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Quality and Sensory Evaluation of Cookies Produced from Cassava, African Yam Beans, Sweet Potato and *Okoho* (*Cicuss populnea*) Flour Blends

Solomon Achimugu[1*], Aminat Okolo Shaibu[2], Ojonugwa Hafsat Yakubu[3], and Margaret Iye Ochimana[4]

[1]Department of Food, Nutrition and Home Science, Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria.
[2]Department of Food, Nutrition and Home Science, Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria.
[3]Department of Food, Nutrition and Home Science, Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria.
[4]Department of Food, Nutrition and Home Science, Prince Abubakar Audu University, Anyigba, Kogi State, Nigeria.
Corresponding author email: *solomonachimugu77@gmail.com*

ABSTRACT

This study was carried out on the physical, proximate, mineral composition and sensory properties of cookies produced from cassava, African yam beans, sweet potato and Okoho flour blends. Cookies were produced from different proportion of cassava flour, African yam beans flour, sweet potato and 10% Okoho flour blends and compared with wheat flour cookies. The physical properties, proximate, mineral and sensory properties were determined using standard methods and data was analyzed using One-Way ANOVA. The results of physical properties showed that cookies produced from 100% wheat flour had the highest mass, thickness, diameter and volume, while cookies from the blends of 50% cassava flour, 25% African yam beans, 25% sweet potato flour and 10% Okoho flour had the highest spread ratio. Addition of 50% African yam beans flour resulted into increased in the moisture, ash, fiber, fat and protein content of the cookies. The mineral composition result showed that cookies sample with 50% cassava flour had the highest significant values for sodium (50.80mg/kg), potassium (59.72mg/kg), calcium (189.62mg/kg), phosphorus 411.49mg/kg) and magnesium (85.61mg/kg). The sensory evaluation result also showed that no significant (p>0.05) difference was observed in cookies in terms of appearance, crispiness, flavour and aftertaste, however, cookies from 100% wheat flour had the highest rating for taste and overall acceptability. The study showed that production of cookies from the composite flour consisting of 25% Cassava, 50% African yam beans, 25% sweet potato and 10% Okoho flour produced a well-accepted cookie.

Keywords: *Cookies, Cassava, African Yam Beans, Sweet Potato, Okoho*

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INTRODUCTION

Cookies are wheat flour-based products produced from dough with the application of heat and transformed into an appetizing product (Obasi, *et al*., 2012; Ikuomola, *et al*., 2017). It forms part of the bakery products that are widely consumed worldwide by all ages (Sengev, *et al*., 2015). Cookies are ready to eat, Products for snacking that are affordable and nutritious (Adeyeye, and Akingbala, 2015). The principal ingredients are wheat flour, fat, sugar and water and optional ingredients include milk, salt, flavouring agent, aerating agent, food additives and others. Soft wheat flour has been the major ingredient used in the production of cookies but imported by countries with unfavorable climatic conditions such as Nigeria. The rise in imports may put the economy at risk, drive up the cost of these baked goods, and jeopardize food security. This makes it necessary to design a strategic plan for using low-cost local resources to produce cookies. Cassava (*Manihot esculenta Crantz*) the "food of the poor" has developed into a multifunctional crop that adapts to the challenges faced by developing nations, trends in the global economy, and of climate change (FAO, 2013). It is a nutty flavoured, starch-tuber in the spurge family (*Euphorbiaceae*) of plants. Advantages of cassava as a crop include flexibility in planting and harvesting time, drought tolerance and in addition to providing more nutritional energy per hectare and working hours than any other major crop, its capacity to thrive and produce in low-nutrient soils (Fregene, 2011). The major biochemical constituent in cassava is starch, it makes up between 65 and 70 percent of the dry content, and cassava is regarded as a beneficial and cheap source of carbohydrates. Its major limitation is the presence of cyanogenic glycosides (linamarin and lotaus-tralin). However, several studies have shown that these cyanogenic glycosides are easily removed because they are extremely soluble and volatile in water by processing methods such as drying, soaking, and fermentation (Oke, 2014). Certain cassava cultivars have naturally low levels of these cyanogenic glycosides, which makes them more useful in a variety of food formulations (Ubbor, 2016).

African Yam Bean (*Sphenostylis stenocarpa*) (AYB) belongs to the family *Febaceae*, is a lesser-known legume from tropical and sub-tropical regions of the world that has drawn attention recently. It is a significant legume in Africa with two food products: seeds and tubers (Jennifer, 2021). It is rich in carbohydrate, protein, vitamins and minerals (Iwuoha and Eke, 2016). The protein found in African yam beans is composed of more than 32% essential amino acids, with leucine and lysine making up the majority (Onyenekwe *et al*., 2011). African yam beam will result in more nutritious diet/snacks. It is a good source of protein, carbohydrate, minerals. African Yam Beans is high in phytochemicals and dietary fiber, both of which may be beneficial to health (Ndidi *et al*., 2014; Ojinnaka *et al*., 2017; Onuoha *et al*., 2017).

