

# **PHYTOCHEMICALS, ANTIOXIDANT, PHYSICO-CHEMICAL AND SENSORY PROPERTIES OF YAM BASED COOKIES PRODUCED FROM FLOURS OF FIVE YAM VARIETIES**

## **ABSTRACT**

The desire to reduce post-harvest losses of yams via the promotion of utilization of the abundant readily available yam food raw materials for industrial purposes and production of health enhancing foods prompted this research. This work focused on evaluating the *phytochemicals*, antioxidant, physico-chemical and sensory properties of yam based Cookies produced from flours of five Yam varieties. Established standard procedures were used in all the analysis carried out. Results showed; Phytochemical compounds such as Phenolics, Flavanoids, Alkaloids, Saponins and Tannins were found present in the yam based Cookies in the range of 0.24- 0.37mg/100g, 0.26- 0.40 mg/100g, 0.6- 2.13mg/100g, Saponins was not detected in all the yam flours Cookies and only a trace of 0.05 mg/100g observed in wheat flour Cookies (the control), 0.01- 0.17mg/100g. Antioxidant activities of the yam based Cookies revealed that DPPH, FRAP, MCA, HRSA SRSA and GSH (Gluthanion as standard) ranged from 41.19-84.32, 0.29-0.95, 34.15-78.51, 29.64 -69.54 and 24.13- 81.52 accordingly. The general trend observed was that, in all cases; sample HKC had the least, OGC and ARC had higher antioxidant activities amongst the yam based Cookies, while GSH (the control) had highest. proximate values for Moisture, ash, crude fiber, crude protein, fat, carbohydrate and energy of yam based Cookies ranged from 7.31- 8.80%, 1.10 - 2.30%, 0.13 – 4.27%, 8.53-10.48%, 2.24 – 3.84%, 73.70-78.38% and 334.06 – 359.28 Kcal/100g. Physical properties of the Yam based Cookies such as diameter, width, thickness, weight, Spread ratio, spread factor and fragility ranged from 3.70 - 4.67 cm, 23.93 - 28.00 cm, 2.63 -4.33cm, 5.16 - 9.67g, 0.83-1.64, 54.63-106.84 and 430.00 – 790.00g respectively. Cookies from all samples showed good physical quality features for cookies and biscuits production. Sensory properties such as appearance, texture, crispiness aroma, taste and general acceptability of Yam based Cookies ranged from 5.32-8.30, 6.48-8.44, 7.50-8.44, 6.36-7.68, 7.48-8.50, and 6.30-7.84 on a 9point hedonic scale. Data from this study proved it was feasible to produce acceptable Cookies from the flours of five Yam varieties selected. Overall, samples GBC and ARC Cookies competed favorably with the control-wheat Cookies and are recommended to be used for mass production. Particularly, sample ARC which also combined good nutritional, phytochemical quality and strong antioxidant activities that could be of health benefits to consumers.

**Keywords:** Post-harvest losses; *Phytochemicals*; Antioxidants; Health benefits, Confectioneries

## **1. INTRODUCTION**

Cookies are Biscuit which are customarily made from wheat flour, but escalating cost and limited supply of wheat in developing nations is demanding that consideration be given to the application of indigenous roots and tuber crops to substitute wheat in bakery products (Amandikwa *et al.*, 2015). Several authors have reported on production of Cookies from wheat flour substituted with fruit pomace, grains, root and tuber crops (Mercy & Ezema, 2016), (Awobusuyi *et al.*, 2020), (Oluseye *et al.*, 2018). Yams have *industrial* values, so postharvest losses of yams can be reduced by converting highly perishable Yam tubers at harvest into shelf stable yam flours to be used for processing of baked products like biscuits, cookies, cakes, bread, muffins, Shortbread, etc to scale up or diversify uses of yams to reduce post-harvest losses of the yams (Oyeyinka *et al.*, 2017), (Zhu, 2015). This will resolve the issue of rising cost and limited supply of wheat, post-harvest losses of local crops, production of foods that have improve nutritional value and health benefits (Effah-manu *et al.*, 2022). Production of a confectionery like Cookies from yam flours will transform the bulky yams to a convenience food, ease transportation, enable the exportation of yams as finished rather than primary products and also prolong shelf life of yams (Awoyale *et al.*, 2015). This implies more wealth to the farmers, more productivity and increased capacity to employ more hands leading to reduction in unemployment and poverty. Also, Yam and its byproducts would be obtainable at inexpensive prices all times, Rural-urban migration will be reduced and reduction of foreign exchange on wheat flour importation achieved (Aighewi, 2015). Therefore, this research investigated the feasibility of baking nutritious, acceptable and health benefitting Cookies from processed flours of five yam varieties.

## **2. MATERIALS AND METHODS**

### **2.1 Sources of Materials**

Five varieties of Yam tubers were purchase from Ukum Local Government area of Benue state in the month August 2022. The five yam varieties used in this research included, four (4) types of white yams-*Discorea rotundata* known as Ichi (Akweya), Angwo(Etulo), Ihi (Idoma), Ijuh (Igede), Doya (Hausa), Iyou (Tiv) and Water yam-*Discorea alata* known as Ipem/Ibem (Akweya), Angumo (Etulo), Ebuna/Obuna (Idoma), Ochua (Igede), Sakata (Hausa), Agbo (Tiv) (Agishi, 2010). The specific white yam varieties used were Ogoja, Faketsa, Hembankwase, Amura (*Discorea rotundata*) and Gwebe (Water yam - *Discorea alata*). The yam samples were authenticated by an experienced botanist - J. I. Waya from the Department of Biological Sciences, Benue State University. The Wheat flour (control) and all other baking ingredients such as eggs, baking powder, fat, and sugar were purchase from Wurukum Market Markudi, Benue State, Nigeria.

## 2.2 Method

### 2.2.1 Production of Yam flours

Flours from the five yam varieties were produced using method of Oluwole *et al.*, (2013) with slight modification as shown in figure 1. And Cookies modified recipe is as in table 1.

