content of the fried chin-chin ranges between 64.89 ± 0.48 and 193.78 ± 6.50 mg/100 g. Chin-chin produced from 100% tigernuts flour has the highest mean value while chin-chin produced from 100% plantain flour has the lowest mean value. The Iron content of the fried chin-chin ranges from 0.14 ± 0.10 to 0.35 ± 0.06 mg/100 g. The Iron content of the fried chin-chin also increases as the level of tigernuts flour substitution increases. The Calcium content of the fried chin-chin ranges between 2.35 ± 0.07 to 7.03 ± 0.04 mg/100 g. Chin-chin produced from 100%

Table 4. mineral composition of plantain-tigernuts black pepper spiced chin-chin

Sample/ Component	Magnesium (mg/100 g)	Phosphorus (mg/100 g)	Potassium (mg/100 g)	Iron (mg/100 g)	Calcium (mg/100 g)
A	21.43 ± 0.11^{f}	26.51 ± 0.83^{g}	64.89 ± 0.48^{g}	0.14 ± 0.10^{d}	7.03 ± 0.04^{a}
B	24.34 ± 0.53^{e}	43.86 ± 0.23^{f}	95.42 ± 0.64^{f}	0.19 ± 0.01^{cd}	5.73 ± 0.07^{b}
C	26.86 ± 0.09^{d}	58.55 ± 0.64^{e}	118.18 ± 0.13^{e}	0.22 ± 0.01^{bc}	4.99 ± 0.01^{c}
D	28.98 ± 0.09^{c}	68.34 ± 0.55^{d}	138.20 ± 0.39^{d}	0.25 ± 0.01b	4.16 ± 0.09^{d}
E	31.07 ± 0.01^{b}	82.18 ± 0.04^{c}	148.60 ± 0.92^{c}	0.27 ± 0.00^{b}	3.86 ± 0.20^{e}
F	31.38 ± 0.68^{b}	95.02 ± 0.28^{b}	175.92 ± 0.13^{b}	0.33 ± 0.01^{a}	2.99 ± 0.21^{f}
G	32.28 ± 0.04^{a}	113.62 ± 2.03^{a}	193.78 ± 6.50^{a}	0.35 ± 0.06^{a}	2.35 ± 0.07^{g}

Values are means and standard deviation (±) of replicate determination. Values with different superscript in the same column are significantly different at $P < 0.05$. Sample: A: 100% plantain flour, B: 70% plantain flour and 30% tigernut flour, C: 60% plantain flour and 40% tigernut flour, D: 50% plantain flour and 50% tigernut flour, E: 40% plantain flour and 60% tigernut flour, F: 30% plantain flour and 70% tigernut flour, and G: 100% tigernut flour.

plantain flour has the highest mean value for Calcium, while chin-chin produced from 100% tigernuts flour has the lowest value.

The vitamin results of the fried chin-chin were shown in Table 5. The results show that there is significant difference ($P < 0.05$) in the vitamin composition of the fried chin-chin. The vitamin C content of the fried chin-chin ranges between 0.76 ± 0.21 and 2.27 ± 0.21 mg/100 g. Increase in the level of tigernuts flour substitution increases the vitamin C content of the chin-chin. The mean value of vitamin B1 content of the fried chin-chin ranges from 0.011 ± 0.00 to 0.015 ± 0.00 mg/100 g. Increase in the level of tigernuts flour substitution decreases the vitamin B1 content of the chin-chin.

The vitamin A content of the fried chin-chin ranges between 15.59 ± 0.72 to 53.26 ± 0.39 mg/100 g. There is increase in the vitamin A content of the chin-chin as the level of tigernuts flour substitution increases. This shows that tigernuts is richer in vitamin A than Plantain. The results of the vitamin E content ranges from 0.15 ± 0.01 to 5.35 ± 0.63 mg/100 g for the fried chin-chin. There is also increase in vitamin E content of the fried chin-chin as the level of tigernuts flour substitution increases. Generally, the results obtained in this study have shown that as the level of tigernuts flour substitution increases the mineral and vitamin contents increases. This indicated that tigernuts flour is richer in vitamins and mineral elements than plantain flour and could therefore be consider a good supplement for plantain flour.