The main obstacles to the widespread use of African yam beans (AYBs) are their antinutrient levels and hardness, which require lengthy cooking times (Aremu and Ibirinde, 2012; Abioye *et al*., 2015). Therefore, it is crucial to discover other ways to use them than cooking in order to stop future neglect and encourage cultivation. In spite of all this, when African yam beans are used to manufacture composite flour for cookies, it will become easily accessible for consumption by everyone (Day, 2013).

Ipomoea batatas, sometimes known as sweet potato, is a dicotyledonous plant that is a member of the *Convolvulaceae* family, which also includes bindweed and morning glory. Its big, sweet-tasting, tuberous, starchy roots are used as a vegetable root. Sometimes the young branches and leaves are consumed as greens. The sweet potato, especially the orange variety, is often called a "yam" in parts of North America but is unrelated to true yams (Woolfe, 2012). Sweet potato cultivars have been bred to produce tubers with different colored meat and skin. Because sweet potato cultivars with dark orange flesh contain more beta-carotene, which when digested becomes a greater vitamin A content, their cultivation is being encouraged more in Africa, where vitamin A insufficiency is a severe health concern (Neela and Fanta, 2019). Sweet potato flour is substituted for regular flour for making gluten-free products and is used as a dough conditioner in baking. It has been shown to enhance the toasting qualities and nutrient composition, lessen staling, and provide baked goods like bread and biscuits a unique flavor (Adeyeye and Akingbala, 2015; Noorfarahzihah *et al*., 2014; Onabanjo and Ighere, 2014).

The growing expense of importing wheat and the challenges of growing wheat in tropical regions with adverse climates, like Nigeria, have drawn attention to the necessity of investigating the use of alternative local flours as supplements or replacements for wheat flour in the baking sector. An economic downturn, exorbitant costs for these baked goods, and a risk to food security could result from the rise in wheat imports. In order to produce cookies, it is necessary to strategically develop the utilization of low-cost local resources that have an optimal nutritional value and appropriate processing qualities.

MATERIALS AND METHODS

Materials

Cassava, African Yam Bean (AYB), Sweet Potato, *Okoho* and other ingredients such as sugar, margarine, egg, milk, preservative, flavor, nutmeg and baking powder were purchased from the local market in Anyigba, Dekina Local Government Area of Kogi State. Physical analysis, chemical composition and mineral contents of the samples were carried out using equipments in the Food Processing Laboratory of Prince Abubaka Audu Universiy, Anyigba Kogi State.

Methods

Preparation of cassava flour

The most widespread traditional unit operations involved in making cassava flour as described by Oke (2014) involves peeling, cutting roots to chunk/chipping into small pieces, washing, soaking in water or heaping fermentation (3-5days), draining or dewatering and sun dried for two or three days (or dried in a hot air oven at 55^0C). The chips were milled and sieved through 80μm mesh sieve. The flour was packaged in plastic or polyethylene bags for further use.

Preparation of African yam beans flour

African Yam Bean flour was prepared according to the methods described by Enwere (2013). The African Yam

Bean (AYB) was sorted and winnowed to remove all contaminants such as stones, pods, fragments, and immature beans. It was soaked in water for 12 hrs. and blanched for 15 minutes to reduce the anti-nutritional factors and bean flavour that might be present. The blanched African Yam Beans was dehulled and oven-dried at 55°C for 12 h., milled into flour, and sieved with a 80 µm aperture sieve to obtain fine African Yam Beans flour then packaged for further use.

Preparation of potato flour

The preparation of potato flour was done according to the method described by Etudaiye, and Aniedu (2018) with some modifications. This involves sorting, washing of fresh roots, peeling, slicing, washing, soaking (24 hours to leach out sugars), draining of water, drying (solar drying) of chips, milling, sieving to obtain fine flour and packaged for further use.

Preparation of *Okoho* (Cissus populnea) flour

The stems of *Ciccus populnea* was cut to 30 cm long, scraped, washed, shredded, dried (solar drying), pounded, milled into flour and sieved with muslin cloth to produce fine particles. It is then packaged and stored for further use (Balami, and Bangudu, 2012).

