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Comparative Study on the Physicochemical and Sensory Attributes of *Okoho* Root *(Cissus Populnea)* and the Two Varieties of *Ogbono* Seeds *(Irvingia Gabonensis and Irvingia Wombolu)*

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Abstract:
This study investigated the physicochemical and sensory attributes of *Okoho* (*Cissus populnea*) and varieties of *Ogbono* seeds (*Irvingia gabonensis* and *Irvingia wombolu*). *Okoho* root and *Ogbono* seeds were processed into flours. The flours were used to formulate six samples which were analysed for functional properties, proximate composition, phytochemical composition and sensory attributes. The result of the functional properties of the flour samples showed that the value of the bulk density ranged from 0.65 to 0.95 g/ml, oil absorption capacity (9.23 to 10.53 g/ml), water absorption capacity (0.93 to 10.00 g/ml), swelling index (1.68 to 10.53 g/ml), foam capacity (0.98 to 11.76 g/ml), emulsion capacity (23.77 to 40.33 g/ml), wettability (0.46 to 7.37 min/sec), viscosity (3.02 to 3.19 Pa.s), gelation temperature (39.02 to 80.04 ^{o}C), and gelation time (0.43 to 2.30 min/sec. The result of the proximate composition showed that the moisture content ranged from 6.30 to 8.53%, crude protein (8.02 to 20.62%), crude fibre (2.04 to 20. 72%), ether extract (3.34 to 69.68%), ash (2.52 to 3.57%), and carbohydrate (10.24 to 43.65%). For phytochemical composition of the flour samples, the values of phytate ranged from 0.09 to 0.72%, oxalate (0.02 to 2.15%), phenol (0.11 to 10.27 mg/100g), saponin (0.61 to 2.72 mg/100g), steroid (0.01 to 6.16 mg/100g), tannin (0.25 to 1.67 mg/100g), alkaloid (0.87 to 1.72%), and flavonoid (1.16 to 4.87 mg/100g). The result of the sensory evaluation showed that the soup samples were generally acceptable by the consumers. The result of this study showed that *Okoho* root contained the highest vital nutrient and could be used as a substitute for the costly and over-used *Ogbono* seeds.

Keywords: Soup thickeners, *Okoho* root, *Ogbono* seeds, Food gum, Functional properties.

1. Introduction

Okoho (*Cissus populnea*) is an under-exploited plant that belongs to the family *Amplidaceae* (*Vitaceae*). It is commonly grown in Nigeria and other African countries including Senegal, Uganda, Sudan and Abyssinia (Achikanu and Ani, 2020). *Okoho* is a shrub which usually climbs on trees with height up to 3 m or more depending on its age and the tree supporting it (Yaaya, 2019). It is a food gum and functions as a thickening agent in the thickening of soups in different parts of Nigeria. It is well known in the middle belt of Nigeria by some ethnic groups such as *Igala*, *Tiv*, and *Idoma*; where it is part of the cuisine (Adebowale et al., 2015). In Nigeria, the *Igala* and *Idoma* ethnic groups refer to this plant as *Okoho*, Yoruba as *Ogbolo*, and Hausa as *dafaaraa*. The thickening, gelling, coating/binding properties of *Okoho* has made it useful in the food industries as hydrocolloid, in the production of jam, jelly, marmalade, salad dressings and in the production of baked foods (Ibrahim and Dawes, 2000; Eichie and Amalime, 2007). Aguoru et al. (2014) reported that extract from *Okoho* root can be used to treat and manage skin diseases, boils, infected wounds, thus suggesting antibacterial potency of the plant. *Okoho* has also been used in ethno-medicine for treating various diseases especially infertility (Danladi et al., 2023).

Ogbono (*Irvingiaspp*) belong to the *Irvingiacceae* plant family (Tsobeng et al., 2021). In Africa, there are roughly seven *Irvingia*varieties, but *Irvingia gabonensis* and *Irvingia wombolu* are commonly known in Nigeria (Orisa et al., 2024). They are commonly referred to as bush/wild mangoes or African mangoes because of their mangoe-like fruits. They are usually grown for their fruits and seeds commonly referred to as *ugiri* and *ogbono* respectively by the Igbos in South Eastern part of Nigeria (Ohaeri and Ohaeri, 2015).*Irvingia gabonensis* and *Irvingia wombolu* are similar but can be differentiated by their fleshy mesocarps. The fleshy mesocarp of *I. gabonensis* is sweet, edible, and can be eaten fresh or used to make juice, while the fleshy mesocarp of *Irvingia wombolu* is bitter and not edible (Fasogbon et al., 2017; Ezenwaet al., 2023). *Irvingia wombolu* is usually grown for its seeds. The fruits of *Irvingia* are smooth yellow spheres with a hardened endocarp (kernel), which houses the seed. The seeds which are of interest, are ground into flour and used to make draw soup commonly called ogbono soup. Etebu (2012) reported the presence of health beneficial phytochemicals such as alkaloids, saponins, glycosides and tannins. *Ogbono* have become so popular because it has been shown to help promote weight loss in several ways. It helps to boost the level of leptin; a hormone that helps suppress appetite. It has been shown to reduce low density lipoprotein (LDL), while simultaneous boosting the high-density lipoprotein (HDL), which helps to clean out the arteries; thereby preventing Atherosclerosis (Ngondi et al., 2005).