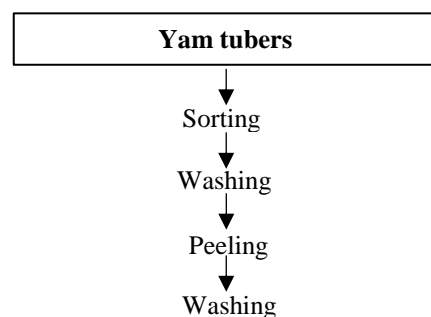


Figure 1. Flow Chart for Production of Yam Flours.  
Source: (Oluwole *et al.*, 2013)

### **2.2.2 Cookies Recipe.**

**Table 1. Cookies Production Formula**

SN	INGREDIENT	GRAMS(g)	MODIFIED (g)
1	Flour	49.5	50.0
2	Margarine	20.0	10.0 (King Vegetable oil)
3	Beaten eggs	10.0	10.0
4	Sugar	20.0	10.0
5	Sodium Bicarbonate	0.5	0.5
6	Salt	-	1.0
7	Water	-	20.0

**Source:** Modified Chinma & Gernah, (2007).

### 2.2.3 Methodology for Production of the Cookies

All dried ingredients were mixed first then poured into the liquid ingredients and mixed thoroughly. The batter was kneaded to a uniform thickness of 5.0mm and cut into Cookies shapes. Baking was carried out in the hot air oven (Horizontal Drying Oven, 101-1AB. PEC- MEDICAL USA) at 90°C for 120mins at the University of Mkar, Mkar Gboko Food Science Laboratory. They were cooled for 30mins and stored in airtight containers until needed for analysis. Cookies made from 100% wheat served as control (Chinma & Gernah, 2007 and Alfeo et al., 2020).

## 2.3 Analyses

### 2.3.1 Proximate Analysis of the flours.

Proximate composition was determined using AOAC, (2012) methods. Carbohydrate was calculated by difference. Energy content of the flours were determined using Atwater factor as shown in equation 1.

$$\text{Energy (kcal/100 g)} = 4 \times \% \text{Protein} + 9 \times \% \text{Fat} + 4 \times \% \text{Carbohydrate} \quad (1)$$

### 2.3.2 Determination of Phytochemicals of the Cookies produced from Flours of Five Yam varieties

#### 2.3.2.1 Determination of total phenolic content

The total phenolic content of the Samples was carried out using Folin Ciocalteu's phenol reagent as described by (Mujic et al., 2009). The concentrations of the phenolic compounds in the Samples were extrapolated from standard curve and expressed as mg gallic acid equivalent per g (mg GAE/g) taking into consideration the dilution factor of the samples.

#### 2.3.2.2 Tannin determination

The Tannin content of the Samples was evaluated as described by Makkar et al., (1996).

#### 2.3.2.3. Determination of total flavonoid concentration

The concentration of flavonoids in the Samples was determined spectrophotometrically according to the procedure of Cong-Hau *et al.*, (2021) The concentrations of the flavonoids was expressed as milligram catechin equivalent per g of extract (mg CA/g extract).

#### 2.3.2.4 Alkaloid determination

The *Alkaloid* content in the Samples was determined as described by Nwalo *et al.*, (2017).

$$\% \text{ALKALOID} = \text{weight before-weight after/weight before} * 100$$

#### 2.3.2.5 Saponin determination

The spectrophotometric method used by Adewole, (2015) for Saponin determination.

### 2.3.3 Determination of Antioxidant Properties of the Cookies produced from Flours of Five Yam Varieties

#### 2.3.3.1 DPPH radical scavenging activity

The free radical scavenging ability of the Samples were determined using the stable radical DPPH (2, 2-diphenyl-1-picrylhydrazyl hydrate) method described by Pownall *et al.*, (2010).

The free radical scavenging ability was calculated using the equation below.

$$\% \text{ DPPH} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100$$

#### 2.3.3.2 Metal chelating ability assay

The metal-chelating assay of the Samples was carried out according to the method of Pownall *et al.*, (2010). The inhibition of ferrozine-Fe<sup>+2</sup> complex formations was calculated using the formula:

$$\text{Chelating effect} = \frac{A_{\text{control}} - A_{\text{sample}}}{A_{\text{control}}} \times 100$$

Where  $A_{\text{control}}$  = absorbance of control sample (the control contained 1 mL each of FeCl<sub>2</sub> and ferrozine, complex formation molecules) and  $A_{\text{sample}}$  = absorbance of sample.

#### 2.3.3.3 Ferric reducing antioxidant power (FRAP) of the samples

The FRAP of the Samples were determined using colorimetric method of Benzie and Strain (1999) used by Firuzi et al., (2005) The FRAP of the samples obtained in mg AAE/ mL was expressed in mg AAE/ g using the equation

$$FRAP = \left( \frac{mgAAE}{g} \right) = \left( \frac{mgAAE}{mL} \right) \times \left( \frac{mL\ solvent}{g\ sample} \right) \times \text{dilution factor}$$

#### 2.3.3.4 Superoxide radical scavenging activity (SRSA)

The method described by Pownall et al., (2010) was used to determine SRSA of the Samples

The superoxide scavenging activity was calculated using the following equation:

$$SRSA = \frac{\text{slope of blank for SRSA} - \text{slope of sample for SRSA}}{\text{slope of absorbance per minute of blank of SRSA}} \times 100$$

#### 2.3.3.5 Hydroxyl radical scavenging activity

Hydroxyl radical scavenging activity (HRSA) of the samples was determined using the method described by Olagunju *et al.*, (2018). The HRSA value calculated as followed:

$$HRSA = \frac{\text{slope of blank for HRSA} - \text{slope of sample for HRSA}}{\text{slope of absorbance per minute of blank for HRSA}} \times 100$$

#### 2.3.4 Physical Properties of Cookies

According to Chinma et al., (2012), Cookies width (w) was measured by placing six cookies edge to edge, measuring their width, rotating them through 90° and re-measuring them, to get the average width in millimeter (mm). Cookies thickness (T) was measured by stacking six cookies on top of each other, measuring the thickness, restacking in a different order and re-measuring them to get the thickness in millimeter (mm). Both were done with meter rule. The spread factor (SF) was determined from width and thickness figures where;  $SF = \frac{W}{T} \times C.F \times 10$ . C.F is the correction factor for adjusting  $\frac{W}{T}$  to constant atmospheric pressure. For this work correction factor C,F = 1.00.