Preparation of cookies from the flour blends

The modified recipe of Onabanjo and Ighere (2014) after preliminary experimentation was adopted for the preparation of cookies: flour (250 g), fat (63 g), sugar (63 g), salt (1 g), whole egg (20 ml), powder milk (5 g), nutmeg (1.5 g), baking powder (1 g), and water (20–60 ml). Cookie (biscuit) was prepared using the traditional creaming method described by Chinma and Gernah (2013). The fat and sugar were mixed in a bowl until the mixture is fluffy. Eggs and milk were added, while mixing continues. All the dry ingredients such as baking powder, nutmeg, potato flour, cassava flour, African Yam Beans flour and pinch of salt were introduced into the mixture to form soft dough. The dough was removed from the bowl and kneaded on a flat surface to obtain a uniform mix. The kneaded dough was rolled out into sheets on a pastry board using a rolling pin and cut into the desired shapes using a cutter. The cut mass was transferred to a greased baking tray and baked at 180°C for 17 min then cooled for 30 minutes before packaged.

Analytical procedures

The various cookies samples (WWF, CFS1, CFS2 and CFS3) were analyzed for physical analysis, chemical composition, mineral contents and sensory characteristics in the Food Processing Laboratory in the Faculty of Agriculture, Prince Abubaka Audu Universiy, Anyigba Kogi State.

Physical analysis

The cookies were selected randomly for physical analyses (mass, diameter, thickness, spread ratio, and Density).

Weight/Mass

The weight of the cookies was taken after baking using a weighing balance. The average weight of 6 biscuits was noted.

Spread ratio

The spread ratio of cookies was determined by AACC method 10–52 (AACC International 2000). Six cookies were laid edge to edge and total diameter was measured using a ruler, then cookies were rotated and re-measured again and average of two measurements was calculated. For the thickness determination, six cookies were laid one over the other one, and thickness was measured using a calliper, cookies were rearranged and thickness was measured again, and average was taken. Spread ratios were calculated from the formula

$$\text{Spread ratio} = \frac{\text{Diameter}}{\text{Thickness}}$$

Density

The volume of the biscuits was determined by seed displacement. In this method measuring cylinder was filled with some rice grains. The grains were removed and a biscuit sample was put into the cylinder. The grains were now poured over the biscuit in the cylinder and leveled. The remaining grains were poured into a measuring cylinder and volume was obtained. Using the mass and volume measured, density of sample was calculated as shown below.

$$\text{Density (g/cm}^3\text{)} = \frac{\text{mass}}{\text{volume}}$$

Proximate analyses

Proximate analyses (moisture, protein, fat, crude fibre, ash content, and carbohydrate) were carried out according to the Official Method of Analysis described by the Association of Analytical Chemists (AOAC, 2019).

Protein content determination

Protein determination was carried out by Kjedahl digestion method. 5g of the sample was measured into the Kjedahl digestion flask, one tablet of the selenium catalyst was added and 5ml of concentrated H_2SO_4. The sample was place on the digestion stand to digest. The digested sample was transfer into 250ml volumetric flask and make up with distilled water. 10ml of the digest was measure into the "Markham" distilled apparatus, 10ml of 0.1 NaOH was added to the sample and distilled into a 4% boric acid, using ma-zua-zaga indicator. The distillate was titrated with $0.02NH_2SO_4$ to the end point.

Calculation

$$\% \text{ Nitrogen} = \frac{\text{Vs}-\text{VB x Nacid x } 0.0140}{\text{Weigh of sample}} \times \frac{100}{1}$$

Where V_s =Volume (ml) of acid required to titrate sample,
V_B = Volume (ml) of acid required to titrate the blank,
N_{acid} = Normality of acid (0.01N),
W= Weight of sample (g),
% crude protein = N x (conversion factor)
(100% Nitrogen in protein) =Conversion factor

Fat content determination

The total crude fat was determined by the method of refluxing in Soxhlet apparatus.

i. 250ml of clean boiling flasks was dried in an oven at 105-110°c for about 30minutes
ii. It was transferred into a desiccator and allowed to cool
iii. 2g of sample was weighed accurately into labeled thimbles
iv. Correspondingly labeled and cool boiling flasks was weighed
v. The boiling flasks was filled with 300ml of petroleum ether (boiling point 40-60°C)
vi. The extraction thimble was lightly plugged with cotton wool
vii. The Soxhlet apparatus was assembled and allowed to reflux for about 3-6 h
viii. The thimble was carefully removed and petroleum ether was collected into the top container of the set-up and drained into a container for re-use.
ix. When flask is almost freed of ether, it was removed and dry at 105-110 °C for 1hour
x. It was transferred from the oven into desiccators, cooled, and weighed.