Soups are important accompaniments to meals. According to Onighinde (2005), soups as a liquid food is made by boiling meat, vegetables, seasonings, and herbs and are often served as the first course of a meal. In Nigeria, soups are usually thickened with various ingredients; such as *Okoho*, *Ogbono* etc. Soups prepared with these thickeners can be eaten served with these thickeners can be eaten with or served as accompaniments to various meals such as millet-garri, pounded yam, cassava *fufu*, semolina etc. There is paucity of information on the uses and potentials of indigenous underutilized food crops. *Okoho*, a soup thickener is one of the indigenous underutilized plant. There have been so much concentration on the consumption of *Ogbono*; a well-known soup thickener, without having interest on other soup thickeners that might have the same nutritional value with *Ogbono*. This attitude of consumers has really affected food security (i.e the availability, accessibility, and affordability of safe and nourishing foods, in sufficient quantities for household or nation) in this period that foods are scarce and costly. Comparing and evaluating the physicochemical and sensory properties of *Okoho* root and *Ogbono* will complement literature in making known the potential of this underutilized plant, *Okoho* and as well as providing consumers with the opportunity of having substitute for *Ogbono*; which is now very expensive. This will curtail the monotony associated with the consumption of *Ogbono*. The main objective of this project is to compare and evaluate the physicochemical and sensory attributes of *okoho* root and *ogbono* seeds.

2. Research Methods

Material

The raw materials that were used in this study were root of *Okoho* and two varieties of *Ogbono* Fruits (*Irvingia gabanensis* and *Irvingia wombolu*). The root of *Okoho* was obtained from a farm at Umuezike – Aku village in Igbo Etiti Local Government area of Enugu state, Nigeria. Then, the two varieties of *Ogbono* Fruits (*Irvingia gabanensis* and *Irvingia wombolu*) were obtained from a farm, at Amaoba village in Ikwuano Local Government Area of Abia State, Nigeria. They were taken to the Food Processing laboratory of Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike, Abia State prior to further analyses. Figure 1. shows the pictures of the raw materials.

Methods

Production of flour from *okoho* root

The *Okoho* root was prepared according to the method described by Onojah et al. (2015). The root was washed and the bark scrapped with stainless kitchen knife. The scrapped roots were cut into smaller sizes (3 cm length and 0.3 cm width). The size-reduced roots were dried in the oven at 65^{o}C for three (3) days, and then milled into flour using hammer milling machine. The flour was sieved with woven wire sieve of 0.1cm mesh size and packaged in air-tight container prior to further analyses.

a

b

c

d

e

f

Figure 1. Raw materials (a) Fresh *Okoho* root, (b) Dried *Okoho* root, (c) *Irvingia gabonensis* fruit, (d) *Irvingia gabonensis* seeds, (e) *Irvingia wombolu* fruits and (f) *Irvingia wombolu* seeds.

Production of flour from *ogbono* seeds

The method described by Ekpe et al. (2007) was adopted with slight modification. The two varieties of *ogbono* fruits were collected and were packed differently in sack bags. They then were allowed to ferment for a period of two weeks at room temperature. The fermented fruits were manually de-pulped to obtain the seeds. The seeds obtained were also dried for 7 days and then cracked to release the white cotyledons. The cotyledons from the different varieties were dried in the oven at 65^{0}C for 48 hours and milled into flour using hammer milling machine. The flours were sieved using woven wire sieve of mesh size 0.1cm. They were packaged in air-tight containers and labelled accordingly prior to further analyses.

The *Okoho* root flour and the flours from the two varieties of *Ogbono* were used to formulate another 3 samples by blending each in equal proportions. Altogether, six samples were formed as presented in table 1.

Table 1. Sample formulation and codes

Sample Proportion	Sample Code
100% *okoho*	OKH
100% *Irvingia gabonensis*	IGB
100% *Irvingia wombolu*	IWB
Okoho: *Irvingia gabonensis*; 50 : 50	OGB
Okoho Irvingia wombolu; 50 : 50	OWB
Irvingia gabonensis : *Irvingia wombolu*; 50 : 50	WGB

Research Procedures

Determination of functional properties of flour blends

The functional properties of the flours were determined according to the method described by Onwuka (2018). These include bulk density, water/oil absorption capacity, viscosity, emulsion capacity, gelatinization temperature and time, wettability and swelling index.