Spread ratio was determined by diameter and thickness of the Cookies.

$$SP = \frac{\text{Diameter}}{\text{Thickness}} \text{ (McWatters27 )}$$

Cookies diameter was determine by the use of vernier calliper and fragility of the cookies by use of standard weights. Fragility was determined using the method described by Okaka, & Isieh, (1990). A representative sample of cookies from each formulation (of same average weight) was placed centrally between two parallel wooden bars. Standard weights were then placed on the bar incrementally until the cookie fractured. The least weight that caused the breaking of the cookie was regarded as the fragility of the cookie. Three representative samples were analyzed from each blend formulated. Cookies weight was determined using an electronic weighing balance.

### **2.3.5 Sensory Properties of the Cookies.**

Sensory evaluation of the cookies was determined with slight modification using same procedure as Chinma *et al.*, (2012) and Okpala, *et al.*, (2013) based on six attributes: appearance, aroma, crispiness, texture, taste and overall acceptability on a 9-point hedonic scale where higher score indicates better quality attributes. Twenty-four hours after preparation of the cookies, sensory evaluation was carried out. A total of 50 semi-trained panelists were recruited from staff and students of the Benue State University, Makurdi. Each panelist evaluated all the samples prepared for each treatment in one session. Criteria for selection of panelists were that, panelists were regular consumers of cookies and were not allergic to any food. Panelists were instructed to evaluate appearance, taste, texture, crispness, and general acceptability of the cookies. A nine-point Hedonic scale was neither like nor dislike, and = dislike extremely = 1 used, with 9 = like extremely10 Samples were identified with three-digit code numbers and presented in a random sequence to panelists. The panelists were instructed to rinse their mouths with water after every sample and not to make comments during evaluation to prevent influencing other panelists. They were also asked to comment freely on samples on the questionnaires given to them.

### **3. STATISTICAL ANALYSIS**

Determinations were carried out in triplicate. Results are presented as mean value  $\pm$  standard deviation and analyzed by analysis of variance (ANOVA) using SPSS software package version 26. Significant differences between means were determined by Duncan multiple range test (DMRT) at 95 % confidence limit.

### **4. RESULTS AND DISCUSSIONS**

#### **4.1 Proximate composition of Yam based Cookies produced from the different Yam flour samples**

The proximate composition of foods is used to evaluate the nutritive value and acceptability of the food products. The result of proximate composition are as presented in Table 2. The parameters such as Moisture, ash, crude fiber, crude protein, fat, carbohydrate and energy of yam based Cookies produced from the flours of five Yam varieties ranged from 7.3-8.80%, 1.10-2.30%, 0.13-4.27%, 8.53-10.48%, 2.24-3.84%, 73.70-78.38% and 334.06-359.28 Kcal/100g respectively. There was significant ( $p < 0.05$ ) difference between all the samples in their proximate parameters. Lowest moisture content was observed in sample GBC and highest in HKC. Crude ash was lowest in FTC; highest in ARC. Lowest crude fiber was in WFC (wheat-Control) and highest ARC. The crude protein was lowest in GBC and highest in ARC. The fat contents was lowest in FTC, highest WFC. The carbohydrate content was calculated by difference, lowest observed in HKC, highest in GBC. Energy value was lowest in HKC and highest recorded in GBC. Some authors had reported lower values of proximate composition of yam flours/products particularly protein and fat content compared to higher values 8.53 - 10.48% (proteins) and 2.24 - 3.47 % (fats) observed in the Cookies produced in this work. For instance; Omohimi et al., (2018) reported-proximate composition of traditionally-processed yam product: chips, flakes and flours as ranging from 2.70 - 4.30% (protein) and 0.70 - 1.10% (fat); (Lawal & Akinoso, 2019), produced flours from the two Cultivars of Aerial yam (D.

bulbifera) at two different stages of maturation with 3.92 - 6.24 % (protein) and 0.52 - 2.20% (Fat); (Gunasekara, *et al.*, 2020) observed composition of four selected underutilized yam varieties in Sri Lanka with 3.97 - 5.70% (protein) and 0.36 - 1.09% (fat); while (Ayo, *et al.*, 2018), reported protein composition of pre-treated aerial yam (*Discorea bulbifera*) flour as 5.65 - 7.59% and fat content of 2.63 - 3.86% (which falls within same range of 2.24 - 3.47 % (fat) in the present work). The increase in the proximate composition of yam based Cookies particularly protein and fat contents compared to the proximate composition of the yam flours (the starting material), could be due to presence of eggs and vegetable oil in the ingredients mixed for baking of the Cookies. This is in consonance with the work of Chinma & Gernah, (2007) where Cookies produced using 100% cassava flour had higher values of 6.83% (protein) and 2.25% (fat) compared with the values from the 100% cassava flour of 1.10% (protein) and 1.05% (fat). The same trend is reported by Okpala, *et al.*, (2013), who used 100% Cocoyam flour as one of their samples in production of Cookies.