Calculation

$$\% \text{ fat} = \frac{\text{weight of fat}}{\text{Original weight of sample}} \times \frac{100}{1}$$

Ash content determination

The total ash was determined by the method of AOAC (2019).

A. 2-5g of finely ground, dry sample was weighed into a porcelain crucible.
B. Sample was charred on a Bunsen flame inside a fume cupboard to drive away smoke.
C. Sample was transferred into a pre-heated muffle furnace at 550 °C and left at this temperature for 2hours or until white or light gray ash is formed. When the residue became black, it was moistened with a small amount of water to dissolve salts, dried in an oven and the ashing process was repeated.
D. It was cooled in a desiccator and weighed.

Calculation: this was done thus:

$$\% \text{ Ash (dry basis)} = \frac{\text{weight of ash}}{\text{Weight of Original food}} \times \frac{100}{1}$$

$$\% \text{ Ash (dry basis)} = \frac{W_3 - W_1}{W_2 - W_1} \times \frac{100}{1}$$

Where: W_1 = weight of empty crucible,
W_2 =weight of crucible + sample before ashing,
W_3 = weight of crucible +ash.

Moisture content determination

The moisture content was determined according to the standard methods of the Association of Official Analytical Chemists (AOAC, 2019). Crucibles were cleaned and dried in the oven at 100°c for 1 hour to achieve a constant weight. They were cooled in a desiccator and weighed. 2g of each sample was placed in one dish respectively and dried in the oven at 100°c until a constant weight is achieve. The samples in the dishes were removed from the oven, cooled in a dessicator and weighed.

Calculation: this was done thus:

$$\% \text{ Moisture content} = \frac{W_2 - W_3}{W_2 - W_1} \times 100$$

Where: W_1 = weight of empty dish,

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

Crude fiber content determination

The crude fibre was determined according to the process described by Onwuka (2015) thus:

1. 2g of sample was defatted with petroleum ether
2. Sample was boiled under reflux for 30 minutes with 200ml of a solution containing 1.25g of H_2SO_4 per 100ml of solution
3. The solution was filtered through several layers of cheese cloth on a fluted funnel

4. It was washed with boiling water until the washings was no longer acidic
5. The residue was transferred to a beaker and boiled for 30 minutes with 200ml of a solution containing 1.25g of carbonate –free NaOH per 100ml
6. The final residue was filtered through a thin but closed pad of wash and ignite asbestos in a Gooch crucible

Calculation: this was done thus:

The loss in weight after incineration x 100 = % crude fibre

Carbohydrate content determination

Carbohydrate was determined by difference i.e.

Carbohydrate content =100% — (% protein + % fat + % fibre + % ash + % moisture)

Mineral analyses

The mineral elements that were selected for determination are calcium, magnesium, sodium, potassium, and phosphorus. They were determined using Techcomp AA6000 Atomic Absorption Spectrophotometer and further confirmed using a digital flame photometer, while phosphorus was determined through Colorimetry. The colour was developed using ammonium molybdate reagent and read on spectronic 20. All determinations follow AOAC (2019) procedure.

Sensory evaluation

The sensory evaluation of the cookie's samples from the experimental cassava, African yam beans and potato flour blends were carried out in the Sensory Evaluation Laboratory of the Department of Food, Nutrition and Home Sciences, Faculty of Agriculture, Prince Abubakar Audu University, Anyigba. Twenty (20) semi trained panelists from the Faculty of Agriculture, Prince Abubakar Audu University, Anyigba, evaluated the products for appearance, texture, taste, flavor, colour and overall acceptability based on 9-point Hedonic scale as described by Iwe (2002).

Statistical analysis

The data obtained was subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Scores (SPSS) version (23). The significant difference was separated by Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Physical properties of cookies sample produced from Cassava, African yam bean, sweet potato and *Okoho* flour blends.

The results of the physical properties of cookies produced from cassava, African yam bean, sweet potato and *Okoho* flour blends are presented in (Table 1). The mass of cookies produced from different flour blends differed significantly ($p<0.05$) from the sample with 100% wheat flour. The mass of samples ranged from 2.30 to 5.59 g with sample CFS_3 having the least mass of 2.30g while sample WWF had the highest mass of 5.59g. This could be that the sugar available in cassava and sweet potato are more susceptible to yeast catabolism. The study's results are consistent with those previously published for cookies prepared with composite flours consisting of defatted pumpkin seeds (Atuonwu and Akobundu, 2010) and wheat-quality protein maize (Ikuomola, *et al*., 2017). On the contrary, (Atuonwu and Akobundu, 2010; Alobo, 2001; Okpala and Chinyelu, 2011) found that the weight of biscuits made with wheat-soybean, cowpea-wheat, millet-sesame flour, pigeon pea-cocoyam, and green bean-wheat flour blends decreased, respectively. The fact that some cookies were made using wheat flour with a partial substitution of legumes may account for the observed differences.