Determination of proximate composition of the flour blends

Proximate analyses of the flours were carried out as described by AOAC (2023). These include the moisture content, ash, crude protein, crude fat and crude fibre. Carbohydrate was calculated by difference.

Determination of Phytochemical composition of the flour blends

Phytochemical analyses of the flours were carried out as described by Onwuka (2018). These include phytate, oxalate, phenol, tannin, alkaloid and flavonoid. The saponin and steroid content were determined using the method described by Trease and Evans (1996).

Sensory Evaluation of the soup samples

The various (six) flour samples were used to prepare soup with the same quantity of ingredients as presented in table 2. The prepared soups were accompanied with millet-garri dough meal (swallow) and served to 20 semi-trained panelists selected from the Department of Food Science and Technology, Michael Okpara University of Agriculture, Umudike. According to Iwe (2010). The panelists were asked to taste the soup samples and evaluate the following parameter; appearance, drawability, taste, aroma, and general acceptability; indicating how much they like or dislike each soup sample by using 9-point hedonic scale.

Table 2. Recipe for the soup sample

Ingredients	Quantity
Sample	30 g
Oil (palm oil)	75 mL
Water	1000 mL
Maggi knorr (seasoning)	8 g
Salt	5 g
Okpei	0.5 g
Ground crayfish	5 g
Ground fresh pepper	5 g
Dried catfish	50 g
Beef	200 g

Experimental design and analysis

Completely randomized design was used for this study. All experiments in this study were reported as mean of duplicate analyses. One way analysis of variance using the Statistical Product of Service Solution version 22.0 was carried out to compare between the means, while treatment means were separated using Duncan multiple range test at 95% confidence level ($p<0.05$).

3. Results and Discussion

Functional Properties of the Flour Samples

The result of the functional properties of the flour blends is presented in table 3. The result showed that there was a significantly different ($p<0.05$) in the bulk density of the flour blends. The bulk density values obtained ranged from 0.65 to 0.95 g/mL with *I.gabonensis: I.wombolu* flour blend having the highest bulk density, whereas *Okoho* flour had the lowest bulk density. This indicated that *I.gabonensis: I.wombolu* flour particles were better aligned and easily packed together. This could also be an advantage during transportation and distribution, since a large amount of material might be accommodated in a smaller volume. The low bulk density of *Okoho* flour would make it useful in the formulation of complementary foods which require flours with low bulk density. The values of bulk density obtained in this study were higher than 0.56 to 0.62 g/mL and 3.53 to 4.27g/mL for ready-to-cook *ogbono* mix flour and instant *ogbono* powder as reported by Ogunbusola et al. (2014) and Bamidele et al. (2015) respectively. The variations in the result might be due to the differences in the raw materials used.

The water absorption capacity (WAC) and the oil absorption capacity (OAC) of the flour blends were significantly different ($p<0.05$).The values obtained ranged from 8.77 to 10.00g/mL and 9.23 to 10.53g/mL for WAC and OAC respectively. The WAC was observed to be highest in *I.wombolu* flour and lowest in *Okoho* flour. The high WAC in flours has always been associated with the leaching and solubility of amylase, and loss of starch crystalline structure. The flour with high WAC may have more hydrophilic constituents such as polysaccharide. Protein has both hydrophilic and hydrophobic nature, and therefore can interact with water in foods. The high WAC of *Irvingia wombolu* flour proved it to be useful in products such as soups where good viscosity is required (Butt and Batools, 2010). The high OAC observed in *Okoho*: *I. gabonensis* flour blend suggested that the flour had more hydrophobic interaction site.