**Table 2 Proximate composition of Yam based Cookies produced from the different flour samples**

Samples	Moisture	Ash (%)	Fiber (%)	Protein (%)	Fat (%)	Cho (%)	Energy
	(%)						Kcal/100g
WFC(Wheat Cookies)	8.43 <sup>cd</sup> ±0.13	1.77 <sup>c</sup> ±0.03	0.13 <sup>a</sup> ±0.01	9.43 <sup>b</sup> ±0.02	3.84 <sup>f</sup> ±0.19	76.40 <sup>c</sup> ±0.58	358.78 <sup>e</sup> ±1.16
OGC(Ogoja Cookies)	8.64 <sup>d</sup> ±0.02	1.29 <sup>b</sup> ±0.01	2.43 <sup>c</sup> ±0.04	10.16 <sup>c</sup> ±0.05	2.32 <sup>b</sup> ±0.17	75.16 <sup>b</sup> ±0.31	343.37 <sup>c</sup> ±0.82
FTC(Faketsa Cookies)	8.21 <sup>c</sup> ±0.01	1.10 <sup>a</sup> ±0.04	4.18 <sup>e</sup> ±0.03	9.23 <sup>b</sup> ±0.03	2.24 <sup>a</sup> ±0.10	75.04 <sup>b</sup> ±0.26	338.48 <sup>b</sup> ±1.23
HKC(Hembakwase Cookies)	8.80 <sup>e</sup> ±0.07	2.06 <sup>d</sup> ±0.05	4.27 <sup>f</sup> ±0.01	8.57 <sup>a</sup> ±0.04	2.60 <sup>c</sup> ±0.30	73.70 <sup>a</sup> ±0.32	334.06 <sup>a</sup> ±1.80
ARC(Amura Cookies)	7.67 <sup>b</sup> ±0.03	2.30 <sup>f</sup> ±0.01	0.98 <sup>b</sup> ±0.02	10.48 <sup>d</sup> ±0.05	2.72 <sup>d</sup> ±0.09	76.26 <sup>c</sup> ±0.04	350.74 <sup>d</sup> ±0.62
GBC(Gwebe Cookies)	7.31 <sup>a</sup> ±0.04	2.17 <sup>e</sup> ±0.03	0.14 <sup>a</sup> ±0.01	8.53 <sup>a</sup> ±0.02	3.47 <sup>e</sup> ±0.20	78.38 <sup>d</sup> ±0.58	359.28 <sup>e</sup> ±0.45

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly (p<0.05) different.

#### **4.2 Phytochemical screening of Yam based Cookies produced from the different yam flour samples.**

Phytochemical compounds found in the Cookies produced from flours of the five Yam varieties are as presented in Table 3. The compounds like Phenolics, Flavanoids, Alkaloids, Saponins and Tannins ranged from 0.24-0.37mg/100g, 0.26-0.40 mg/100g, 0.6-2.13mg/100g Saponins was not detected and 0.01-0.17mg/100g accordingly. Significant ( $P < 0.05$ ) difference in the phytochemical contents was observed in all the Cookies samples. Phenolic was lowest in HKC, highest in OGC followed by ARC. Flavanoids; lowest in HKC, highest in OGC followed by ARC. Alkaloids recorded lowest in WFC, then HKC; highest in FTC followed by ARC. Saponins; not detected in all the Cookies samples and only a trace of 0.05 mg/100g was observed in the wheat flour Cookies (the control). Tannin was lowest in WFC, then HKC and highest OGC followed by ARC. The general trend observed amongst the yam samples was, the highest presence of the phytochemicals was observed in the sample OGC followed by ARC and lowest HKC in all cases. This implies there might be lower bioactive activities in the sample HKC. This data reveal phytochemical contents in our yam based Cookies that contrasted and were higher than values reported by Ugo *et al.*, (2022) for Cookies produced from composite flour mixture of wheat, Cocoyam, Groundnut and wheat, Cocoyam, Cashewnut. Same also, for phytochemical values of biscuits produced from composites flours of wheat enriched with okra pod by Joy, (2019). This pattern could be credited to longer baking time at lower temperature that the Cookies samples were subjected to. As relevant literature had indicated that lower baking temperature and the high exposure time promoted starch degradation and the release of bound polyphenols resulting to free polyphenols. This is in line with Alfeo *et al.*, (2020) whose work showed that longer baking time seems to increase the free polyphenol fractions which could impact on antioxidant activity. According to them, antioxidant ability is positively affected by increasing baking time, lower temperature and sugar amount, though the principal effect been the baking time. They stressed that the more,

the release of polyphenols from the food matrices, the more the increases in their bioavailability making available these nutraceutical compounds for the intestinal absorption. This indicated that beside HKC, the other Cookies samples exhibited high phytochemical content implying our local yams could serve as rich source of phytochemical compounds which might be beneficial to consumer's health.

**Table 3 Phytochemical screening of Yam based Cookies produced from the different yam flour samples (mg/100g)**

SAMPLES	Phenolics	Flavanoids	Alkaloids	Saponins	Tannins
WFC	0.28 <sup>b</sup> ±0.01	0.25 <sup>b</sup> ±0.00	0.16 <sup>a</sup> ±0.03	0.05 <sup>b</sup> ±0.01	0.10 <sup>a</sup> ±0.00
OGC	0.57 <sup>e</sup> ±0.03	0.40 <sup>f</sup> ±0.00	1.03 <sup>c</sup> ±0.01	0.00 <sup>a</sup> ±0.00	0.17 <sup>d</sup> ±0.00
FTC	0.34 <sup>c</sup> ±0.00	0.30 <sup>d</sup> ±0.00	2.13 <sup>f</sup> ±0.02	0.00 <sup>a</sup> ±0.00	0.12 <sup>c</sup> ±0.00
HKC	0.24 <sup>a</sup> ±0.01	0.24 <sup>a</sup> ±0.00	0.86 <sup>b</sup> ±0.02	0.00 <sup>a</sup> ±0.00	0.11 <sup>b</sup> ±0.00
ARC	0.37 <sup>d</sup> ±0.01	0.31 <sup>e</sup> ±0.00	1.25 <sup>e</sup> ±0.04	0.00 <sup>a</sup> ±0.00	0.12 <sup>c</sup> ±0.00
GBC	0.28 <sup>b</sup> ±0.00	0.26 <sup>c</sup> ±0.00	1.12 <sup>d</sup> ±0.04	0.00 <sup>a</sup> ±0.00	0.11 <sup>b</sup> ±0.00

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly ( $p < 0.05$ ) different.