Table 5. Vitamin composition of plantain-tigernut black pepper spiced chin-chin

Sample/ Component	Vitamin C (mg/100 g)	Vitamin B1 (mg/100 g)	Vitamin A (μg/100 g)	Vitamin E (mg/100 g)
A	0.76 ± 0.21^{d}	0.015 ± 0.00^{a}	15.59 ± 0.72^{f}	0.15 ± 0.01^{e}
B	1.14 ± 0.11^{cd}	0.014 ± 0.00^{ab}	18.92 ± 0.83^{e}	1.27 ± 0.02^{d}
C	1.29 ± 0.11^{c}	0.014 ± 0.00^{abc}	33.58 ± 0.53 ^{d}	2.48 ± 0.24^{c}
D	1.69 ± 1.84^{b}	0.013 ± 0.00^{bcd}	36.82 ± 0.47^{c}	2.83 ± 0.09^{c}
E	1.72 ± 1.49^{b}	0.012 ± 0.00^{cd}	38.12 ± 0.10^{b}	3.21 ± 0.32^{c}
F	1.90 ± 0.11^{ab}	0.011 ± 0.00^{d}	39.14 ± 0.30^{b}	4.27 ± 0.54^{b}
G	2.27 ± 0.21^{a}	0.011 ± 0.00^{d}	53.26 ± 0.39 ^{a}	5.35 ± 0.63^{a}

Values are means and standard deviation (±) of replicate determination. Values with different superscript in the same column are significantly different at $P < 0.05$. Sample: A: 100% plantain flour, B: 70% plantain flour and 30% tiger nut flour, C: 60% plantain flour and 40% tigernut flour, D: 50% plantain flour and 50% tigernut flour, E: 40% plantain flour and 60% tigernuts flour, F: 30% plantain flour and 70% tigernut flour, and G: 100% tigernut flour.

Table 6. Sensory properties of plantain-tigernut-black pepper spiced chin-chin

Sample	Appearance	Taste	Crispness	Flavor	Crunchiness	Color	Overall acceptability
A	7.35 ± 1.09^{a}	5.45 ± 2.14^{b}	6.75 ± 0.97^{a}	5.40 ± 1.79^{b}	7.25 ± 1.16^{a}	6.80 ± 1.11^{a}	6.55 ± 1.54^{a}
B	7.30 ± 0.92^{ab}	6.65 ± 1.63^{a}	6.55 ± 1.40^{a}	6.25 ± 1.29^{ab}	7.15 ± 0.81^{ab}	6.70 ± 1.03^{a}	7.15 ± 1.60^{a}
C	7.00 ± 1.08^{abc}	6.80 ± 1.71^{a}	6.45 ± 1.05^{a}	6.30 ± 1.53^{ab}	7.00 ± 0.86^{ab}	6.70 ± 1.22^{a}	7.00 ± 0.92^{a}
D	6.65 ± 0.99^{abc}	6.90 ± 1.02^{a}	6.55 ± 1.32^{a}	6.55 ± 1.10^{a}	6.65 ± 0.93^{ab}	6.70 ± 1.03^{a}	6.95 ± 0.95^{a}
E	6.60 ± 1.10^{bc}	6.90 ± 1.29^{a}	6.66 ± 1.54^{a}	6.75 ± 1.52^{a}	6.60 ± 1.10^{ab}	6.75 ± 1.83^{a}	7.10 ± 0.91^{a}
F	6.45 ± 0.69^{c}	7.00 ± 1.17^{a}	6.60 ± 1.10^{a}	6.90 ± 1.17^{a}	6.35 ± 1.73^{bc}	6.65 ± 1.09^{a}	7.05 ± 1.10^{a}
G	6.45 ± 1.28^{c}	7.30 ± 1.34^{a}	6.70 ± 1.46^{a}	7.00 ± 1.26^{a}	5.70 ± 1.38^{c}	6.65 ± 1.23^{a}	7.05 ± 1.50^{a}

Values are means and standard deviation (±) of replicate determination. Values with different superscript in the same column are significantly different at $P < 0.05$. Sample: A: 100% plantain flour, B: 70% plantain flour and 30% tigernut flour, C: 60% plantain flour and 40% tigernut flour, D: 50% plantain flour and 50% tigernut flour, E: 40% plantain flour and 60% tigernut flour, F: 30% plantain flour and 70% tigernut flour, and G: 100% tigernut flour.