Table 3. Functional properties of the flour blends

Properties	IGB	IWB	OKH	OGB	OWB	WGB
BD (g/ml)	$0.91^{b}\pm 0.01$	$0.87^{c}\pm 0.01$	$0.65^{f}\pm 0.01$	$0.75^{e}\pm 0.01$	$0.78^{d}\pm 0.01$	$0.95^{a}\pm 0.02$
OAC (g/ml)	$9.23^{f}\pm 0.02$	$10.27^{b}\pm 0.02$	$9.31^{e}\pm 0.01$	$10.53^{a}\pm 0.01$	$10.19^{c}\pm 0.01$	$9.67^{d}\pm 0.01$
WAC (g/ml)	$9.83^{b}\pm 0.06$	$10.00^{a}\pm 0.00$	$8.77^{d}\pm 0.06$	$9.83^{b}\pm 0.06$	$9.83^{b}\pm 0.06$	$0.93^{f}\pm 0.00$
SI (g/ml)	$2.74^{c}\pm 0.01$	$1.68^{e}\pm 0.01$	$10.53^{a}\pm 0.01$	$2.97^{b}\pm 0.01$	$1.91^{d}\pm 0.02$	$3.03^{a}\pm 0.02$
FC (g/ml)	$2.94^{c}\pm 0.02$	$2.88^{e}\pm 0.01$	$0.98^{f}\pm 0.01$	$6.02^{b}\pm 0.01$	$11.76^{a}\pm 0.01$	$3.86^{d}\pm 0.01$
FC (g/ml)	$25.55^{e}\pm 0.08$	$23.77^{f}\pm 0.08$	$40.33^{a}\pm 0.03$	$39.45^{b}\pm 0.00$	$29.47^{c}\pm 0.11$	$27.46^{d}\pm 0.10$
W (min/sec)	$7.28^{b}\pm 0.01$	$7.37^{a}\pm 0.02$	$1.27^{de}\pm 0.01$	$0.57^{e}\pm 0.01$	$0.46^{f}\pm 0.01$	$4.38^{c}\pm 0.01$
V (Pa.s)	$3.12^{c}\pm 2.89$	$3.02^{e}\pm 1.73$	$3.19^{a}\pm 1.15$	$3.17^{ab}\pm 1.00$	$3.15^{bc}\pm 1.15$	$3.07^{df}\pm 6.14$
G.Tem (^{0}C)	$80.04^{a}\pm 0.01$	$54.86^{c}\pm 0.58$	$39.02^{e}\pm 0.02$	$57.67^{b}\pm 0.56$	$47.33^{b}\pm 1.54$	$57.00^{b}\pm 1.00$
G.T (min/sec)	$2.30^{a}\pm 0.02$	$1.14^{c}\pm 0.02$	$0.43^{e}\pm 0.01$	$0.55^{d}\pm 1.00$	$0.45^{e}\pm 0.01$	$2.19^{b}\pm 0.02$

Note: Value are means of triplicate determinations $\pm$ standard deviation.$^{a-f}$ values with different superscript on the same row are significant different at $p<0.05$. KEY: BD = Bulk density; OAC = Oil absorption capacity; WAC = Water absorption capacity; SI = Swell index; FC = Foam capacity; EC = Emulsion capacity; W = Wettability; V = Viscosity;G.Tem = Gelation temperature; G.Time = Gelation time.

The result showed that there was a significant difference ($p<0.05$) in the swelling index of the flour blends, which ranged from 1.23 to 3.03g/mL. The highest swelling index was observed in the flour blend (*I. wombolu*: *I.gabonensis*) while the lowest swelling index was observed in *Okoho* flour. The ability of flours to absorb water and swell is an important factor in the choice of soup thickener (Onuegbu and Ojukwu, 2013). The values of the swelling index obtained in this study was lower than 5.66 to 2.04 g/mL for instant *ogbono* powder as reported by Bamidele et al. (2015), but were within the range of 2.90 to 7.20 g/mL for maize and mushroom composite flour as reported by Bamidele and Fasogbon (2020). The variations could be due the differences in the raw materials used and the processing methods.

There was a significant difference ($p<0.05$) in the foaming capacity (FC) of the flour blends, with the values ranging from 0.98 to 11.76 g/mL. *I. wombolu* flour had the highest value, while *Okoho* flour had the lowest value. Foaming capacity is used to measure the amount of interfacial area created by protein during foaming (Zhu et al., 2017).

There was a significant difference ($p<0.05$) in the emulsion capacity (EC) of the flour blends, with the values ranging from 23.77 to 40.33 g/mL .*Okoho* flour had the highest value, while *I. wombolu* flour the lowest value. The unfolding of proteins at the water/oil interface plays an important role in the emulsifying capacity and stability due to increased hydrophobicity. The ability of flours to form emulsions is an important characteristics of soup thickeners in southern Nigeria, since the oil and water phase in the soup must not be separated (Onuegbu and Ojukwu, 2013). This implied that *Okoho* flour with highest emulsions capacity could be the best flour for thickening soups. However, the values of emulsion capacity of the flour blends in this study were lower than 237 to 242 g/mL for ready-to-cook *Ogbono* mix flour as reported by Ogunbusola et al. (2014).

The flour samples had wettability capability of 0.46 to 7.37 min/sec, with *I. wombolu* flour having the highest value of wettability, while *Okoho: I. wombolu* flour blend had the lowest value of wettability. There was a significant difference ($p<0.05$) in the wettability capability of the flour samples. Wettability capacity measures the rate at which flours get wet when in contact with water. The high wetting capacity of *I. wombolu* flour could be attributed to its high lipid content (which is hydrophobic). The low wetting capacity of *Okoho: I. wombolu* flour could be attributed to the blending effect with *Okoho* flour, which recorded low fat content in this study; thereby making the flour blend to absorb water faster than others.