#### **4.3 Antioxidant properties of Yam based Cookies produced from the different yam flour samples (mg/100g)**

Antioxidant activities of the Cookies produced from the flours of five Yam varieties are as presented in Table 4.

The general trend observed was that; there was significant ( $p < 0.05$ ) difference in the antioxidant activities of all the samples. Amongst the yam based Cookies; in all cases, sample HKC had the least antioxidant activity, higher observed in the OGC followed by ARC and the highest in GSH (the control).

The 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activity (DPPH) of the yam based Cookies samples ranged from 41.19-84.32%. HKC having the least antioxidant activity, the highest recorded in the OGC followed by ARC. Ferric reducing antioxidant properties (FRAP):0.29-0.95%. HKC had the least, highest in the OGC then ARC. Metal chelating activities (MCA): 34.15-78.51%. HKC had the least, highest activity in the OGC followed by ARC. Hydroxyl radical scavenging activities (HRSA):29.64-69.54%. HKC had the least, the highest in the OGC then ARC. And Superoxide radical scavenging activities (SRSA):24.13-81.52 %. HKC had the least, and the highest in the OGC followed by ARC. The result of the Antioxidant activities of Yam flour based Cookies showed appreciable antioxidant activities. But the lowest was observed in the sample HKC (Cookies) indicating, HKC might had least free radical scavenging activities. While the highest antioxidant activity was observed in the OGC sample followed by the ARC. This could be a result of their inter specie variation. The result of (%RSA) for the yam based Cookies samples which ranged from 29.64% to 35.36 % aligned with antioxidant activity in Cookies made from purple yam flour and peanuts reported by Ibdal, S. & Defita Fajar, (2023) where the percentage of radical scavenging activity (%RSA) was around 39.7%. Hence, this data revealed that some of our local yams can be processed into antioxidant-rich flours and subsequently antioxidant rich finished food products.

**Table 4 Antioxidant activities of Yam based Cookies produced from the different yam flour samples (mg/100g)**

SAMPLES	DPPH	FRAP	MCA	HRSA	SRSA
WFC	43.60 <sup>c</sup> ±0.37	0.30 <sup>b</sup> ±0.00	35.32 <sup>b</sup> ±0.10	31.48 <sup>b</sup> ±0.60	24.54 <sup>b</sup> ±0.02
OGC	51.39 <sup>f</sup> ±0.06	0.52 <sup>f</sup> ±0.00	40.18 <sup>f</sup> ±0.03	34.05 <sup>d</sup> ±0.04	35.36 <sup>e</sup> ±0.07
FTC	42.58 <sup>b</sup> ±0.23	0.31 <sup>c</sup> ±0.00	35.51 <sup>c</sup> ±0.13	31.53 <sup>b</sup> ±0.11	27.26 <sup>c</sup> ±0.16
HKC	41.19 <sup>a</sup> ±0.02	0.29 <sup>a</sup> ±0.00	34.15 <sup>a</sup> ±0.05	29.64 <sup>a</sup> ±0.02	24.13 <sup>a</sup> ±0.02
ARC	46.23 <sup>e</sup> ±0.02	0.41 <sup>e</sup> ±0.00	38.43 <sup>c</sup> ±0.01	32.09 <sup>c</sup> ±0.03	27.44 <sup>d</sup> ±0.01
GBC	45.63 <sup>d</sup> ±0.17	0.36 <sup>d</sup> ±0.00	38.10 <sup>d</sup> ±0.02	31.87 <sup>bc</sup> ±0.16	27.27 <sup>c</sup> ±0.06
GSH	84.32 <sup>g</sup> ±0.01	0.95 <sup>g</sup> ±0.01	78.51 <sup>g</sup> ±0.07	69.54 <sup>e</sup> ±0.22	81.52 <sup>f</sup> ±0.06

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly (p<0.05) different. \*GSH- (Gluthanion as standard)

#### **4.4 Physical properties of Yam based Cookies produced from the different yam flour samples**

Physical properties such as diameter, width, thickness, fragility, weight. Spread ratio and spread factor of cookies produced from the five Yam varieties flours are presented in Table 5. The result showed that the physical characteristics of the prepared cookies varied with the variation of individual flours. The diameter of cookies samples ranged 3.70 - 4.67 cm. Width ranged 23.93 - 28.00 cm. The thickness ranged 2.63 -4.33cm. Weight ranged from 5.16 - 9.67g. The spread ratio ranged 0.83-1.64. The spread factor ranged 54.63-106.84. And the fragility of ranged 430.00 – 790.00g. Cookies from all samples showed good quality physical features for cookies and biscuits production. The results showed that the physical characteristics of the yam based cookies varied with the variation of individual flours. Similar observations had been reported by other authors (Okpala, et al., 2013); (N et al., 2014); (Igbabul et al., 2015). The diameter of the wheat Cookies was the smallest. This could be due to the presence of gluten protein in wheat that aids in binding the particles together, giving it the elastic nature thus preventing spreading. This finding agree with the observation of Belorio et al., (2019) who reported a decrease in cookie diameter in wheat flour cookies. According to Orisa, *et al.*, (2023) dough's with lower viscosity cause cookies to spread at faster rate and vice versa hence the greater spread in yam flour cookies. Nugraheni *et al.*, (2019) had earlier documented that the spread ratio of cookies increased with increase in the content of non-wheat protein. Increase in spread ratio could also be attributed to increase in the hydrophilic sites in the dough mixture leading to increase in water absorption and swelling index (Hussein *et al.*, 2011)