The thickness of the cookies showed no significant ($p>0.05$) difference between sample WWF and CFS_2 but both differed significantly from other samples. The thickness value ranged from 2.62 to 3.89 cm. The difference in the thickness could be due to the difference in the water absorption capacity of the flours. Furthermore, the irregular rolling thickness of the dough could possibly be the cause. The value obtained in this present study is in consonant with that reported by Oluwamukomi, *et al*., (2011) on biscuit produced from wheat-cassava fortified with soy-flour.

There was a significant ($p<0.05$) difference in the diameter of the cookie samples. Values for diameter decreased significantly with increase in the level of sweet potato flour and ranged from 2.17 to 3.05 cm. Sample CFS_3 had the least value of 2.17 cm with no significant ($p>0.05$) difference observed between CFS_1 and CFS_2 however sample WWF cookies had the highest value of 3.05cm for diameter. This might be because of the elastic network of wheat dough resulting in expansion during proofing. Other investigations reported similar conclusions about diameter (Mridula, *et al*., 2007; Oluwamukomi, *et al*., 2011).

The result showed significant ($p<0.05$) difference among samples in terms of volume. The volume of the cookies varied from 5.49 to 9.00 cm^3. Sample CFS1 had the lowest value of 5.49cm^3while the sample with 100% wheat flour had the highest volume of 9.00 cm^3. According to Oyelade, *et al*. (2012), a desirable quality cookie is expected to have

Table 1: Physical properties of cookies sample produced from Cassava, African yam bean, sweet potato and *Okoho* flour blends.

Samples	Mass (g)	Thickness (cm)	Diameter (cm)	Volume (cm^3)	Spread ratio	Density (g/cm^3)
WWF	$5.59^a±0.01$	$3.89^a±0.01$	$3.05^a±0.07$	$9.00^a±0.00$	$0.80^b±0.01$	$0.60^b±0.03$
CFS1	$3.15^c±0.08$	$2.81^b±0.01$	$2.78^b±0.01$	$5.49^d±0.01$	$0.99^a±0.01$	$0.56^c±0.01$
CFS2	$4.95^b±0.07$	$3.88^a±0.01$	$2.69^b±0.02$	$7.01^b±0.01$	$0.70^c±0.01$	$0.70^a±0.00$
CFS3	$2.80^d±0.01$	$2.62^c±0.03$	$2.17^c±0.04$	$6.49^c±0.02$	$0.82^b±0.01$	$0.42^d±0.01$

Values are mean ± standard deviation (n=2). Values with same superscript in the same column are not significantly different (p>0.05)
WWF= 100% wheat flour
CFS 1= 50% Cassava flour + 25% African Yam beans flour + 25% sweet potato flour + 10% *Okoho* flour Sample
CFS 2= 25% Cassava flour + 50% African Yam beans flour + 25% sweet potato flour + 10% *Okoho* flour Sample
CFS 3= 25% Cassava flour + 25% African Yam beans flour + 50% sweet potato + 10% *Okoho* flour Sample

Tables 2: Proximate composition of cookies sample produced from Cassava, African yam bean, sweet potato and *Okoho* flour blends (%)

Samples	Moisture	Ash	Fibre	Fat	Protein	Carbohydrate
WWF	$8.61^c±0.01$	$2.41^d±0.01$	$1.19^b±0.02$	$15.19^b±0.02$	$6.01^d±0.01$	$66.61^a±0.03$
CFS1	$9.07^b±0.04$	$2.96^b±0.01$	$1.56^b±0.51$	$14.03^c±0.04$	$10.49^c±0.01$	$61.90^b±0.52$
CFS2	$9.72^a±0.01$	$3.91^a±0.01$	$2.50^a±0.01$	$16.87^a±0.01$	$14.01^a±0.01$	$53.45^c±0.62$
CFS3	$8.48^d±0.01$	$2.56^c±0.00$	$1.89^{ab}±0.01$	$13.43^d±0.01$	$11.83^b±0.01$	$61.82^b±0.04$