Table 7. Pearson's correlation matrix between functional and sensory properties of chin-chin

Quality	WAC	OAC	BD	SI	FC	EA	CLR	TASTE	FLVR	CRISP	CRN
Parameters											
WAC	1.000										
OAC	0.956**	1.000									
BD	−0.624*	−0.766**	1.000								
SI	−0.870**	−0.943**	0.790**	1.000							
FC	−0.822**	−0.903**	0.851**	0.966**	1.000						
EA	−0.798**	−0.840**	0.721**	0.943**	0.948**	1.000					
CLR	0.169	0.111	0.355	−0.137	−0.019	−0.180	1.000				
TASTE	-0.695**	−0.767**	0.713**	0.670**	0.700**	0.533**	0.085	1.000			
FLVR	−0.650*	−0.781**	0.846**	0.734**	0.780**	0.610*	0.216	0.950**	1.000		
CRISP	0.083	0.105	−0.086	−0.004	−0.027	0.076	−0.071	−0.130	−0.173	1.000	
CRN	0.762**	0.803**	−0.712**	−0.855**	−0.889**	−0.893**	0.051	−0.500	−0.601*	0.163	1.000

**.Correlation is significant at the 0.01 level (two-tailed).
*.Correlation is significant at the 0.05 level (two-tailed).
EA–emulsifying activity, BD–bulk density, FC—foaming capacity, SI–solubility index, FLVR—sensory flavour, CRISP—crispness, CRN—crunchiness, WAC–water absorption capacity, OAC–oil absorption capacity, CLR–sensory color.

Table 6 shows the mean sensory scores for plantain-tigernuts black pepper spiced chin-chin. There were significant differences ($P < 0.05$) in terms of appearance, taste, flavor, and crunchiness. Meanwhile, no significant difference ($P < 0.05$) was observed in terms of color, crispiness, and overall acceptability. The mean value for the appearance of the chin-chin ranges from 6.45 ± 1.28 to 7.35 ± 1.09 mg/100 g, with chin-chin made from 100% plantain flour having the highest mean value and consequently, the most accepted in terms of appearance. The mean value scores of chin-chin in terms of taste and flavor ranges from 5.45 ± 2.14 to 7.30 ± 1.34 mg/100 g and 5.40 ± 1.79 to 7.00 ± 1.26 mg/100 g, respectively, with chin-chin produced from 100% tigernuts flour having the highest mean value and consequently the most accepted in terms of taste and flavor. Tigernut flour has been described as having good taste and distinct flavor, such that it is used as flavoring agent for ice cream and biscuit (Osagie & Eka, 1998).

The mean value scores for crunchiness ranges between 5.70 ± 1.38 to 7.25 ± 1.16 mg/100 g. The crunchiness of the fried chin-chin decreases as the level of tigernuts flour substitution increases. This shows that the chin-chin samples produced from 100% plantain flour is the crunchiest among the chin-chin samples.

The mean value scores for the chin-chin in term of color, crispiness, and overall acceptability ranges from 6.65 ± 1.23 to 6.80 ± 1.11 mg/100 g, 6.45 ± 1.05 to 6.75 ± 0.97 mg/100 g, and 6.55 ± 1.54 to 7.15 ± 1.60 mg/100 g, respectively. In terms of color and crispiness, chin-chin made from 100% plantain flour (sample A) has the highest values. However, there was no significant difference among the mean value score of the samples. In terms of overall acceptability, all the samples were accepted as there was no significant difference among the mean value scores for the samples. However, sample B produced from 70% plantain flour and 30% tigernuts flour has the highest mean value score for overall acceptability. The incorporation of black pepper spice into foods production is feasible as evident in the results obtained from this study and could improve food digestibility. The black pepper spiced chin-chin could therefore be used as an appetizer.

Correlation study of the relationship between functional properties of the composite flour samples and sensory qualities of the plantain-tigernuts black pepper spiced chin-chin indicated significantly ($P < 0.05$) high negative correlation ($r^2 = -0.78$) between oil absorption capacity and flavor, while emulsion activity compared with crunchiness indicated high negative significant ($P < 0.05$) correlation ($r^2 = -0.893$), as shown in Table 7. The negative association indicated that as the oil absorption capacity decreases, flavor increases while increasing emulsion activity decreases crunchiness.

14. Conclusion

This study has demonstrated the possibility of compositing plantain and tigernuts flour at varying proportions in the production of snacks (chin-chin). Increased substitution of tigernuts flour considerably enhanced the protein, fat, ash, the dietary fiber contents, mineral, vitamin content, and sensory properties (such as taste and flavor) of the snack (chin-chin). While increased substitution of plantain flour improves the carbohydrate content of the chin-chin. It also improves sensory properties such as crispiness and crunchiness and has the highest mean score in terms of appearance. This study has also shown successful incorporation of black pepper into snacks (chin-chin) production. This study has shown that incorporation of black pepper spice into chin-chin production will enhance commercial utilization of black pepper in food formulations.