**Table 5 Physical properties of Yam based Cookies produced from the different yam flour samples**

SAMP LES	Diamete r (Mm)	Width (Mm)	Thicknes s (Mm)	Weight (g)	Spread Ratio (D/T)	Spread Factor (W/T*10* 1)	Fragility (g)
WFC	3.70 <sup>a</sup> ± 0.46	23.93 <sup>a</sup> ± 0.15	4.43 <sup>d</sup> ±0 .15	9.67 <sup>c</sup> ±1 .53	0.83 <sup>a</sup> ±0 .12	54.03 <sup>a</sup> ±1 .81	790.00 <sup>c</sup> ± 10.00
OGC	4.47 <sup>b</sup> ± 0.31	28.60 <sup>c</sup> ± 0.92	3.73 <sup>c</sup> ±0 .15	6.67 <sup>b</sup> ± 0.57	1.20 <sup>b</sup> ± 0.11	76.76 <sup>b</sup> ±5 .53	620.00 <sup>b</sup> ± 98.49
FTC	4.30 <sup>b</sup> ± 0.10	27.73 <sup>bc</sup> ± 0.61	2.90 <sup>ab</sup> ± 0.26	6.32 <sup>ab</sup> ± 0.19	1.49 <sup>bc</sup> ± 0.20	96.02 <sup>cd</sup> ± 6.39	510.00 <sup>a</sup> ± 10.00
HKC	4.30 <sup>b</sup> ± 0.10	28.00 <sup>c</sup> ± 0.27	3.23 <sup>abc</sup> ± 0.51	6.77 <sup>b</sup> ± 0.64	1.35 <sup>bc</sup> ± 0.17	88.08 <sup>bc</sup> ± 14.09	490.00 <sup>a</sup> ± 10.00
ARC	4.30 <sup>b</sup> ± 0.10	28.00 <sup>c</sup> ± 0.44	2.63 <sup>a</sup> ±0 .21	5.16 <sup>a</sup> ±0 .17	1.64 <sup>c</sup> ±0 .11	106.84 <sup>d</sup> ± 9.80	430.00 <sup>a</sup> ± 60.83
GBC	4.67 <sup>b</sup> ± 0.15	26.87 <sup>b</sup> ± 0.35	3.47 <sup>bc</sup> ± 0.49	6.18 <sup>ab</sup> ± 0.03	1.37 <sup>bc</sup> ± 0.26	78.73 <sup>bc</sup> ± 13.05	490.00 <sup>a</sup> ± 10.00

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly (p<0.05) different.

#### 4.5 Sensory properties of Yam based Cookies produced from the different yam flour samples

Sensory properties such as appearance, aroma, taste, crispiness, texture and general acceptability of Cookies produced from the five Yam varieties flours respectively are as presented in the Table 6. Sensory evaluation is an important tool in determining the overall characteristics of a product. Traditionally sensory attributes are evaluated independently of each other by receptors of the different senses, although the possibility of a multimodal perception by human beings has recently been suggested (Abdus-salaam *et al.*, 2022) . Industries and academia have embraced sensory evaluation as an invaluable tool for creating successful products and understanding the sensory properties of materials. Appearance ranged from 5.32-8.30, texture:6.48-8.44, crispiness:7.50-8.44, aroma:6.36-7.68, taste:7.48-8.50, and overall acceptability:6.30-7.84 respectively. All the sensory parameter differed significantly amongst samples. It was observed samples HKC had noticeable trace of yam taste; samples

FTC and OGC had a bitter after taste; while samples GBC and ARC had no noticeable taste (bland taste like the control-wheat flour). Taste is an important sensory attribute of any food because of its influence on acceptability. In term of taste, Samples ARC (Amura Cookies) and GBC (Gwebe Cookies) competed favourably with wheat cookies which was the control. Hence, samples GBC and ARC could be used for mass production of Cookies.

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**Table 6 Sensory properties of Yam based Cookies produced from the different yam flour samples**

Samples	Appearance	Texture	Crispy	Aroma	Taste	General Acceptability
WFC	5.56 <sup>a</sup> ±1.18	6.48 <sup>a</sup> ±0.50	7.50 <sup>a</sup> ±0.51	8.02 <sup>c</sup> ±0.59	8.50 <sup>b</sup> ±0.51	7.84 <sup>c</sup> ±0.37
OGC	5.36 <sup>a</sup> ±0.48	8.38 <sup>c</sup> ±0.49	8.38 <sup>b</sup> ±0.49	6.36 <sup>a</sup> ±0.49	7.48 <sup>a</sup> ±0.50	6.30 <sup>a</sup> ±0.99
FTC	6.50 <sup>b</sup> ±0.51	8.00 <sup>b</sup> ±0.57	8.50 <sup>b</sup> ±0.51	6.84 <sup>b</sup> ±0.37	7.68 <sup>a</sup> ±0.47	6.82 <sup>b</sup> ±0.89
HKC	5.32 <sup>a</sup> ±0.47	8.50 <sup>c</sup> ±0.51	8.50 <sup>b</sup> ±0.51	7.68 <sup>d</sup> ±0.47	7.68 <sup>a</sup> ±0.47	6.54 <sup>ab</sup> ±1.11
ARC	7.58 <sup>c</sup> ±0.49	8.00 <sup>b</sup> ±0.53	8.58 <sup>b</sup> ±0.49	7.42 <sup>c</sup> ±0.49	8.26 <sup>b</sup> ±0.83	7.70 <sup>c</sup> ±0.84
GBC	8.30 <sup>d</sup> ±0.71	8.44 <sup>c</sup> ±0.50	8.44 <sup>b</sup> ±0.50	7.42 <sup>c</sup> ±0.49	8.38 <sup>b</sup> ±0.90	7.74 <sup>c</sup> ±0.92

Values are mean ± SD of triplicate determination. Samples with different superscripts within the same column were significantly ( $p < 0.05$ ) different.