There was a significant difference ($p<0.05$) in the viscosity of the flour blends. The viscosity values ranged from 3.02 to 3.19 Pa.s with *Okoho* flour having the highest viscosity while *I. wombolu* have the lowest viscosity. The viscosity foods can be influenced by the size and shape of the starch granules, ionic charge on the starch, type and degree of crystallinity within the granules, amount of fat and protein, and molecular size and degree of branching of amylose and amylopectin. The values of viscosity obtained in this study were higher than 1.26 to 3.17 Pas.s for *Ogbono*/*Egusi* premix powder as reported by Kiin-Kabari and Akusu (2017). The variation might be due to the differences in the raw material used.

The result also showed that there was a significant difference ($p<0.05$) in the gelation temperature and time of the flour samples. The gelation temperature of the flour samples varied from 39.02 to 80.04^{0}C, with *I.gabonensis* flour sample having the highest gelation temperature, while *Okoho* flour sample had the lowest gelation temperature. The gelation time of the flour samples ranged from 0.43 to 2.30 min/sec, with *I.gabonensis* flour sample having the highest gelation time, while *Okoho* flour sample have the lowest gelation time. The low gelatinization point of *Okoho* flour sample might be attributed to the high starch content of the *Okoho* flour compared to *I. gabonensis* which had a higher gelatinization point and low starch content.

Proximate Composition of the Flour Samples

The result presented in Table 4 shows the proximate composition of the flour blends. The result showed that there was a significant difference ($p<0.05$) in the moisture content of the flour blends, with the values ranging from 6.30 to 8.30%.*Okoho: I.gabonensis* flour had the highest value while *I. wombolu* have the lowest value. The variation could be as a result of the differences in the varieties of the thickeners. Moisture contents is of great importance for the safe storage of flour regarding microorganism, particularly certain species of fungi. The low moisture content obtained in this study suggests that the flours can be would have a prolonged shelf life when properly stored. The values of the moisture content of the flour blends obtained in this study were similar with that of 6.00 to 8.00% for ready-to-cook *Ogbono* mix flour as reported by Ogunbusola et al., (2014), but were higher than that of 3.82 to 4.86% for *Ogbono*/*Egusi* premix as reported byKiin-Kabari and Akusu (2017).

The protein content of the flour blends varied significantly ($p<0.05$). The values ranged from 8.02 to 20.63%, with *Okoho* flour having the highest value, while *I.gabonensis* flour have the lowest value. The value of the protein content of *Okoho* flour was similar with the value (21.0%) of *Okoho* root as reported by Onojahet al. (2015). This implies that *Okoho* root is a good source of proteinand can be recommended for use in food formulations that require high protein content. The values protein content obtained in the study were lower than 25.66 to 54.77% for *Ogbono*/*Egusi* premix as reported by Kiin-Kabari and Akusu (2017). The variation in the results could be due the differences in the raw materials used.

Table 4. Proximate composition of the flour blends

Samples	IGB	IWB	OKH	OGB	OWB	WGB
Moisture (%)	$7.43^{b}\pm0.06$	$6.30^{e}\pm0.26$	$8.53^{a}\pm0.06$	$8.37^{a}\pm0.11$	$7.13^{c}\pm0.11$	$6.65^{d}\pm0.13$
Crude protein (%)	$8.02^{f}\pm0.01$	$8.82^{d}\pm0.06$	$20.62^{a}\pm0.02$	$14.82^{c}\pm0.02$	$15.27^{b}\pm0.40$	$8.42^{e}\pm0.01$
Crude fibre (%)	$2.04^{fc}\pm0.01$	$3.33^{d}\pm0.33$	$20.73^{d}\pm0.02$	$10.37^{c}\pm0.01$	$13.63^{b}\pm0.01$	$2.23^{e}\pm0.02$
Ether extract (%)	$69.68^{a}\pm0.01$	$65.35^{c}\pm0.02$	$3.34^{f}\pm0.02$	$36.44^{d}\pm0.01$	$34.68^{e}\pm0.01$	$65.99^{b}\pm0.30$
Ash (%)	$2.61^{e}\pm0.01$	$2.52^{f}\pm0.04$	$3.13^{d}\pm0.02$	$3.57^{a}\pm0.01$	$3.41^{b}\pm0.01$	$3.33^{c}\pm0.01$
Carbohydrate (%)	$10.24^{e}\pm0.06$	$13.68^{d}\pm0.29$	$43.65^{a}\pm0.10$	$26.43^{b}\pm0.80$	$25.89^{c}\pm0.37$	$13.38^{d}\pm0.36$

Note: Values are means of triplicate determinations $\pm$ standard deviation. $^{a-f}$values with different superscript on the row are significantly different ($p<0.05$).