Funding
The authors declare that there is no funding for this study.

Competing Interests
The authors declares no competing interests.

Author details
Ebenezer Oluwaseun Adelekan[1]
E-mail: bendelek046@gmail.com
Mojisola Olanike Adegunwa[2]
E-mail: moadegunwa@gmail.com
Abdulrasaq Adesola Adebowale[2]
E-mail: rasaq.debo@gmail.com
Henri Adegoke Bakare[3]
E-mail: bakare65@gmail.com
Emmanuel Oladeji Alamu
E-mail: o.alamu@cgiar.org[3]
ORCID ID: http://orcid.org/0000-0001-6263-1359
[1] Department of Food Science and Technology, Federal University of Agriculture, Abeokuta, Nigeria.
[2] Department of Hospitality and Tourism, Federal University of Agriculture, Abeokuta, Nigeria.

[3] Food and Nutrition Sciences Laboratory, International Institute of Tropical Agriculture (IITA), Southern Africa Hub, PO Box 310142, Chelstone, Lusaka, Zambia.

Cover Image
Source: Author.

Conflicts of Interest
The authors declare no conflict of interest.

Data availability
All the data for this study are used for data analysis and results are presented in this article.

Citation information
Cite this article as: Quality evaluation of snack produced from black pepper (*Piper nigrum L.*), plantain (*Musa paradisiaca L.*), and tigernut (*Cyperus esculentus L.*) flour blends, Ebenezer Oluwaseun Adelekan, Mojisola Olanike Adegunwa, Abdulrasaq Adesola Adebowale, Henri Adegoke Bakare & Emmanuel Oladeji Alamu, *Cogent Food & Agriculture* (2019), 5: 1614285.

References

A.O.A.C. (1995). *Official methods of analysis* (16th ed.). Arlington, VA: Association of Official Analytical Chemists.

A.O.A.C. (2005, August). *Official methods of analysis of the association of analytical chemists international* (18th ed.). Gathersburg, MD: Official methods.

Abbasi, B. H., Ahmad, N., Fazal, H., & Mahmood, T. (2010). Conventional and modern propagation techniques in Piper nigrum. *Journal of Medicinal Plants Resources*, 4, 007–012.

Adegunwa, M. O., Adebowale, A. A., Bakare, H. A., & Ovie, S. G. (2014). Compositional characteristics and functional properties of instant plantain-breadfruit flour. *International Journal of Food Research (IJFR)*, *1*, 1–7.

Adegunwa, M. O., Adelekan, E. O., Adebowale, A. A., Bakare, H. A., & Alamu, E. O. (2017). Evaluation of nutritional and functional properties of plantain (*Musa paradisiaca* L.) and tigernut (*Cyperus esculentus* L.) flour blends for food formulations. *Cogent Chemistry*, *3*, 1383707. doi:10.1080/23312009.2017.1383707

Adejuyitan, J. A. (2011). Tigernut processing: Its food uses and health benefits. *American Journal of Food Technology*, *6*(3), 197–201. doi:10.3923/ajft.2011.197.201

Ahmad, N., Fazal, H., Abbasi, B. H., Rashid, M., Mahmood, T., & Fatima, N. (2010). Efficient regeneration and antioxidant potential in regenerated-tissues of Piper nigrum L. *Plant Cell, Tissue and Organ Culture*, *102*, 129–134. doi:10.1007/s11240-010-9712-x

Ahmad, N., Fazal, H., Ayaz, M., Mohammad, I., & Fazal, L. (2011). Dengue fever treatment with Carica papaya leaves extracts. *Asian Pacific Journal of Tropical Biomedicine*, 330–333. doi:10.1016/S2221-1691(11)60055-5

Akubor, P. I. (2004). Protein contents, physical and sensory properties of Nigerian snack foods (cake, chinchin and puff-puff) prepared from cowpea-wheat flour blends. *International Journal of Food Science & Technology*, *39*(4), 419–424. doi:10.1111/ifs.2004.39.issue-4

Anderson, J. W., Smith, B. M., & Gustafson, N. J. (1994). Health benefits and practical aspects of high fibre diets. *American Journal of Clinical Nutrition*, *59*, 1242S–1247S. doi:10.1093/ajcn/59.5.1242S

Awen, B. Z., Ganapati, S., & Chandu, B. R. (2010). Influence of sapindus mukorossi on the permeability of ethyl cellulose free film for transedermal use. *Research Journal of Pharmacology, Biology and Chemical Sciences*, *1*, 35–38.