## 5. CONCLUSION

Industrial production of Yam flours to be used for confectioneries should be encouraged to reduce dependence on imported wheat flour for baking. The yam based Cookies showed good quality in terms of phytochemical content, antioxidant activities, physical properties and nutritional composition. However, Sample HKC exhibited lowest phytochemical and antioxidant activities potential. Based on sensory evaluation; only sample samples GBC and ARC had no noticeable taste of yam or any bitter after taste so competed favorably with the control sample WFC (wheat Cookies). Since taste is an important sensory attribute of any food because of its influence on acceptability, samples GBC and ARC Cookies are suggested to be used for mass production. Particularly, sample ARC which also combined good nutritional, phytochemical quality and strong antioxidant activities that are desirable characteristics in food products where bioactive composition is of great importance and could be beneficial to consumer's health. Generally, considering the over-all acceptance of the Cookies, the use of yam flours in production of the Cookies may enhance the nutritional and health status of the consumers, increase utilization of yams curbing post-harvest losses of the same, reduce total dependence on wheat flour and prevalent incidences of chronic illnesses like diabetes, celiac disease etc.

## REFERENCES

- Abdus-salaam, R. B., Abegunde, T. A., Agbalaiya, K. K., Olaleye, B. O. & Titilope, A. (2022). Production and Quality Evaluation Of Cookies From Composite Flour of Wheat , Tigernut and Coconut flour using Date as Sugar substitute. *ISTEAMS, July*. <https://doi.org/10.22624/>
- Adewole, E. (2015). Phytochemical Evaluation of Phytochemicals of Cassia Podocarpa. *Global Journal of Science Frontier Research: B Chemistry, 15(4)*, 1–7.
- Agishi, E. (2010). *Tiv, Idoma, Etulo, Igede, Akweya, Hausa, English and Scientific names of plants*.
- Aighewi, B. A. (2015). Improved propagation methods to raise the productivity of yam ( *Dioscorea rotundata* Poir .). *Food Security*, 823–834. <https://doi.org/10.1007/s12571-015-0481-6>
- Alfeo, V., Bravi, E., Ceccaroni, D., Sileoni, V., Perretti, G. & Marconi, O. (2020). Effect of Baking Time and Temperature on Nutrients and Phenolic Compounds Content of Fresh Sprouts Breadlike Product. *Foods*, 9(1447), 1–12.
- Amandikwa, C., Iwe, M. O., Uzomah, A., & Olawuni, A. I. (2015). Physico-chemical properties of wheat-yam fl our composite bread. *Nigerian Food Journal, November*, 1–6. <https://doi.org/10.1016/j.nifoj.2015.04.011>
- AOAC. (2012). Official methods of analysis (18th ed). *Gaithersburg, USA: Aoac International*.
- Awobusuyi, T. D., Pillay, K. & Siwela, M. (2020). Consumer acceptance of biscuits supplemented with a sorghum–insect meal. *Nutrients, 12(4)*. <https://doi.org/10.3390/nu12040895>
- Awoyale, W., Maziya-dixon, B., Sanni, L. O. & Shittu, T. A. (2015). Effect of water yam ( *Dioscoreaalata* ) flour fortified with distiller ’ s spent grain on nutritional , chemical , and functional properties. *Food Science & Nutrition, 4(1)*, 24–33. <https://doi.org/10.1002/fsn3.254>
- Ayo, J. A., Ojo, M. & Obike, J. (2018). Proximate composition, functional and phytochemical properties of pre-heated aerial yam flour. *Research Journal of Food Science and Nutrition, 3(1)*, 1–8. <https://doi.org/10.31248/rjfsn2017.035>
- Belorio, M., Sahagún, M. & Gómez, M. (2019). Influence of flour particle size distribution on the quality of maize gluten-free cookies. *Foods, 8(2)*. <https://doi.org/10.3390/foods8020083>
- Chinma, C. E., Igbabul, B. D. & Omotayo., O. O. (2012). Quality Characteristics of Cookies Prepared from Unripe Plantain and Defatted Sesame Flour Blends. *American Journal of Food Technology, 7(7)*, 398-408. <https://doi.org/10.3923/ajft.2012.398.408>
- Chinma, C., & Gernah, D. (2007). Physicochemical and sensory properties of cookies produced from cassava/soyabean/mango composite flours. *Journal of Food Technology, 5(3)*, 256-260.
- Cong-Hau, N., Anh-Dao, L. T., Nhon-Duc, L. & Thanh-Nho, N. (2021). Spectrophotometric determination of total flavonoid contents in tea products and their liquors under various brewing conditions. *Malaysian Journal of Analytical Sciences, 25(5)*, 740–750.