There was a significant difference ($p<0.05$) in the crude fibre content of the flour blends. The values ranged from 2.04 to 20.73%, with *Okoho* having the highest value, while *I.gabonensis* had the lowest value. The high fibre content of *Okoho* suggests that the flour would have some nutritional and health benefits like prevention of diseases such as constipation, haemorrhoids, colon cancer heart diseases, obesity and diabetes. The values of fibre content (1.56 to 3.88%) for *Ukpo*, *Akpalata*, and *Achi* composite flour as reported by Asoiro et al. (2022) were within the range of the values of the fibre content obtained in this study. The values of the fibre content of 2.00 to 2.60% for ready-to-cook *ogbono* mix flour as reported by Ogunbusola et al. (2014) were also within the range of the values of the fibre content obtained in this study. The variations in the result could be as a result of the differences in the raw materials used and the processing methods.

The values obtained for ether extract (crude fat) of the flour blends showed that there was a significant difference($p<0.05$) in the crude fat content of the flour blends. The values ranged from 3.34 to 69.68%, with *I.gabonensis* flour having the highest value, while *Okoho* flour sample had the lowest value. The result revealed that *I.gabonensis* flour contained very high fat content and the value obtained in this study was in line with the previous findings on crude fat (68.37%) of *I. gabonensis* by Ogunsina (2012). The low fat content of *Okoho* suggests that, it may be useful for individuals seeking to reduce their fatty food intake for health reasons. The crude fats content recorded for *Okoho* flour was also in agreement with the previous finding on the crude fat of *Okoho* root by Onojah et al. (2015).

The ash content of the flour blends varied significant ($p<0.05$). The value ranged from 2.52 to 3.57% with *Okoho*: *I. gabonensis* flour blend having the highest value, while *I. wombolu* flour had the lowest value. The result showed that the ash content (3.13) of *Okoho* flour agreed with the previous report on the ash content of *Okoho* root by Onojah et al. (2015). The ash content (2.61%) of *I. gabonensis* flour was also in line with the ash content (2.32) of *I. gabonensis* reported by Ogunsina (2012).

There was a significant difference ($p<0.05$) in the carbohydrate content of the flour blends. The values ranged from 10.24 to 43.65 %, with *Okoho* flour having the highest value, while *I. gabonensis* flour had the lowest value. Carbohydrate constitutes a major class of naturally occurring organic compounds that the body needs for energy. This implied that *Okoho* flour with the highest carbohydrates contents would be more useful as raw material for food formulations requiring high carbohydrate content.

Phytochemical Composition of the Flour Samples

The result of the phytochemical composition of the flour blends is presented in Table 5. Phytochemicals are natural bioactive constituents which are present in plants and these natural constituents work with nutrients and dietary fibres to protect humans against diseases (Altemimi et al., 2017; Danladi et al., 2023). The result showed that there was significant difference ($p<0.05$) in the phytate content of the flour blends. The values ranged from 0.09 to 0.72%, with *Okoho* flour having the highest phytate content, while *I.gabonensis* flour had the lowest phytate content. The result obtained for *Okoho* agreed with the findings on the phytate content (0.71%) of *Okoho* root as reported by Onojahet al. (2015). The consumption of dietary phytate has been reported to prevent kidney stone formation, protect against diabetes mellitus, caries, atherosclerosis and coronary heart disease as well as against a variety of cancers (Gemede, 2014).

There was significant difference ($p<0.05$) in the oxalate content of the flour blends. The result revealed that the oxalate content of the flour blends ranged from 0.02 to 2.15%, with *I. wombolu* sample having the highest oxalate content while *I.gabonensis* sample had the lowest oxalate content. The result also showed that the oxalate content (0.03%) of *Okoho* sample was in agreement with the previous report on the oxalate content (0.03 %) of *Okoho* root by Onojah et al. (2015). High content of oxalate can bind to calcium present in food, thereby rendering calcium unavailable for normal physiological, and biochemical role such as the maintenance of strong bone, teeth, co-factor in enzymatic reaction, nerve impulse transmission, and as clotting factor in the blood (Thakur et al., 2019). However, food processing such as soaking and cooking of foodstuffs with high oxalate can reduce the oxalate content by leaching.

There was significant difference ($p<0.05$) in the phenol content of the flour blends. The phenol content of the flour blends ranged from 0.11 to 10.27 mg/100g, with *Okoho* flour having the highest phenol content, while *I.gabonensis* flour had the lowest phenol content. The value of phenol obtained for *Okoho* flour was in conformity with the earlier report on the phenol content of *Okoho* root (10.34 mg/100g) by Onojah et al. (2015). Phenol functions as antioxidant and anti-microbial compound. Thus, the high content of phenol in *Okoho* flour could be indication of its apparent anti-microbial potential which might be considered in the treatment of typhoid fever and other bacterial infections (Adeolu and Enesi, 2013).

There was significant difference ($p<0.05$) in the saponin content of the flour blends. The saponin content of the samples ranged from 0.61 to 2.72 mg/100g), with *I.wombolu* sample having the highest saponin content, while *Okoho*: *I. wombolu* sample had the lowest saponin content. Saponin has a bitter taste which could be associated with pharmacological potentials including hemolytic activities. They have beneficial effect on blood cholesterol levels bone health's cancer and stimulation of the immune system (Adeolu and Enesi, 2013). The high content of saponin in *I. wombolu* sample suggest its use for traditional treatment of ailment and in pharmalogical formulation. The result also showed that the value of saponins obtained for *Okoho* flour (0.74 mg/100g) agreed with the previous report on the saponin content of *Okoho* root sample (0.77 mg/100g) by Onojah et al. (2015).