Values are mean ± standard deviation (n=2). Values with same superscript in the same column are not significantly different (p>0.05)
WWF = 100% wheat flour
CFS 1= 50% Cassava flour + 25% African Yam beans flour + 25% sweet potato flour + 10% *Okoho* flour Sample
CFS 2= 25% Cassava flour + 50% African Yam beans flour + 25% sweet potato flour + 10% *Okoho* flour Sample
CFS 3= 25% Cassava flour + 25% African Yam beans flour + 50% sweet potato + 10% *Okoho* flour Sample

bean, sweet potato, and *Okoho* flour blends

Samples	Na (mg/kg)	K (mg/kg)	Ca (mg/kg)	P (kg/kg)	Mg (kg/kg)
WWF	$40.31^d±0.01$	$30.21^d±0.01$	$123.65^d±0.07$	$341.28^d±0.04$	$49.52^d±0.03$
CFS1	$50.80^a±0.00$	$59.72^a±0.03$	$189.62^a±0.02$	$411.49^a±0.01$	$85.61^a±0.01$
CFS2	$48.51^c±0.01$	$50.82^b±0.03$	$166.42^b±0.02$	$398.49^b±0.02$	$69.32^c±0.11$
CFS3	$48.79^b±0.02$	$50.21^c±0.01$	$164.81^c±0.04$	$392.49^c±0.02$	$70.02^b±0.02$

Values are mean ± standard deviation (n=2). Values with same superscript in the same column are not significantly different (p>0.05)
WWF = 100% wheat flour
CFS 1 = 50% Cassava flour + 25% African Yam beans flour + 25% sweet potato flour + 10% *Okoho* flour Sample
CFS 2 = 25% Cassava flour + 50% African Yam beans flour + 25% sweet potato flour + 10% *Okoho* flour Sample
CFS 3 = 25% Cassava flour + 25% African Yam beans flour + 50% sweet potato + 10% *Okoho* flour Sample

Table 4: Sensory properties of cookies sample produced from Cassava, African yam bean, sweet potato, and *Okoho* flour blends (9-points *Hedonic* scale)

Samples	Appearance	Crispiness	Taste	Flavour	Aftertaste	Overall acceptability
WWF	$7.85^a±0.99$	$7.40^a±1.05$	$8.25^a±0.72$	$7.90^a±0.91$	$8.05^a±0.83$	$8.25^a±0.91$
CFS1	$8.10^a±0.72$	$7.15^a±0.99$	$7.40^b±1.05$	$7.45^a±1.00$	$7.50^a±1.05$	$8.00^{ab}±0.72$
CFS2	$8.10^a±1.02$	$7.70^a±0.73$	$7.75^{ab}±1.12$	$7.75^a±1.07$	$7.65^a±0.88$	$7.90^{ab}±1.21$
CFS3	$7.80^a±0.89$	$7.20^a±1.15$	$7.55^b±0.94$	$7.25^a±1.33$	$7.35^a±1.19$	$7.55^b±1.05$

Values are mean ± standard deviation (n=20). Values with same superscript in the same column are not significantly different (p>0.05)
WWF = 100% wheat flour
CFS 1 = 50% Cassava flour + 25% African Yam beans flour + 25% sweet potato flour + 10% *Okoho* flour Sample
CFS 2 = 25% Cassava flour + 50% African Yam beans flour + 25% sweet potato flour + 10% *Okoho* flour Sample
CFS 3 = 25% Cassava flour + 25% African Yam beans flour + 50% sweet potato + 10% *Okoho* flour Sample

great specific volume, which is the ratio of biscuit volume to biscuit weight. The diameter to thickness ratio is represented by cookie spread. Therefore, the effects of sugar on thickness (which inhibits the formation of gluten) and diameter (which dissolves sugar) are merged into a single metric. The result of the spread ratio as presented in (Table 1) showed that there exist a significant ($p<0.05$) difference among the cookies sample except for sample WWF and CFS_3 that were not significantly different ($p>0.05$).

The value ranged from 0.70 to 0.99 with sample CFS_3 cookies having the least value of 0.70 while sample CFS_1 cookies had the highest value of 0.99. According to Hoseney and Rogers (1994), dough viscosity appears to be the determining factor in cookie spread rate; cookies spread quickly when the dough is less viscous and vice versa. Additionally, when there is a lot of water present in the dough system while mixing, more sugar dissolves, this causes the initial dough viscosity to decrease, allowing the cookie to spread during heating more quickly (Noorfarahzihah, *et al*., 2014). There can be less water available for the dissolution of sugar if grain components have a high water absorption capacity (Hoseney and Rogers, 1994). As a result, the viscosity is higher at first and the cookies spread less when baking. There exists a significant difference ($p<0.05$) among cookies samples in term of density.