- Effah-manu, L., Wireko-manu, F. D., Agbenorhevi, J. K., Oduro, I., Wireko-manu, F. D., Agbenorhevi, J. K., Wireko-manu, F. D. & Agbenorhevi, J. K. (2022). Chemical, functional and pasting properties of starches and flours from new yam compared to local varieties. *CyTA - Journal of Food*, 20(1), 120–127. <https://doi.org/10.1080/19476337.2022.2093401>
- Firuzi, O., Lacanna, A., Petrucci, R., Marrosu, G. & Saso, L. (2005). Evaluation of the antioxidant activity of flavonoids by “ferric reducing antioxidant power” assay and cyclic voltammetry. *Biochimica et Biophysica Acta - General Subjects*, 1721(1–3), 174–184. <https://doi.org/10.1016/j.bbagen.2004.11.001>
- Gunasekara, D., Bulathgama, U., Wickramasinghe, I. & Wijesekara, I. (2020). Comparison of selected underutilized yam flours for their proximate and phytochemical composition. *International Journal of Food Science and Nutrition*, 5(1), 91–95.
- Hussein, A. A., Amal, M. S., Amany, M. H. & R., G. H. (2011). Physicochemical, sensory and nutritional properties of corn-fenugreek flour composite biscuits. *Australian J. Basic Appl. Sci.*, 57, 84–95.
- Ibdal, S., & Defita Fajar, E. (2023). Physicochemical Characteristics, Antioxidant activity and Sensory of Cookies based on Mocaf, Purple yam, and Cinnamon flour. *National Nutrition Journal*, 18(3), 212–225.
- Igbabul, B. D., B.M, I. & N, U. E. (2015). Physicochemical and sensory properties of cookies produced from composite of wheat, cocoyam and African yam bean. *J. Food Res*, 4(2), 150–158.
- Joy, A.C. (2019). Nutrient, Phytochemical and Sensory evaluation of Biscuits Produced from Composite Flours of Wheat enriched with Okra Pod. *Journal of Agriculture and Food Sciences*, 17(1), 65–78.
- Lawal, A. I. & Akinoso, R. (2019). Physical properties, proximate composition and antioxidant activities of aerial yam (*Dioscorea bulbifera*) bulbils grown in Nigeria. *Acta Periodica Technologica*, 50, 143–151. <https://doi.org/10.2298/APT1950143L>
- Makkar, H. P. S., Goodchild, A. V., Abd El-Moneim, A. M. & Becker, K. (1996). Cell-constituents, tannin levels by chemical and biological assays and nutritional value of some legume foliage and straws. *Journal of the Science of Food and Agriculture*, 71(1), 129–136. [https://doi.org/10.1002/\(SICI\)1097-0010\(199605\)71:1<129::AID-JSFA558>3.0.CO;2-L](https://doi.org/10.1002/(SICI)1097-0010(199605)71:1<129::AID-JSFA558>3.0.CO;2-L)
- Mercy, A. H. & Ezema, P. N. (2016). *Chemical Analysis and Organoleptic Evaluation of Snacks from Composite Flour of Dioscorea alata and Telifairia occidentalis Seeds Flour*. 4(4).
- Mujic, I., Dudaš, S., Živković, J., Tomin, J., Zekovic, Z., Alibabic, V., Jukic, H. & Šahinovic, R. (2009). Determination of total phenolic compounds in cultivars of *Castanea Sativa* Mill. *Acta Horticulturae*, 815(2015), 63–68. <https://doi.org/10.17660/ActaHortic.2009.815.8>
- N, J. & F, S. (2014). Production and quality assessment of enriched cookies from wholewheat and full fat soya. *European Journal of Food Science and Technology*, 2(2), 19–29.
- Nugraheni, M., Sutopo, Purwanti, S. & Handayani, T. H. W. (2019). Nutritional, physical and sensory properties of high protein gluten free cookies enriched with resistant starch type

3 of Maranta arundinaceae and flaxseed. *Food Research*, 3(6), 658–663.

- Nwalo, F. N., Echeta, J. O., Ude, G. D. & Itumoh, M. O. (2017). Determination of Phytochemical Composition and Antioxidative Properties of Selected Medicinal Plants in Ikwo, Ebonyi State, Nigeria. *FUNAI Journal of Science and Technology*, 3(2), 41–55. [www.fjst.org](http://www.fjst.org)
- Okaka, J. & Isieh, M. (1990). Development and quality evaluation of cowpea-wheat biscuits. *Nigerian Food Journal*, 8, 56-62.
- Okpala, L., Okoli, E. & Udensi, E. (2013). Physico-chemical and sensory properties of cookies made from blends of germinated pigeon pea, fermented sorghum, and cocoyam flours. *Food Science & Nutrition*, 1(1), 8–14.
- Olagunju, A. I., Omoba, O. S., Enujiugha, V. N., Alashi, A. M. & Aluko, R. E. (2018). Antioxidant properties, ACE/renin inhibitory activities of pigeon pea hydrolysates and effects on systolic blood pressure of spontaneously hypertensive rats. *Food Science and Nutrition*, 6(7), 1879–1889. <https://doi.org/10.1002/fsn3.740>
- Oluseye, O. A., Lateef, O. S. & Abdul -Rasaq, A. A. (2018). PROXIMATE, FUNCTIONAL AND PASTING PROPERTIES OF WHEAT – YAM FLOUR AS A FUNCTION OF PERCENTAGE LEVEL OF YAM ( *D. alata* AND *D. cayenensis*) FLOUR SUBSTITUTION. *Annals. Food Science and Technology*, 19(3), 414–422.
- Oluwole, O. B., Olapade, A. A., Awonorin, S. O. & Henshaw, F. O. (2013). *Physicochemical properties of extrudates from white yam and bambara nut blends*. 69–74. <https://doi.org/10.2478/v10247-012-0069-8>
- Omohimi, C. I., Piccirillo, C., Roriz, M., Ferraro, V., Vasconcelos, M. W., Sanni, L. O., Tomlins, K., Pintado, M. M. & Abayomi, L. A. (2018). Study of the proximate and mineral composition of different Nigerian yam chips, flakes and flours. *Journal of Food Science and Technology*, 55(1), 42–51. <https://doi.org/10.1007/s13197-017-2761-y>
- Orisa, C. A., Amadi, A. O. & Owuno, F. (2023). Physicochemical and sensory properties of cookies produced from blends of wheat and defatted African elemi pulp flours. *International Journal of Food Science and Nutrition*, 8(4), 16–24. <https://doi.org/10.33545/27068919.2023.v5.i9a.1041>
- Oyeyinka, S. A., Oyeyinka, A. T., Kayode, R. M. & Folake, O. (2017). *A review on the functionality and potential applications of bitter yam starch*. 18(3), 364–375.
- Pownall, T. L., Udenigwe, C. C. & Aluko, R. E. (2010). Amino acid composition and antioxidant properties of pea seed (*Pisum sativum* L.) Enzymatic protein hydrolysate fractions. *Journal of Agricultural and Food Chemistry*, 58(8), 4712–4718. <https://doi.org/10.1021/jf904456r>
- Ugo, C. H., Onuorah, U. M. & Chiwenite, M. C. (2022). Evaluation of Nutrient, Phytochemical and Organoleptic properties of Cookies made from Wheat, Cocoyam, Cashew and Groundnut paste blends. *World Journal of Pharmaceutical Research*, 11(16), 1–18. <https://doi.org/10.20959/wjpr202216-26123>
- Zhu, F. (2015). Isolation, composition, structure, properties, modifications, and use of yam starch. *Comprehensive Reviews in Food Science and Food Safety*, 14(14), 357–386.