There was significant difference ($p<0.05$) in the steroid content of the flour blends. The steroid content of the sample ranged 0.01 to 6.16 mg/100g, with *I.gabonensis* sample having the highest steroid content, whereas *Okoho* sample had the lowest steroid content. Steroids are important in drug production due to their relationship with such compounds as sex hormone (Okwu, 2001). Thus, high steroid content of *I.gabonensis* suggested its use in the formulation of drugs for improving sex stimulating hormones.

Table 5. Phytochemical composition of the flour blends

Components (mg/100g)	IGB	IWB	OKH	OGB	OWB	WGB
Phatate	$0.09^{f}\pm0.01$	$0.44^{c}\pm0.01$	$0.72^{a}\pm0.02$	$0.31^{d}\pm0.01$	$0.55^{b}\pm0.01$	$0.25^{f}\pm0.01$
Oxalate	$0.02^{d}\pm0.01$	$2.15^{a}\pm0.01$	$0.03^{d}\pm0.01$	$0.35^{c}\pm0.04$	$1.13^{b}\pm0.01$	$1.12^{b}\pm0.02$
Phenol	$0.11^{d}\pm0.01$	$0.71^{b}\pm0.02$	$10.27^{a}\pm0.01$	$0.13^{cd}\pm0.01$	$0.14^{c}\pm0.01$	$0.12^{d}\pm0.01$
Sapponin	$0.76^{c}\pm0.01$	$2.72^{a}\pm0.02$	$0.74^{c}\pm0.02$	$0.68^{d}\pm0.01$	$0.61^{e}\pm0.01$	$0.84^{b}\pm0.02$
Steroid	$6.16^{a}\pm0.01$	$5.68^{b}\pm.01$	$0.01^{f}\pm0.12$	$3.01^{e}\pm0.01$	$3.31^{c}\pm0.01$	$3.19^{d}\pm0.01$
Tannin	$0.25^{f}\pm0.01$	$1.67^{a}\pm0.01$	$0.68^{d}\pm0.01$	$0.54^{e}\pm0.02$	$1.42^{b}\pm0.02$	$0.75^{c}\pm0.01$
Alkaloid	$0.87^{f}\pm0.01$	$1.72^{a}\pm0.02$	$1.04^{d}\pm0.01$	$0.96^{d}\pm0.05$	$1.52^{c}\pm0.01$	$1.46^{e}\pm0.02$
Flavonoid	$1.16^{f}\pm0.01$	$1.72^{d}\pm0.02$	$4.87^{a}\pm0.01$	$2.11^{c}\pm0.02$	$2.63^{b}\pm0.01$	$1.46^{e}\pm0.02$

Note: Values are means of triplicate determinations $\pm$ standard deviation. $^{a-f}$values with different superscript on the same row are significantly different at $p<0.05$.

There was significant difference ($p<0.05$) in the tannin content of the flour blends. The tannin content of the flour blends ranged from 0.25 to 1.67 mg/100g, with *I. wombolu* sample having the highest tannin content, while *I.gabonensis* sample had the lowest tannin content. Tannin compounds are considered to have antinutritional properties (Ojo, 2018) as well as antimicrobial effect when consumed at low level. Thus, the high amount of tannin observed for *I. wombolu* sample suggested that it can be useful in the production of drugs for treatment of bacterial and viral infections.

There was significant difference ($p<0.05$) in the alkaloid content of the flour blends The alkaloid content of the flour blends ranged from 0.87 to 1.72%,with *I. wombolu* flour having the highest alkaloid content, while *I.gabonensis* flour had the lowest alkaloid content. Alkaloids are considered to be anti-nutrients because of their toxic action including the disruption of the cell membrane in the gastrointestinal tract (Friedman et al., 2003). Low level of alkaloids mediate important pharmacological activities such as analgesic reducing blood pressure, killing tumour cells stimulating circulation and respiration (Simee, 2011).

There was significant difference ($p<0.05$) in the flavonoid content of the flour blends The flavonoid content of the samples ranged from 1.16 to 4.87 mg/100g, with *Okoho* sample having the highest flavonoid content, while *I.gabonensis* sample had the lowest flavonoid content. Flavonoid have anti-oxidant, antifungal and anti-bacterial properties, thus the availability of flavonoid in the flours suggested that their use might offer protection against ailments related to free radicals, bacterial and fungal activities (Adeolu and Enesi, 2013).