The value ranged from 0.42 to 0.70 g/cm^3.Sample CFS_3 had the least value of 0.42 g/cm^3 while sample CFS_2 had the highest value of 0.70 g/cm^3. This could be that the sugar available in cassava and sweet potato are more susceptible to yeast catabolism, resulting in mass loss and a proportionate reduction in density. Similar finding was observed by Saha, *et al*. (2011) who reported density of 0.38 to 0.74 g/cm^3 for cookies produced from wheat, soybeans and cassava flour blends.

Proximate composition of cookies sample produced from Cassava, African yam bean, sweet potato and *Okoho* flour blends (%).

The result for proximate analysis is presented in (Tables 2). The moisture content of the cookies was significantly ($p<0.05$) different, ranging from 8.48 to 9.72%. Sample CFS_3 had the least moisture content while sample CFS_2 had the highest moisture content. A product's moisture content serves as a gauge for how long it will last on the shelf. The moisture level of the composite cookies is below the required range of 0-10% for preservation of cookies without microbial deterioration of the triglyceride (Singh *et al*., 2013).

Significant difference ($p < 0.05$) in ash content was observed for all samples. Ash content of cookies increased from 2.41 to 3.91%. The lowest value of ash content (2.41%) was observed in sample WWF (control) followed by CFS_3 (2.56%) and CFS_1 (2.96%), while highest value (3.91%) was reported in CFS2. The sample with 50% African yam beans had the highest ash content followed by the sample with 50% cassava flour. The variations observed in the ash content of samples could be due to the proportion of ash present in each raw material (cassava, African yam beans and sweet potato) used for the cookies production. These results are in accordance with Wani, (2015) who noted that the amount of whey protein in cookies produced increased along with the ash content. Fiber content of the cookies ranged from 1.19 to 2.50% with sample WWF having the least but was not significantly ($p>0.05$) different from sample CFS_1 and sample CFS_2 had the highest value (2.50%). The higher fiber content observed in sample CFS_2 cookies could be attributed to the higher fiber content in African yam beans (Chia and Chong, 2015).

African Yam beans flour has between 2.47–9.57% of crude fiber which is higher than in wheat flour (Bala, *et al*., 2015). Fat content ranged from 14.05% to 16.87% with the sample CFS_3 having the lowest fat content while CFS_2 had the highest fat content. The high value recorded for CFS_2 could be attributed to increase in the proportion of African yam beans flour in the composite flour as it had been reported that African yam beans, possess high fat content (Enwere, 2018). The cookies' high fat level is indicative of their high energy content. One drawback is that cookies with a high fat content may not store as well because of a higher risk of rancidity. Fat helps to increase the sensory aspects of baked goods and preserves flavor (Ikpeme-Emmanuel, *et al*., 2011).

The protein content ranged from 6.01%to 14.01%. There were significant ($p<0.05$) differences among the samples. The least protein content was recorded in control sample (6.01%) while the highest protein value was recorded in sampleCFS_2 (14.01%). Protein increased with decrease in cassava flour and increase in African yam beans and sweet potato flour. T

his shows that African yam beans and sweet potato flour contain appreciable amount of protein than wheat and cassava flour and can be used to improve the protein content in cookies. Protein is an essential nutrient for human body.

They are among the components that make up body tissue. Padmaja (2015) revealed that adding legume flours to the tuber-based composite flours could increase their protein content.

The increase in protein content would be useful in eliminating the challenges of kwashiorkor among children especially in areas where many people can hardly afford protein foods because of its high cost (Basman and Koksel, 2013). Carbohydrate contents ranged from 53.45 to 66.61%. It was observed that there was no significant different ($p>0.05$) between sample CFS_1 and CFS_3, although they differ significantly ($p<0.05$) from other samples.

The lowest carbohydrate content was found in sample CFS_2 while the highest carbohydrate content was found in control sample WWF. This could be because African yam beans are included, which reduces the amount of carbohydrates in the cookies made using composite flours.

Mineral composition of cookies sample produced from Cassava, African yam bean, sweet potato, and *Okoho* flour blends

The mineral compositions of cookies produced from wheat, cassava, African yam beans, sweet potato and *Okoho* flour is as presented in (Tables 3). There was significantly different among the samples in all the analyzed minerals. Sample WWF had the least sodium content (40.31 mg/kg) while sample CFS_1 had the highest value (50.80 mg/kg), this may be that cassava flour has more dietary sodium content compared to other flours. These values are not adequate to provide for the daily sodium intake requirement (2300 mg) for adults.