Bamigbola, Y. A., Awolu, O. O., & Oluwalana, I. B. (2016). The effect of plantain and tigernut flours substitution on the antioxidant, physicochemical and pasting properties of wheat-based composite flours. *Cogent Food & Agriculture*, *2*(1), 1245060. doi:10.1080/23311932.2016.1245060

Cortes, C., Esteve, M., Frigola, A., & Torregrosa, F. (2005). Quality characteristics of horchata (a Spanish vegetable beverage) treated with pulsed electric fields during shelf-life. *Food Chemistry*, *91*(2), 319–325. doi:10.1016/j.foodchem.2004.06.014

De Vries, F. T. (1991). Chufa (*Cyperus esculentus*, Cyperaceae): A weedy cultivar or a cultivated weed? *Economic Botany*, *45*, 27–37. doi:10.1007/BF02860047

Evelyn, N. B. (2007). Incorporation of peanut as a substitute for egg in a master mix of a pastry product: Composition and acceptability studies. *African Journal of Food Science*, *1*(1), 001–004.

Ezebor, F., Igwe, C. C., Owolabi, F. A. T., & Okoh, S. O. (2005). Comparison of the physico-chemical characteristics, oxidative and hydrolytic stabilities of oil and fat of *cyperus esculentus L*. and *butyrospermum parkii* (shea nut) from middle-belt states of nigeria. *Nigerian Food Journal*, *23*, 33–39.

Falola, A. O., Olatidoye, O. P., Adesala, S. O., & Amusan, M. (2014). Modification and quality characteristics of cocoyam starch and its potential for chin-chin production. *Pakistan Journal of Nutrition*, *13*(12), 768–773. doi:10.3923/pjn.2014.768.773

FAO. (2006). Food and agriculture organisation of the united nations. the state of food insecurity in the world. *Eradicating World Hunger – taking stock ten years after the World Food Summit*. Food and Agriculture Organization of the United Nations Viale delle Terme di Caracalla, 00153 Rome, Italy, ISBN 92-5-105580-7. Retrieved from http://www.fao.org/3/a-a0750e.pdf

Gambo, A., & Da'u, A. (2014). Tiger nut (Cyperus esculentus): Composition, products, uses and health benefits – a review. *Bayero Journal of Pure and Applied Sciences*, *7*(1), 56–61. doi:10.4314/bajopas.v7i1.11

Gomez, M. I., House, L. R., Rooney, L., & Dendy, D. (1992). *Proc. int. Symp. On Utilization of Sorghum and Millets ICRISAT*, Patancheru, 1–22.

Hussain, A., Naz, S., Nazir, H., & Shinwari, Z. K. (2011). Tissue culture of black pepper (*Piper nigrum L.*) in Pakistan. *Pakistan Journal of Bot*any, 43, 1069–1078.

Idolo, I. (2011). Sensory and nutritional quality of madiga produced from composite flour of wheat and sweet potato. *Pakistan Journal of Nutrition*, *10*(11), 1004–1007.

Larmond, E. (1991). *Laboratory methods for sensory evaluation of foods*. Ottawa, Canada: Canadian Agricultural publications. Series IV.

Mepba, D. H., 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), 1–22.

Obinna, N. C., Nwodo, S. C., Olayinka, O. A., Chinwe, O. I., & Kehinde, O. O. (2009). Antibacterial effects of extracts of ocimum gratissimum and piper guineense on escherichia coli and staphylococcus aureus. *African Journal of Food Science*, *3*, 077–081.

Official Journal of European Commission. (2012). *COMMISSION REGULATION (EU) No 1047/2012 of 8 November 2012; amending Regulation (EC) No 1924/2006 with regard to the list of nutrition claims*. doi:10.1094/PDIS-11-11-0999-PDN

Ogazi, P. O., Oyewusi, F. A., Ozumba, A. U., Ogundipe, H. O., Osifo, B. O. A., & Lukambi, F. A. (1996). Development and sensory evaluation of soyamusa: A soybean-plantain baby food. *ISHS Acta Hortic.*(p.540). International Conference on Banana and Plantain for Africa.