Sensory evaluation of the soup samples

The result of sensory evaluation of the soup samples is presented in Table 6. The result showed that the appearance scores for *I. wombolu* and *Okoho* soup samples varied significantly ($p<0.05$), while other soups were significantly the same ($p>0.05$).*I. wombolu* soup sample had the highest appearance score of 7.45, while*Okoho* soup sample had the lowest appearance score of 6.30. The highest score recorded for *I. wombolu*soup sample showed that the panelists mostly preferred the appearance of *I. wombolu* soup sample.

There was a slight difference ($p<0.05$) in the sensory scores for taste of the soup samples. *I. wombolu* soup sample had the highest score, while *I. wombolu:I. gabonensis*had the lowest score for taste. The highest scores for taste of *I. wombolu* and *Okoho*:*I. gabonensis* samples showed that the panelists had higher preference for *I. wombolu*and *Okoho*: *I. gabonensis* soup samples in terms of tastethan the others.

The sensory scores obtained for aroma of all the samples showed that there was no significant difference ($p>0.05$) among the soup samples. This means that the panelists liked the aroma of the soup samples similarly.

The result showed that the scores for drawabilty of *Okoho* and *Okoho*: *I. gabonensis* soups differed significantly ($p<0.05$) and they also differ from other soup samples which are significantly the same ($p>0.05$). *I. wombolu:I. gabonensis*soup sample had the highest score of 7.10, while *Okoho* soup sample had the lowest score of 5.55. This implied that all the soup samples had the ability to draw with *Okoho* sample having the least drawability. The result of the general acceptability showed that almost all the panelists accepted all the soup samples similarly and the scores obtained in all the sensory parameters were above 5.0. This implies that the panelists liked all samples beyond average.

Table 6. Sensory attributes of the soup samples

Samples	Appearance	Taste	Aroma	Drawabilty	G. Acceptability
IGB	$6.60^{ab}\pm1.93$	$6.90^{ab}\pm1.45$	$6.80^{a}\pm1.20$	$6.95^{a}\pm0.89$	$7.30^{ab}\pm0.92$
IWB	$7.45^{a}\pm1.10$	$7.20^{a}\pm1.20$	$6.90^{a}\pm0.91$	$7.05^{a}\pm1.28$	$7.50^{a}\pm1.10$
OKH	$6.30^{b}\pm1.42$	$6.05^{b}\pm1.05$	$6.35^{a}\pm1.14$	$5.55^{c}\pm1.33$	$6.05^{b}\pm1.40$
OGB	$7.00^{ab}\pm1.08$	$7.10^{a}\pm1.25$	$6.80^{a}\pm1.32$	$6.30^{b}\pm1.75$	$7.20^{a}\pm1.15$
OWB	$6.75^{ab}\pm1.52$	$6.85^{ab}\pm1.46$	$6.85^{a}\pm1.39$	$7.00^{a}\pm1.08$	$7.25^{a}\pm1.33$
WGB	$7.05^{ab}\pm1.23$	$6.25^{ab}\pm1.68$	$6.85^{a}\pm1.18$	$7.10^{a}\pm1.25$	$7.15^{a}\pm0.81$

Note: values are means of triplicate determinations $\pm$ standard deviation. $^{a-b}$ values with different superscript on the same column are significantly different at $p<0.05$.

Conclusion

The result of this study showed that some of the physicochemical properties of *Okoho* and the two varieties of *Ogbono* were similar, while some were different. The functional properties of the *Okoho* flour, *Ogbono* flours and the blended flours differed significantly. The viscosity and emulsion capacity of *Okoho* were higher than that of *Ogbono* and the blends. However, *Ogbono* flour and the flour blends have higher value than *Okoho* in other functional properties such as oil/water absorption capacity, wettability, gelation temperature etc. The moisture content and the ash content of *Okoho* flour, *Ogbono* flour and the flour blends differed slightly. The crude protein, carbohydrate and crude fibre content of *Okoho* were higher than the crude protein, carbohydrate and crude fibre content of *Ogbono* and the flour blends. The fat and energy value of *Ogbono* flours were higher than *Okoho* and the flour blends. Phytochemicals such as phytate, phenol, and flavonoid are abundant in *Okoho* flour than *Ogbono* flour and the blended flours. Abundant steroid content was obtained for the two varieties of *Ogbono* than *Okoho*. *I. wombolu* have higher content of oxalate, saponin, tannin and alkaloid. The sensory result shows that the soup samples all have good appearance, taste, aroma and drawability. This study shows that the underutilized soup thickener, *Okoho* contain some vital nutrients and health beneficial phytochemicals as the over-utilized *Ogbono*. The Okoho soup sample was also accepted generally by consumers. Therefore, it is recommended that *Okoho* and/or blends of *Okoho* and *Ogbono* should be in use as a substitute for overused and costly *Ogbono*; so as to reduce the monotony in the consumption of *Ogbono* and help enhance food security.

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