Potassium content of cookies varied significantly ($P<0.05$) and ranged between 30.21 and 59.72 mg/kg with sample WWF having the least value (30.21 mg/kg) while sample CFS_1 hadthe highest value (59.72 mg/kg). The variations observed in this study could be due to the proportion of potassium content in each of the composite flour in the cookie samples. Potassium protects against arterial hypertension (Obse, 2017), it is also necessary to preserve the pH of the body, the osmotic balance of bodily fluids, the control of glucose absorption, the regulation of muscle and nerve irritability, and the enhancement of normal protein retention throughout growth (Mbata, *et al*., 2017). The potassium content of this present study is higher compared to the daily requirement of 4.70mg/kg.

The calcium content obtained for cookies ranged from123.65 to 189.62mg/kg. Sample WWF had the lowest significant ($P<0.05$) value (123.65 mg/kg) while sample CFS_1 had the highest significant ($P<0.05$) value (189.62 mg/kg) for calcium, this may be as a result of low value of calcium (28.60 mg/kg) in wheat flour as reported by Franko and Albertson (2012). Also, this may be due to the fact that cassava flour has higher calcium content than wheat flour (Ahmadou, *et al*., 2013). Calcium plays an important role in building strong and keeping healthy bones and teeth in both early and later in life. The calcium of this study is lower than the 2500mg daily requirement for adult and children. In addition to its crucial roles in maintaining proper bone health and structure, calcium also plays a vital role in supporting nerve and muscle function.

The phosphorus content obtained for the cookies ranged from 341.28 mg/kg to 411.49mg/kg. The least phosphorus content was observed in sample WWF while sample CFS_1 had the highest value. This could be due to higher ash content observed among composite biscuit compared to the control. Energy production and the maintenance of body functions depend on phosphorus. It functions in concert with calcium to preserve strong teeth and bones (Serrem, *et al*., 2011). The phosphorus content observed is higher compared to the daily requirement of phosphorus (12.50 mg/kg).

Magnesium content ranged from 49.52 to 85.61 mg/kg, sample WWF had the least significant ($P<0.05$) value (49.53 mg/kg) while sample CFS_1 had the highest significant ($P<0.05$) value (85.6 1mg/kg). Proportion of cassava flour was high in sample CFS_1 and this may be the reason for the increased magnesium content observed in the sample. Magnesium is an essential cofactor for over 300 enzyme systems that control a wide range of biochemical activities in the body, including as blood glucose balance, blood pressure regulation, muscle and neuron function, and protein synthesis (Obse, 2017). Glycolysis, oxidative phosphorylation, and the creation of energy all require magnesium. It is necessary for DNA, RNA, and the antioxidant glutathione synthesis as well as for the structural growth of bone. Magnesium also contributes to the active movement of potassium and calcium ions across cell membranes, which is necessary for muscular contraction, nerve impulse conduction, and a healthy heart rhythm (Solomon, 2012).

Sensory properties of cookies sample produced from Cassava, African yam bean, sweet potato, and *Okoho* flour blends (9-points *Hedonic* scale)

The scores of sensory evaluations for appearance, crispiness, taste, flavour, aftertaste and overall acceptability were obtained from semi-trained panelists and tabulated in (Table 4). The composite flour blends from cassava, African yam beans, sweet potato and *Okoho* flour blends did not affect the sensory properties of the cookies except for the taste and overall acceptability. The values ranged from 7.80 to 8.10, 7.15 to 7.70, 7.25 to 7.90 and 7.35 to 8.05 for appearance, crispiness, flavour and aftertaste respectively. The mean score for taste of the cookies sample showed significant difference ($p<0.05$) with sample WWF rated highest 8.25 and sample CSF_1 rated lowest 7.40 with no significant difference ($p>0.05$) from sample CFS_3. Sample CFS_2 compared favourably with the control for taste. All other samples were rated higher than average for taste acceptance. This implies that the flours used had little or no effect in the taste and overall acceptability of the cookies.

Conclusion and recommendations

This study determined the chemical, physical and sensory attributes of cookies. Cookies of acceptable quality were produced from composite flours of wheat, cassava, African yam beans, sweet potato and *Okoho* flour. The cookies produced had increased nutrient contents which are all desirable for good health and wellbeing. The study shows that production of cookies from the composite flour consisting of 25% cassava, 50% African yam beans, 25% sweet potato and 10% *Okoho* produced well accepted cookies. The use of composite flour from root and legume in cookies will significantly improve the consumers' nutrition, health, and well-being and lessen their reliance on wheat flour, freeing up significant amounts of foreign cash that might be used for other initiatives. Additionally, it will decrease food insecurity and expand the applications of sweet potatoes, cassava, and African yam beans.

Authors' Declaration

We declare that this study is an original research work by us and has not being published or sent for publication to any journal

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