Oladeji, B. S., Akanbi, C. T., & Gbadamosi, S. O. (2013). Comparative studies of physico-chemical properties of yam (*discorea rotundata)*, cocoyam (*collocasia taro)*, breadfruit (*artocapus artilis*) and plantain (*musa parasidiaca*) instant flours. *African Journal of Food Science*, *7*(8), 210–215. doi:10.5897/AJFS12.150

Oladele, A. K., & Aina, J. O. (2007). Chemical composition and functional properties of flour produced from two varieties of tigernut (*Cyperus esculentus*). *African Journal of Biotechnology*, *6*, 2473–2476. doi:10.5897/AJB

Olaoye, O. A., Onilude, A. A., & Idowu, O. A. (2006). Quality characteristics of bread produced from composite flours of wheat, plantain and soybeans. *African Journal of Biotechnology*, *5*, 1102–1106.

Omafuvbe, B. O., & Kolawole, D. O. (2004). quality assurance of stored pepper (piper guineense) using controlled processing methods. *Pakistan Journal of Nutrition*, *3*(4), 244–249. doi:10.3923/pjn.2004.244.249

Opara, C. C., Edem, U. B., & Anierobi, B. U. (2013). Deep fat frying properties of malted sorghum buns with cassava and rice flour as binders. *Greener Journal of Agricultural Sciences*, *3*(2), 185–192.

Osagie, & Eka, (1998). *Nutrition quality of plants foods*. eds Osagie and Eka. Benin City Nigeria: Published by the Post-Harvest Research Unit of the Department of Biochemistry University of Benin.

Purseglove, J. W., Brown, E. G., Green, C. L., & Robbins, S. R. T. (1981). *Spices. Vol.1tropical agric.series.Uk*. London: Longman.

Rita, E. S. (2009). The use of tiger-nut (*cyperus esculentus)*, cow milk and their composite as substrates for yoghurt production. *Pakistan Journal of Nutrition*, *6*, 755–758.

Sánchez-Zapata, E., Fernández-López, J., & Pérez-Alvarez, J. A. (2012). Tiger nut (cyperus esculentus) commercialization: Health aspects, composition, properties, and food applications. *Comprehensive Reviews in Food Science and Food Safety*, *11*, 366–377. doi:10.1111/j.1541-4337.2012.00190.x

Sanni, L. O., Adebowale, A. A., & Tafa, S. O. (2006). Proximate, functional, pasting and sensory qualities of instant yam flour. *A Paper Presented at the 14 ISTRC Symposium, Central Tuber Crops the Research Institute*, Trivandrum, Kerala State,India.

Srinivasan, K. (2007). Black pepper and its pungent principle-piperine. A review of diverse physiological effects. *Critical Reveal of Food Science and Nutrition*, *47*, 735–748. doi:10.1080/10408390601062054

Tiwari, P., & Singh, D. (2008). Antitrichomonas activity of sapindus saponins, a candidate for development as microbicidal contraceptive. *Journal of Antimicrobial Chemotheraphy*, *62*, 526–534. doi:10.1093/jac/dkn223

Ukhum, M. E., & Ukpebor, I. E. (1991). Production of instant plantain flour, sensory evaluation and physico-chemical changes during storage. *Food Chemistry*, *42*(3), 287–299. doi:10.1016/0308-8146(91)90071-U

UNCST. (2007). The biology of bananas and plantains. *Uganda National Council for Science and Technology in collaboration with PBS – a US Agency for International Development (USAID)*. doi:10.1094/PDIS-91-4-0467B

Wongpa, S., Himakoun, L., Soontornchai, S., & Temcharoen, P. (2007). Antimutagenic effects of piperine on cyclophosphamide induced chromosome aberrations in rat bone marrow cells. *Asian Pacific Journal of Cancer Prevention*, *8*, 623–627.

Zaveri, M., Khandhar, A., Patel, S., & Patel, A. (2010). Chemistry and pharmacology of piper longum L. *International Journal of Pharmaceutical Science Review and Research*, *5*, 67–76.

Zhang, H. Y., Hanna, M. A., Yusuf, A., & Nan, L. (1996). Yellow nut-sedge (cyperus esculentus L) tuber oil as a fuel. *Industrial Crops and Products*, *5*(3), 177–181. doi:10.1016/0926-6690(96)89446-5

© 2019 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:
Share — copy and redistribute the material in any medium or format.
Adapt — remix, transform, and build upon the material for any purpose, even commercially.
The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:
Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.
You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.
No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

Cogent Food & Agriculture **(ISSN: 2331-1932) is published by Cogent OA, part of Taylor & Francis Group.**

Publishing with Cogent OA ensures:

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com